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Determinants of bednet ownership and use in visceral leishmaniasis-endemic areas of the Indian subcontinent

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Summary

OBJECTIVE To document ownership and use of bednets with its determinants in the visceral leishmaniasis (VL)-endemic region where mainly non-insecticide impregnated nets are available through commercial channels, and bednets are being considered as a leishmaniasis vector control measure.

METHODS In August–September 2006, semi-structured household (HH) questionnaires and observation guides were used in a random sample of 1330 HHs in VL-endemic districts of India and Nepal to collect data on VL knowledge, HH socio-economic status, bednet ownership and use patterns. An asset index was constructed to allow wealth ranking of the HH. A binary logistic response General Estimating Equations model was fitted to evaluate the determinants of bednet ownership and use.

RESULTS The proportion of HHs with at least one bednet purchased on the commercial market was 81.5% in India and 70.2% in Nepal. The bednets were used in all seasons by 50.6% and 54.1% of the Indian and Nepalese HH owning a bed net. There was striking inequity in bednet ownership: only 38.3% of the poorest quintile in Nepal owned at least one net, compared to 89.7% of the wealthiest quintile. In India, the same trend was observed though somewhat less pronounced (73.6% *vs.* 93.7%). Multivariate analysis showed that poverty was an important independent predictor for not having a bednet in the HH [OR 5.39 (2.90–10.03)].

CONCLUSION Given the inequity in commercial bednet ownership, free distribution of insecticide-treated bednets to the general population seems imperative to achieve a mass effect on vector density.

keywords visceral leishmaniasis, India, Nepal, bednet use, bednet ownership, poverty

Introduction

Visceral Leishmaniasis (VL), deadly if left untreated, is caused by *Leishmania donovani* and transmitted by endophagic and night-biting *Phlebotomus argentipes* in the Indian subcontinent. Because VL transmission is believed to be anthroponotic in this region, its control is based on case detection and treatment and indoor residual insecticide spraying. The potential of insecticide-treated bednets (ITN) as a vector control method in the fight against VL in this region has been recently reviewed (Ostyn *et al.* 2008), and the regional VL elimination initiative (India, Nepal and Bangladesh) is considering to include ITN as one of its control strategies (Sundar *et al.* 2008). ITN have proven efficacy in the prevention of cutaneous leishmaniasis (Tayeh *et al.* 1997; Reyburn *et al.* 2000; Alten *et al.* 2003), but there is so far no supportive evidence for their impact on VL incidence (Bern *et al.* 2000; Ritmeijer *et al.* 2007).

A large community trial in Nepal and India is currently evaluating the efficacy of long lasting insecticide-treated nets (LN) in the prevention of VL (http://www.kalanet-project.org). Vector control policy makers require, beyond evidence on efficacy, also data on current bednet use, as it is informative with regard to future uptake of an LN intervention and its distribution mechanism: free *vs.* subsidized and centrally distributed *vs.* individually purchased. Several authors have pointed to a high demand and an existing market for commercial bednets in the Indian subcontinent, where bednet coverage is reported to be at least 70.0% (Bern *et al.* 2000, 2005; Schenkel *et al.* 2006; Singh *et al.* 2006; Das *et al.* 2007), except for some areas in Nepal where coverage was as low as 36.8% (Koirala

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et al. 1998). As VL is a disease that is mainly affecting the poor (Joshi *et al.* 2008; Boelaert *et al.* 2009), we had a special interest in the question how equitable the ownership (and use) is of those bednets which are currently purchased on the commercial market. Studies on this subject were so far mainly performed on bednet use for malaria in Africa (and some in central Asia), with contradictory results: Webster *et al.* (2005) concluded that markets contribute more to equitable coverage of mosquito nets than subsidized delivery, while several other authors claimed inequity was generated when bednets were only available through commercial channels (Howard *et al.* 2003; Mathanga *et al.* 2006; Skarbinski *et al.* 2007) and advised free of charge distribution to break the vicious cycle of disease and poverty (Guyatt *et al.* 2002).

We report a household (HH) survey in Nepal and India describing current bednet ownership and use patterns in VL-endemic areas and its determinants.

Methods

This study was conducted as one of the baseline assessments within the KALANET community trial project (ClinicalTrials.gov CT-2005-015374). That trial was designed to detect a 50% reduction in *L. donovani* infection incidence rates in 13 intervention clusters using LN compared to 13 matched control clusters [numbers determined by sample size calculations for cluster-randomized trials (Hayes & Bennett 1999)]. This trial takes place in the VL-endemic areas of the Saptari, Sunsari and Morang districts in Terai lowlands, Nepal (10 clusters) and in Muzaffarpur district, Bihar State, India (16 clusters). Trial clusters were selected amongst the villages with highest VL incidence rates and comply with a criterion of a minimum 0.8% average VL incidence rate over the past 3 years. An exhaustive census of all HHs belonging to the clusters collected demographic and socio-economic data. We report here the baseline assessment of bednet acceptability at community level, before any intervention was launched.

Data collection

We randomly selected 50 HHs by systematic random sampling in each of the 26 trial clusters in August–September 2006. The sample size for this baseline survey, (16*50 =) 800 and (10*50 =) 500 HH in India and Nepal, respectively, was calculated to allow later comparison of LN use (data not shown) with pre-trial bednet use and detect a minimal difference between both of 17% (from a baseline proportion of 50%), with an alpha error of 0.05 and power of 80%, given an inter-cluster variation coefficient of 0.25 (Hayes & Bennett 1999).

We conducted interviews with each head of HH, using semi-structured HH questionnaires and observation guides, which were pre-tested and adapted to the local characteristics of each country. One questionnaire was filled out per HH, collecting data on: socio-economic and demographic characteristics, history of clinical VL in HH (ever), knowledge on VL and its transmission, possession of bednet(s) per HH, use of bednets, regularity of use throughout the year by the respondent, reasons and barriers for use and observation of condition of nets.

Data analysis

Frequencies, means and standard deviations, medians and inter-quartile range (IQR) and ranges of responses were computed to describe the basic characteristics of HH in each country. The following definitions of 'correct knowledge' were used in the analysis:

- Correct knowledge of clinical VL: a spontaneous answer including 'fever' plus one or more of the following symptoms: 'weight loss and/or weakness', 'pain in abdomen', 'darkened skin', 'swelling of abdomen'.
- Correct knowledge of vector-borne character of VL: a spontaneous answer including 'sandfly bites' or 'small insect bites' or 'mosquito bites' and no wrong quotations on transmission patterns (as 'polluted air' or 'water')

To allow poverty ranking of the HH, an asset index was constructed with data on ownership of durable assets in the HHs, characteristics of the habitat and access to basic services. This index reflects long-term HH wealth when income and expenditure data are not readily available (Filmer & Pritchett 2001). Principal Component Analysis (Vyas & Kumaranayake 2006) was used to develop the asset index by assigning weights to the indicators so to create the weighted linear combination of the variables that accounts for the largest amount of the total variation in the data. As measurement scales differ between variables, all of them were first standardized. Missing values were replaced with the mean value for that variable. Fourteen variables were included in the initial model, but because of weak correlation, one indicator (number of pigs) in Nepal and two in India (number of poultry and number of goats) were not included in the country asset indexes (Table 1). With these models, 35.4% of variance was explained for Nepal and 28.0% for India. The asset index score was used to classify the HHs in five wealth groups: from the first quintile being the poorest HH up to the fifth quintile being the least poor.

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Table 1 Indicators included in the asset index of India and Nepal, visceral leishmaniasis-endemic areas of Nepal and India (September 2006)

	India	Nepal
Housing structure	Number of living rooms	Number of living rooms
	Type of house (based on wall and roof): made of thatch; mud; mixed cement with others; full cemented	Type of house (based on wall and roof): made of thatch; made of mud; wooden; mixed cement with others; full cemented
Household (HH) access to utilities and infrastructure	Main type of fuel used for cooking: whether it is weed/dried animal dung or not	Main type of fuel used for cooking: weed/dried animal dung; wood/coal/kerosene; gas/electricity
	Electricity in the HH	Electricity in the HH
Productive assets in the HH	Agricultural land	Agricultural land
	Bicycle	Bicycle
	Motorcycle/scooter	Motorcycle/scooter
		Number of poultry
		Number of goats
	Number of cows/bullock	Number of cows/bullock
Non-productive assets in the HH	Radio	Radio
	Television	Television
	Type of bed: none; cot; palang	Type of bed: none; cot; palang

Bivariate analysis was performed on all relevant variables prior to inclusion in subsequent higher order analyses. Odds ratios (OR) and their 95% confidence intervals were calculated. To evaluate the determinants of ownership (defined as 'presence of at least one bednet in a HH') and of use (defined for the HH with at least one bednet, as 'all HH members used bednets the night previous to the interview'), we constructed two separate binary logistic response General Estimating Equations models. This type of model takes into account the clustering of data at trial cluster level. Adjusted odds ratios with 95% confidence intervals were computed.

All data were double-entered by two independent data clerks into an Access database (Microsoft Office Access 2003), and analysis was performed with SPSS v.16.0 software (SPSS Inc., Chicago, IL, USA).

Ethical considerations

The study was approved by the ethical committees of the Universitary Hospital Antwerp (UZA), the London School of Hygiene and Tropical Medicine, the B.P. Koirala Institute of Health Sciences in Nepal and by the Indian Council of Medical Research. HH informed consent was obtained from all HH included in the KALANET-study.

Results

A total of 1330 HHs were included (793 in India and 537 in Nepal) and 1888 bednets inspected (1133 in India and 755 in Nepal). Indian and Nepalese HH of 67.5% and 76.5%, respectively, are living in thatch and mud houses. In about half of the HHs of both countries, the head of HH is illiterate and earns his income by doing daily and unskilled work. We observed significant differences between the Nepalese and the Indian sites on general HH characteristics and use of HH vector control methods (Table 2). More than 98% of the people in both countries complained of mosquito nuisance, which is also reflected in the frequently reported use of vector control tools. The majority of HH (92.9%) in Nepal reported that their houses were sprayed in the previous 12 months, against only 14.8% in India, but in both countries more than 80% of the respondents stated this spraying had in their opinion no or only limited effect on mosquito nuisance.

While only 0.3% of Indian respondents and 11.2% of Nepalese identified the sandfly as the vector of VL, respectively, 58.5% and 85.8% knew that VL was transmitted by a vector. HH in India reported more frequently a positive history of VL in the past in their family than in Nepal (Table 3).

In India, 81.5% of the houses had at least one bednet against 70.1% in Nepal ($P < 0.001$). In Nepal, if there is at least one bednet in the house, it is more likely that all HH members slept under a bednet in the previous night (74.3%) than in India (32.0%). In both countries, the persons not sleeping under a net were more or less equally distributed (around 20% in each group) over son, daughter, wife of head of HH, head of HH and relatives. In both countries, more women or girls (58.9% in Nepal; 57.6% in India) were sleeping under the nets than men or boys (41.1% in Nepal; 42.4% in India). The nets of 0.1% were impregnated with insecticides in India and 6.9% in Nepal. Nets were used indoors by more than 90% of the Indian

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Table 2 General characteristics of households (HH) sampled from visceral leishmaniasis-endemic areas of Nepal and India (September 2006)

	India (*n* = 793 HH) (%)	Nepal (*n* = 537 HH) (%)	*P*
HHs with >5 members	444 (55.9%)	193 (35.9%)	<0.001
Religion			
Hindu	697 (87.9)	487 (90.7)	<0.001
Muslim	96 (12.1)	17 (3.2)	
Other (Christian, Buddhist, Kirat)	–	33 (6.1)	
Caste			
General	76 (9.7)	NA	
Other Backward Classes (OBC)	515 (65.7)	NA	
Scheduled Cast (SC)/Scheduled Tribe (ST)	193 (24.6)	NA	
Female head of HH	50 (6.3)	65 (12.1)	<0.001
Vector control methods commonly used at HH level	765 (96.5)	293 (54.6)	<0.05
Mosquito coil	104 (13.1)	103 (35.2)	
Bednet	495 (62.4)	113 (38.6)	
Cleaning	190 (24.0)	115 (39.2)	
Smokes	540 (68.1)	190 (64.8)	
Spray	3 (0.4)	10 (3.4)	
Hand-fan	162 (21.2)	–	
Other	18 (2.3)	13 (4.4)	

NA, not applicable.

Table 3 Visceral leishmaniasis (VL) related characteristics of households (HH) sampled from VL-endemic areas of Nepal and India (September 2006)

	India (*n* = 793 HH) (%)	Nepal (*n* = 537 HH) (%)	*P*
History of VL in HH	317 (40.0)	87 (16.2)	<0.001
Correct knowledge on clinical VL	445 (56.1)	282 (52.5)	>0.05
Correct knowledge on vector-borne character VL	706 (89.0)	461 (85.8)	>0.05
Houses with bednets observed	646 (81.5)	377 (70.2)	<0.001
	(*N* = 646)	(*N* = 377)	
Number of HH where all HH members slept under the bednet the previous night	207 (32.04)	280 (74.3)	<0.001
Mean number of nets/HH (SD) (min–max)	2 (1) (1–6)	1.96 (1.05) (1–6)	>0.05
Mean number of persons sleeping under one net	2.13	2.0	>0.05
Use of net by respondent in all seasons	328 (50.8)	225 (59.7)	<0.05

and Nepalese HHs. In both countries, about half of the respondents did not use the bednets in all seasons. The reasons evoked for this were not having enough nets (India) and no mosquito nuisance in certain seasons (Nepal and India). In India, 79.2% of the respondents (owning a bednet) *vs.* 71.9% in Nepal were using the net in the rainy season. In India, we observed that 65.6% of the nets were folded and kept away during daytime (against 19.6% in Nepal), which means that nets are often manipulated which could be related with the bad condition in about one-third of the nets (Table 4). In both countries, people were mainly using nets to protect themselves from mosquito and insect bites. Very few respondents (5.4% in India; 2.1% in Nepal) replied having problems while using the nets, and if so, mainly feeling too hot while sleeping under the net.

In India, 99.3% of the HH without a bednet gave as reason that they could not afford to buy one, and only two respondents said it was because they did not like them. In Nepal, less respondents linked the absence of nets to economic reasons (58.1%), 38.7% did not have any explanation and 3.1% did not like them. The association

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Table 4 Description of the use and condition of bednets, present in 838 houses (1888 bednets), visceral leishmaniasis-endemic areas of Nepal and India (September 2006)

	India (*n* = 501 HH) (%)	Nepal (*n* = 377 HH) (%)
Reasons why having a mosquito net		
Protection mosquito bites	497 (99.4)	336 (89.1)
Pleasant sleep	221 (44.3)	263 (69.8)
Protection other insects/snake bites	150 (30.1)	148 (39.3)
Prevent disease	48 (9.6)	35 (9.3)
Privacy	2 (0.4)	6 (1.6)
No answer	1 (0.2)	
	(*n* = 1133 bednets) (%)	(*n* = 755 bednets) (%)
Observation on condition of net		
Intact	202 (17.8)	244 (33.6)
Slightly damaged	516 (45.5)	333 (45.9)
Bad condition	415 (36.6)	148 (20.4)
No information	0 (0)	29 (3.8)
Observation on impregnation of net		
Impregnated	1 (0.09)	50 (6.9)

between poverty and the presence of bednets is presented in Figure 1. A chi-square test for trend was significant for both countries, as was the difference in trend between countries.

Multivariate analysis showed that poverty, head of HH with a lower education and living in Nepal were independent predictors of the absence of bednets in a HH (Table 5). In both countries, the history of VL in the HH was associated with not having nets. No interactions between predictors were detected.

Determinants of use, defined as the fact that all members slept under a mosquito net over the last night, were belonging to a family with fewer than five HH members, higher level of education, belonging to other than Hindu religion, living in Nepal and no history of VL in the HH. No interactions were detected (Table 6).

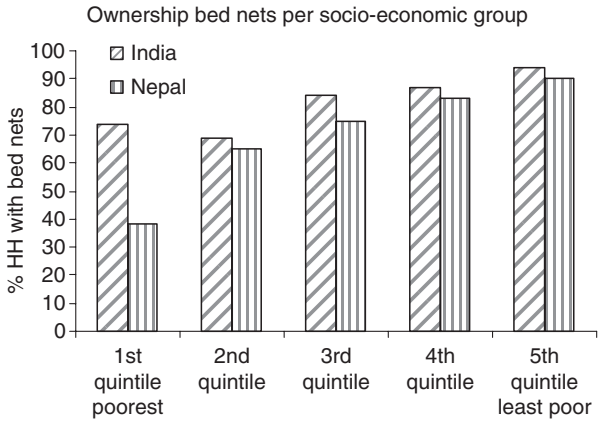

Figure 1 Household ownership of bednets per socio-economic group, visceral leishmaniasis-endemic areas of Nepal and India (September 2006).

Discussion

The proportion of HHs with at least one bednet, purchased on the commercial market, in VL-endemic areas was 81.5% in India and 70.2% in Nepal. There was a striking inequity in bednet ownership, with only 38.3% of the poorest quintile in Nepal owning at least one net compared to 89.7% of the wealthiest quintile. In India, the same trend was observed though somewhat less pronounced (73.6% *vs.* 93.7%). In India, 79.2% of the respondents (owning a bednet) *vs.* 71.9% in Nepal declared using the net in the rainy season, an important parameter, given that the end of the rainy season (September–October) is the main VL transmission season in this area (A. Picado, personal communication). Sandflies are very small insects and their peak-season of activity does not completely overlap with that of *Culex* or *Anopheles* (A. Picado, personal communication), which are responsible for the main mosquito nuisance perceived by the population. In Nepal, a second peak of sandfly density is observed in April–May – a hot and low mosquito nuisance season. Individual protection is not easy to demonstrate (especially in endemic areas because of ethical reasons) but evidence on the provision of personal protection by ITN was described for *Phlebotomus orientalis* in Sudan by Elnaiem *et al.* (1999). To achieve protection from sandfly bites, a permanent use of nets over the year – or at least from the start of the hot season (April) up to the beginning of winter season (October) – would be advisable.

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Table 5 Determinants for ownership [owning at least one bednet in a household (HH)], visceral leishmaniasis (VL)-endemic areas of Nepal and India (September 2006) (reference category). *$P < 0.05$

	n = 1330	
	Crude OR	Adjusted OR
Male head of HH (female)	2.06 (1.38–3.09)*	1.55 (0.90–2.66)
Least poor quintile of HHs (poorest quintile)	7.57 (4.57–12.53)*	5.39 (2.90–10.03)*
No VL history in HH (yes)	1.17 (0.89–1.53)	1.56 (1.18–2.06)*
Highest level of education of the head of HH (lowest level of education)	3.25 (2.10–5.03)*	1.58 (1.03–2.45)*
Correct knowledge on clinical VL (no)	1.37 (1.06–1.79)*	1.31 (0.96–1.79)
Correct knowledge on vector-borne character VL (no)	1.56 (1.09–2.27)*	1.27 (0.80–2.00)
Hindu religion (other religion)	0.85 (0.55–1.30)	0.85 (0.42–1.70)
Family size >5 HH members (≤5 HH members)	1.69 (1.30–2.17)*	1.03 (0.80–1.34)
Country = India (Nepal)	1.86 (1.44–2.41)*	2.67 (1.79–4.83)*

Table 6 Determinants for use (all household (HH) members used a bednet the night previous to the survey), visceral leishmaniasis (VL)-endemic areas of Nepal and India (September 2006) (reference category). *$P < 0.05$

	n = 848	
	Crude OR	Adjusted OR
Male head of HH (female)	0.68 (0.40–1.14)	0.65 (0.33–1.25)
Least poor quintile of HHs (poorest quintile)	1.26 (0.78–2.05)	1.51 (0.86–2.66)
VL history in HH (no)	0.47 (0.35–0.64)*	0.63 (0.46–0.86)*
Highest level of education of the head of HH (lowest level of education)	1.95 (1.38–2.74)*	1.61 (0.99–2.59)
Correct knowledge on clinical VL (no)	0.94 (0.72–1.22)	1.16 (0.83–1.62)
Correct knowledge on vector-borne character VL (no)	0.82 (0.54–1.25)	1.03 (0.72–1.48)
Hindu religion (other religion)	0.93 (0.63–1.39)	0.47 (0.28–0.78)*
Family size ≤5 HH members (>5 HH members)	2.72 (2.08–3.57)*	2.54 (1.74–3.69)*
Country = India (Nepal)	0.29 (0.22–0.38)*	0.37 (0.18–0.76)*

The bednets in the houses were bought by the HH on the commercial markets. No free bednet distribution or/and massive bednet promotion campaign took place in these areas in the year previous to our survey.

A weakness of this study is that the random sample of HH was taken among villages highly affected by VL, and therefore we can not readily extrapolate our findings to the entire population of Bihar or the Terai, as the population in less affected villages might behave differently.

Although Indian HH had a higher percentage of bednet ownership, the use of nets by all HH members was much less common than in Nepal. Use of nets was mainly determined by family size and not by poverty. Though information on use of bednets was obtained through self-reporting and therefore subject to under- or overestimation, we have no indications that these over- or underestimations would be differential over wealth quintiles.

As reported by others (Bern *et al.* 2000; Ritmeijer *et al.* 2007), we observed a positive association between a history of VL in the HH and not owning/using a bednet after controlling for socio-economic status and other factors. Though interesting as it is, this finding is not conclusive with regard to the protection conferred by nets because of the cross-sectional design of this study. HHs may contract VL more readily because they do not sleep under nets – but the disease might also lead families into more destitution, explaining they cannot afford bednets (Joshi *et al.* 2008). Protective efficacy of nets can only be demonstrated in a prospective manner in a controlled trial, and the results of the KALANET community trial are eagerly awaited.

The relation between poverty and possession of nets has been widely debated, but mainly in African countries: most of authors find an association (Nuwaha 2001; Howard *et al.* 2003; Mathanga *et al.* 2006; Pardo *et al.* 2006; Skarbinski *et al.* 2007), but not all agree. Aikins *et al.* (1993) found that socio-economic factors might influence the acquisition of bednets, but argued against a financial barrier, stating that non-users of bednets were purchasing other goods. The lower educational level of head of HH associated with absence of bednets and with decreased use has also been widely debated. In the literature, this

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relationship remains unclear, some authors reporting a significant association (Howard *et al.* 2003), and others failing to demonstrate it (Aikins *et al.* 1993; Alaii *et al.* 2003).

To be able to translate our findings into recommendations on distribution strategies, three facts have to be taken into account: (i) a community-wide coverage is needed to have an impact on *P. argentipes* densities (A. Picado, personal communication); (ii) the preference concerning texture, size and colour of net – another factor influencing use – has been already studied by Das *et al.* (2007), who showed that light-blue polyester LN of rectangular size were preferred by the population of VL-endemic areas in Nepal and India; (iii) high coverage is already reached with the current commercial markets in the VL-endemic areas of the Sub-Indian continent (as shown in our data), but in contrast to findings of Webster *et al.* (2005), the coverage is not at all equitable in our setting. Several years ago, the mass effect of ITN on malaria transmission was evidenced and this led experts (Teklehaimanot *et al.* 2007) to plead for free distribution of nets to the entire population in malaria-endemic areas and not only to targeted groups. Thwing *et al.* (2008) observed that a free distribution of nets in Niger resulted in a coverage with high equity ratio. We plead here for the same approach.

Besides coverage, the regularity of bednet use needs also to be promoted. To achieve a high proportion of people not only owning, but also using the nets in the VL transmission season, a behaviour change is needed and other benefits should probably be stressed as protection from diseases or privacy. A communication strategy should accompany the distribution and take into account the factors that motivate a family to acquire and appropriately use and maintain bednets.

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