Piloting the use of indigenous methods to prevent Nipah virus infection by interrupting bats’ access to date palm sap in Bangladesh

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SUMMARY

People in Bangladesh frequently drink fresh date palm sap. Fruit bats (Pteropus giganteus) also drink raw sap and may contaminate the sap by shedding Nipah virus through saliva and urine. In a previous study we identified two indigenous methods to prevent bats accessing the sap, bamboo skirts and lime (calcium carbonate). We conducted a pilot study to assess the acceptability of these two methods among sap harvesters. We used interactive community meetings and group discussions to encourage all the sap harvesters (n = 12) from a village to use either bamboo skirts or lime smear that some of them (n = 4) prepared and applied. We measured the preparation and application time and calculated the cost of bamboo skirts. We conducted interviews after the use of each method.

The sap harvesters found skirts effective in preventing bats from accessing sap. They were sceptical that lime would be effective as the lime was washed away by the sap flow. Preparation of the skirt took ~105 min. The application of each method took ~1 min. The cost of the bamboo skirt is minimal because bamboo is widely available and they made the skirts with pieces of used bamboo. The bamboo skirt method appeared practical and affordable to the sap harvesters. Further studies should explore its ability to prevent bats from accessing date palm sap and assess if its use produces more or better quality sap, which would provide further incentives to make it more acceptable for its regular use.

Key words: public health intervention development; community-based intervention; Bangladesh

INTRODUCTION

Nipah virus (NiV) infection is an emerging infectious disease with a wildlife origin (Daszak et al., 2000). Large fruit bats (Pteropus species) are the natural reservoir of NiV (Yob et al., 2001; Chua et al., 2002; Olson et al., 2002; Reynes et al., 2005). Antibodies against NiV have been found in Pteropus giganteus in Bangladesh (Hsu et al., 2004) where repeated NiV outbreaks have been recognized since 2001 (Luby et al., 2009b). Infected bats can shed virus through both their saliva and urine (Yob et al., 2001; Reynes et al., 2005; Wacharapluesadee et al., 2005). NiV can survive in fruit juice or urine of fruit bats for days (Fogarty et al., 2008).

In Bangladesh NiV infection is a seasonal disease that coincides with the date palm sap harvesting season (Luby et al., 2009a). People can acquire the virus by drinking raw date palm sap contaminated with infected bat saliva or
In Bangladesh, NiV usually infects previously healthy persons and most commonly causes severe encephalitis or pneumonia (Hossain et al., 2008). Seventy-one percent of infected persons die and 32% of survivors have neurological dysfunction (Sejvar et al., 2007; Luby et al., 2009b). Repeated seasonal outbreaks and the severity of NiV infection require exploring opportunities to prevent NiV spillover through date palm sap in Bangladesh.

In Bangladesh raw date palm sap is collected during the cold season: mid-October to mid-March (Nahar et al., 2010). Date palm sap harvesters (gachhis) shave one side of the date palm tree near the top in a V shape, place a bamboo tap at the base of the V to allow the sap to flow into a clay pot for the whole night and collect it in the early morning (Luby et al., 2006). This raw sap is consumed in the early morning, within a few hours of collection (Luby et al., 2006). As a result, consumers may drink sap contaminated with infectious virus.

In a previous study (Nahar et al., 2010) we found that gachhis identified bats as one of the nuisances to sap collection. Gachhis were more concerned about the effect on the quality of the sap than about the amount of sap bats drink. Bats markedly affect the quality of sap when they lick the stream, which leads to an unpleasant smell, or defecate in the sap. The lower quality decreases the income gachhis earn from the sap. Gachhis occasionally use some preventive methods to keep bats out of the sap and to preserve their income; although they were not attempting to prevent virus contamination. Through interviews and observations from northwest Bangladesh we concluded that two methods, application of a bamboo skirt and application of lime had potential for preventing bat access. The bamboo skirt covers the shaved part of the tree, the place from where the sap drains to a clay pot. It also covers the mouth of the pot and makes it difficult for bats or any other pests to access the sap. Although local people from northwest Bangladesh perceived the bamboo skirt as an effective method to interrupt bat access from date palm sap, they rarely used this method because they considered it too time consuming, a particular problem during their busy sap collection season. However, gachhis from this region often smear lime (calcium carbonate) on the shaved part as well as in the pot to ensure better quality, or clearer sap. They reported that bats avoid lime smeared trees because of its pungent taste.

These two indigenous methods, bamboo skirts and lime, are part of local knowledge from northwest Bangladesh and have passed through generations of gachhis. Several studies have shown that communities can substantially contribute to solve environmental problems using their local knowledge (Corburn, 2003).

In this study we aimed to identify the acceptance of methods that might prevent NiV transmission and would be compatible with the Bangladeshi context. Thus, we introduced these two indigenous methods to gachhis who lived in a village in central Bangladesh where these methods were rarely known. Although sap collection differs slightly from northwest to central Bangladesh, the experience of being a gachhi is similar in both parts of Bangladesh, in terms of the seasonality of sap collection, preparation of the tree, use of sap and considering bat a threat to sap collection (Nahar et al., 2010).

The objective of this study was to test the feasibility and acceptability of having gachhis use bamboo skirts and lime to prevent bat access to date palm sap. Examining the acceptance of the target group as well as the community is important for developing an effective intervention (Stanton et al., 1987). This study might help us to understand if these methods could be used in the future, at the community level, as an intervention to prevent NiV transmission through date palm sap.

**METHODS**

**Setting**

We purposively selected a village from central Bangladesh with a high density of date palm trees. This village is in the Faridpur district where several NiV outbreaks have occurred (Gurley et al., 2007; ICDDR,B, 2010). The study village is located ~8 km from the closest NiV outbreak site. During field selection, we talked to the villagers and they were not aware of NiV or the prior outbreaks.

**Research process and tools**

We conducted this pilot intervention study with a participatory approach and used qualitative
tools to collect data. Throughout the study we followed the grounded theory approach (Glaser and Strauss, 1967) to collect and analyze data in an iterative manner since the study objective involved social interactions and experience that explained a process (Kennedy and Lingard, 2006). We identified all the gachhis (n = 12) from the study village. Among them, two gachhis stopped collecting the sap for that season. With the gachhis and the community leaders we discussed the scope of our intervention in their village. We arranged two community meetings to introduce the interventions, sought community members’, mostly gachhis’ opinions, and planned with them how to carry out the study. In these meetings we also identified those gachhis who were willing to participate in testing the interventions.

Next, to increase our familiarity with the locality and to widen the villagers’ involvement in the research process, we conducted a village mapping exercise with the residents to identify major landmarks, the households of the gachhis and location of date palm trees. Throughout the study period, we conducted 20 informal group discussions with gachhis and the villagers to continue the dialog about the intervention. We used a topic guide focusing on NiV infection and transmission through date palm sap contaminated by infected bat and ways to interrupt bat access. We repeatedly demonstrated and explained the preventive methods when people asked us, and noted any suggestion about the methods and intervention process to plan the next step of the study. Informal group discussions initiated the community participation. Findings from informal group discussions overlapped with the findings from in-depth interviews and community meetings that helped us to understand the context to interpret data.

We conducted in-depth interviews with 10 available gachhis to understand more about the sap collection process, their motivation to use or not to use the proposed preventive methods and their experience as sap collectors (Supplementary data, Appendix S1). After conducting the interview, we drew maps with the four gachhis, who were willing to test the intervention methods, to identify their harvested trees that were most frequently visited by bats in order to test these methods. Two of the gachhis used bamboo skirts only, one used both bamboo skirts and lime and the fourth gachhi used lime only. We observed on average 3 h of the bamboo skirt preparing sessions with each gachhi. We also observed the application of these methods and tracked the amount of time required for each. We conducted follow-up interviews with gachhis in the morning following application to understand their experience with the methods. We asked gachhis to describe how they applied the skirt or lime, effectiveness of these methods against bats, benefits and difficulties they faced while using these methods and how the difficulties could be resolved. We also asked them about their future plans of using any preventive method. We summarized the methods in Table 1.

### Data collection

Four researchers trained in qualitative research conducted the fieldwork and collected data from the first week of February to the first week of March 2008 (Supplementary data, Appendix S1). On average, in-depth interviews lasted for 45 min and follow-up interviews lasted for 20 min. We recorded both on audiotape. We took field notes and expanded those on a daily basis using an iterative process to identify if any new information collected in that day for further exploration.

### Data analysis

We transcribed the audiotapes verbatim. Two researchers reviewed the interviews and identified the emerging concepts/themes separately and then worked together to prepare a final code list. We coded the transcripts manually and checked the consistency of our coding for each transcription. We chose illustrative quotes...
to highlight particular themes. We looked for similarities and differences and compared among concepts to group the data. We reviewed the field notes to understand the context of the categories from each group and classified them based on people’s responses on bats, disease and preventive methods.

Ethical considerations
We discussed the study with gachhis and the villagers and asked for their consent to proceed in their village. Later, we obtained written informed consent from individual gachhis before conducting in-depth interviews. The Ethical Review Committee of the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B) reviewed and approved the study protocol.

RESULTS

Characteristics of gachhis
The mean age of gachhis $(n = 10)$ was 47 years. Eight of them worked primarily as agricultural laborers; four of them did not own any cultivable land. These eight gachhis did not have their own date palm trees. They sharecropped the trees and each day they gave half of the collected sap to the tree owners. Sharecroppers harvested fewer trees (range: 15–80 trees) than tree owner gachhis (range: 150–250 trees). Sharecropper gachhis started to collect sap very early in the sap collection season when the price of molasses was higher. A tree that is shaved too many times becomes thin and dies. Since sharecroppers had already shaved the trees for sap collection several times early in the season, the number of available trees was diminishing. In addition, unlike tree owner gachhis who grew their own source of fuel, sharecropper gachhis also had less access to fuel to make molasses, which led them to collect less sap. We summarized the demographic information in Table 2.

Introducing the intervention: gachhis’ responses
During the community meeting we introduced the bamboo skirt and lime methods to the villagers, including gachhis. They did not know about these methods. All the gachhis said that they had tried to prevent bat access in the past. They used a piece of sack or leaves and thorn of date palm tree to cover the shaved part and the pot but bats made their way to the sap. Since they failed to keep the bats out, they discontinued using the methods. Four gachhis immediately expressed their willingness to use the bamboo skirt, but had little interest in using lime. The rest proposed learning about the methods in order to use them in the next season. This was because the sap collection season would be ending within a month and half. Therefore, they were seeing less bats than early season.

Bamboo skirt
First, we demonstrated the bamboo skirt (Figures 1 and 2) and explained how it covered

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Gachhis tested the preventive methods $(n = 4)$</th>
<th>Gachhis did not test the preventive methods $(n = 6)$</th>
<th>Total gachhi $(n = 10)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Mean 46 (range 26–56 years)</td>
<td>Mean 48 (range 32–60 years)</td>
<td>Mean 47 (range 26–60 years)</td>
</tr>
<tr>
<td>Experience with sap collection</td>
<td>Mean 17 years (range 3–25 years)</td>
<td>Mean 23 years (range 3–42 years)</td>
<td>Mean 20 years (range 3–42 years)</td>
</tr>
<tr>
<td>Number of harvested tree</td>
<td>Mean 117 trees (range 80–150)</td>
<td>Mean 109 trees (range 15–250)</td>
<td>Mean 115 trees (range 15–250)</td>
</tr>
<tr>
<td>Sharecropper gachhis earning from sap collection $(n = 8)$</td>
<td>Mean US$ 6 (per week)</td>
<td>Mean US$ 5 (per week)</td>
<td>Mean US$ 5 (per week)</td>
</tr>
<tr>
<td>Tree owner gachhis earning from sap collection $(n = 2)$</td>
<td>$51</td>
<td>$17</td>
<td>$34</td>
</tr>
<tr>
<td>Main occupation</td>
<td>Agriculture</td>
<td>Agriculture</td>
<td>Agriculture</td>
</tr>
</tbody>
</table>

Table 2: Demographic information of gachhis $(n = 10)$ collected during February and March 2008 from the study village, Fardipur District, Bangladesh

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the shaved part of the tree and the mouth of a sap collection pot and how to tie it with the tree. They examined the skirt and opined that skirt making would not be difficult as it was similar to bamboo fishing nets that villagers made. The gachhis were suspicious that bats could make their way to the sap from beneath the skirt. After seeing the photographs of a skirt placed on a tree they were convinced that it could be effective and those who initially were not interested in skirt preparing became interested. However, gachhis expressed their concern that the skirt might be difficult to apply, time consuming to use and might be impossible to deploy on every tree.

Lime

The gachhis reported that they smeared lime on the pots to obtain clear sap in the late season when the weather becomes warmer and sap becomes cloudy. They said that if they smeared lime on the shaved part of the tree the lime would be washed away by sap flow. They suggested smearing lime around the border of, but not on the shaved part so that bats would not proceed to the sap flow due to the taste of the lime.

Cost and time of intervention methods

To prepare the skirts all of them used bamboo that was already being used for other purposes, even though they had the offer to use fresh bamboo from a community member. The gachhis felt that this bamboo would be better for skirt preparation because it would not shrink like green bamboo, causing the knots to loosen and the skirt to fall apart. This repurposing made it difficult to calculate the real cost for the bamboo they used since used and dried pieces of bamboo were not usually sold in the village.

They used jute rope to tie the skirts because this self-made rope was considered durable. For one skirt, ~100 g of jute was needed, which costs US$ 0.03 (1 kg US$ 0.29). They calculated the cost of the pieces of bamboo they used at ~US$ 0.06–0.07. Thus, the total cost of the supplies to make a skirt was US$ 0.09–0.10.

The bamboo-skirt preparation time varied with the skill of the person. On average to cut down the bamboo and make slices (sticks) it took 35 min, 50 min to make the rope and 20 min to weave the skirt for a total of 105 min. The rope making was the most time-consuming step, the gachhis suggested that they could make the rope in their leisure time, like at night when they do not have a lot of work to do. We bought 1 kg of lime for US$ 0.29 from the local market. It took 1.5 min to dissolve the lime.
Bamboo skirt and lime application
On average, the application of a skirt took 1 min and 10 s and smearing of lime took 50 s. This was excluding the other activities that they would already be doing (climbing the tree, hanging the pot, placing the tap or shaving the tree). Gachhis did not face any unanticipated problems in applying these methods.

Experience with bamboo skirt and lime
Three of the gachhis piloted 7 skirts for 10 days (70 tree nights) on the trees most frequently visited by bats. All of them reported that the bats’ feces did not get into their sap as it had prior to using the skirts. Thus, they assumed that people would be more interested to buy raw sap and molasses from them.

‘This is the first time the owner of the date palm trees took sap from me for raw consumption as the sap was better in quality. The sap became clear and was protected from bats.’

In general all of them talked about the improved quality of sap meaning clear and clean sap. One gachhi claimed that using the skirt slightly increased the quantity of sap collected. They reported that it took time to hang the skirts initially, but once it was in place, the time was reduced because they left the skirts on the trees. They untied one end to remove the pot in the morning and retied it over the pot when they replaced it in the afternoon. After using it a few times, one gachhi reported that a squirrel chewed through the rope and the skirt fell down.

The two gachhis who used the lime were not convinced to use this method in future. They reported that lime was washed away by the sap flow. One of them said that because of lime he got less sap than usual and considered it an impractical method. The second gachhi opined that quantity of sap production depends upon the coolness of the weather. Early in the season trees produce more sap within a few days of the first sap collection. Sap production continues at a steady volume throughout the mid season and declines in the late season when weather becomes warmer. According to him, lime has nothing to do with the quantity of sap. Both of them did not get bat excreta in the sap or on the pot after using lime. They explained that bats absence in lime-smeared trees might be by chance, because they always see fewer bats as bats during this particular period of the year (January–March) as bats may get food from other sources. Gachhis said that the fruits of Banyan trees ripened in February (our study month) and more bats preferred feeding on these fruits rather than sap.

Future plan of gachhis
Three gachhis who used the skirts said they would use them in the next seasons but they were unwilling to use lime in the future. They added that they would make skirts in the rainy season or just before the sap season when they had leisure time. Once they would make a skirt they could use it in the next seasons. They would use the skirt in the period when bats most frequently visit the date palm trees. They also specified trees on which they would use skirts, for example, taller trees that were more affected by bats. One gachhi suggested that he would use iron wire to hang the skirt or place the skirt in the later afternoon when it gets dark to avoid the squirrel cutting the hanging rope of the skirt. Other gachhis from the study village reported that they would use the skirt in the early sap collection season in future to prevent bat access to get better quality of sap.

Diffusion of innovation
We observed that the three gachhis who used skirts advocated for the method when others inquired. They applied skirts on trees near the roadside so that people from other villages could see them, would become curious and adopt the method. They often explained the usefulness of the skirts and shared their experience with their neighbors and people from other villages.

‘In the morning, a person from the next village was passing by and asked me, “Have you got any benefit after using the skirt?” I said, “Listen, bats didn’t take the sap last night; I haven’t got any dirt in the sap. I have got more sap”. The man said, “so the method is not bad”. I said, “You can apply this method in two or three of your trees and you will see if I was right or wrong”. He said, “Okay I will try”.’
We also documented some outcome of their advocacy. A *gachhi* from a neighboring village interacted with one of our study participants and suggested using the skirts only on those sweeter sap producing trees that would be used for raw consumption. His suggestion solved the problem often discussed by *gachhis* of whether it was necessary to use the skirt on every sap-harvesting tree. Because the *gachhis* harvest several trees each day, placing skirts on all of their trees would require making dozens of skirts.

**DISCUSSION**

This pilot study introduced two indigenous methods to prevent fruit bat access to date palm sap to *gachhis* in a village at risk for human NiV infection. *Gachhis* considered the bamboo skirt a practical, affordable and useful tool to improve the quality of sap. Although they had some confusion in the early stage of the study, *gachhis* piloted the skirt, solved problems and came up with new ideas; for example, they tied up one side of the skirt and left it in the tree for further use on subsequent nights and used skirts only on trees that they use for raw consumption. The suggestion to use the skirt only in trees that they consume raw sap could be a practical solution to prevent NiV infection as each *gachhi* would require only a few skirts meaning less time and effort. Lime was not well accepted because it was not perceived to be effective and *gachhis* were reluctant to use it.

The perceived effectiveness of the bamboo skirt is consistent with the results of a study led by our zoonoses team (Khan et al., 2010). The zoonoses team began testing the effectiveness of bamboo skirts and lime by placing infrared cameras in the trees to observe how bats contaminate sap. In the pilot test the skirt prevented bat access to the sap but smeared lime did not work. Taken together these results suggest that bamboo skirts are an appropriate method to continue to develop for future intervention.

We identified a useful communication strategy for future interventions. Since showing photographs of the preventive methods during the community meetings helped to convince the community members including *gachhis* that these would work, future efforts should employ visual materials to enhance *gachhis* understanding about NiV prevention.

The preparation of bamboo skirts was time consuming. Because people are busy with their daily work, it might be an important constraint to implement the intervention unless we target the off season when people have leisure time. However, because *gachhis* mentioned that bats feces and drowned bats make the sap unusable, they might be willing to make bamboo skirts to prevent bats even though preparation takes time. Few *gachhis* (4 out of 10) participated in the intervention study as the study was conducted at the later part of the season. Later in the season *gachhis* noticed fewer bats in the date palm trees. *Gachhis* behavior about accepting any preventive method to interrupt bats access might be different in the early season when there are more bats in the trees and trees are more productive. For a successful intervention, the intervention will need to be applied early in the sap collection season when trees produce more sap, more bats come to date palm trees and sap spoils more frequently. In addition, since we could not do follow up for a full season, we were unable to evaluate the longer term acceptability of the intervention.

This study suggests introduction of that bamboo skirt method might be feasible in villages where date palm sap collection is common. Date palm sap collectors were willing to use bamboo skirts to obtain cleaner sap, though they rarely mentioned the benefit of preventing disease. For *gachhis* cleaner sap means earning a higher price for sap or molasses (Nahar et al., 2010) which might motivate them to use bamboo skirts. In this study, *gachhis* also noticed the demand for sap from skirt-used trees. Better price and increased demand for sap from trees with skirts can be highlighted in future intervention messages.

*Gachhis* recognized bats’ presence by seeing feces on or in the sap collection pot. In addition, they considered clear sap as quality sap. People might not hesitate to drink clear sap, when there is no sign of bat feces from a tree without a skirt protection. In our future health messages we might need to communicate that sap from trees protected by a skirt is better in quality and is not contaminated by bats’ faces, saliva or urine. Since people consider bat-contaminated sap as disgusting for human consumption, they might avoid drinking raw sap from trees without a skirt even if the sap appears clear.
This study involved *gachhis* to reduce the risk of NiV infection in Bangladesh. However, the insights that we gained from this study are relevant beyond this specific concern. This is an example of the active participation of local stakeholders (*gachhis*) to solve a problem that has affect on their earning. *Gachhis* already previously took initiative to prevent bats accessing the sap. Thus, bat preventive methods to protect date palm sap that we introduced were relevant to them that can have both health and economic implications. To improve maternal and child health, several intervention programs from low-income settings became successful as a result of community mobilization that promotes community participation, and empowers the community on health and non-health benefits (*Rosato*, et al., 2008). Involving the local community to plan and implement intervention leads to the ownership of the intervention that can also successfully incorporate the community in the process (*Bracht* et al., 1994) that we initiated in our study.

Our study suggests the use of community resources that can increase the intervention acceptability (*Netto*, et al., 2010) and represents the importance of understanding the culture and economy of the target group. Bamboo was a commonly available material. Bamboo skirt was a low cost, easy to prepare intervention that has similarity with the fishing gear that the community commonly used. Thus, it was accepted by *gachhis*. This shows the significance of developing culturally compelling intervention that is nested within a social and ecological landscape (*Panter-Brick*, et al., 2006). A study on hygiene intervention to reduce childhood diarrhea in rural Bangladesh developed behavior change messages and products considering the cultural and economic setting of the village that was highly accepted by the villagers (*Ahmed*, et al., 1992). The bamboo skirt also has such potential to be a successful program. This study was a small-scale intensive study that involved only a village and a small number of *gachhis* that is difficult to generalize. However, our study findings indicate several practical issues to implement the intervention in a larger scale. Further studies should explore the ability of skirts to prevent bats accessing date palm sap and assess if its use produces more or better quality sap and is further incentive for its use.

**SUPPLEMENTARY DATA**

Supplementary data are available at *HEAPRO* online.

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