HHS Public Access

Author manuscript

Glob Health Promot. Author manuscript; available in PMC 2015 December 01.

Published in final edited form as:

Glob Health Promot. 2014 December ; 21(4): 7–15. doi:10.1177/1757975914528249.

Piloting the promotion of bamboo skirt barriers to prevent Nipah virus transmission through date palm sap in Bangladesh

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Abstract

Drinking raw date palm sap contaminated with infected fruit bat saliva or urine is an important mode of Nipah virus transmission to humans in Bangladesh. Bamboo skirts are an effective way to interrupt bat access to the sap. We conducted a study from November 2008 to March 2009 to explore the effectiveness of higher- and lower-intensity interventions by promoting bamboo skirt preparation and use among sap harvesters (*gachhis*). We spent 280 person-hours in two villages for the higher-intensity intervention and half that amount of time in two other villages for the lower-intensity intervention. To evaluate the interventions we followed up all *gachhis* once a month for three months. A high percentage of *gachhis* (83% in higher-, 65% in lower-intensity interventions) prepared and used a skirt of bamboo or other materials – jute stalk, *dhoincha* (*Sesbania aculeata*), or polythene – at least once after intervention. In general, 15% of *gachhis* consistently used skirts throughout the sap collection season. The intensive nature of this intervention is very expensive for a large-scale programme. Future efforts should focus on developing a low-cost behaviour change intervention and evaluate if it reduces the human exposure to potentially contaminated fresh date palm sap.

Keywords

communicable disease; community; health behaviour; health promotion

Introduction

Bats harbour and disseminate multiple infectious diseases that may infect humans and other mammals and may contribute to the emergence of zoonoses (1–3). A variety of ecological, environmental and demographic factors promote disease emergence, e.g. on increasing human population, its intensive agricultural practices, and deforestation that disrupts the natural habitat of wildlife and brings it into closer contact with humans (3). One example of

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Conflict of interest
None declared.

a bat-transmitted zoonotic disease is Nipah virus (NiV) infection. The first human outbreak of NiV was identified in Malaysia in 1998, causing over 100 human deaths (4–6). In this outbreak, NiV-infected pigs on pig farms transmitted the virus to pig farmers across the country (7). To control the outbreak, more than one million pigs were culled (8).

Since 2001, NiV outbreaks in humans have been recognized almost each year in Bangladesh and over 70% of identified Nipah case patients have died (9, 10). NiV is an important public health issue both because of these recurrent high mortality outbreaks and because of the risk that the virus may develop the potential for pandemic spread (11). NiV has been identified in urine and saliva samples from *Pteropus giganteus* in Bangladesh (12) and from *Pteropus* bats in other locations (13–15). People in Bangladesh occasionally contract NiV infection from bats through a shared food source; specifically, drinking raw date palm sap was associated with becoming infected with NiV in three outbreaks in Bangladesh (16–18). NiV infections in humans also coincide with date palm sap collection season in Bangladesh (19).

In Bangladesh, NiV patients' symptoms include fever, altered mental status, unconsciousness, headache, weakness, cough, respiratory difficulty, vomiting, diarrhoea and convulsions (20). In addition to consumption of bat-contaminated date palm sap, the other major pathway of transmission of NiV is from person to person (21,22). A small number of cases of NiV transmission in Bangladesh also occurred through contact with sick animals (19). In a large outbreak in Malaysia, the primary pathway of human infection was from NiV-infected pigs to people who contacted pig secretions (7).

Date palm sap is collected in Bangladesh from mid-October to mid-March by shaving one side of the tree near the top in a 'V' shape, placing a bamboo tap at the base of the 'V,' allowing the sap to flow into a clay pot that is hung in late afternoon, with the sap being collected in the early morning (16,19,23). This sap is used for making molasses through boiling, for drinking fresh and raw within a few hours of collection and for fermenting into a liquor called *tari* (23). During sap collection, fruit bats visit date palm trees frequently, most commonly contacting the shaved surface to drink the sap (23,24) and may contaminate the sap with NiV that people subsequently ingest.

Although bats are the reservoir of NiV infection, they contribute importantly to the ecosystem. Bats play significant roles in arthropod suppression, seed dispersal, and pollination that help restore the environment (25), so controlling the reservoir of infection is not a viable option. Thus, we took an approach that will not cause any harm to the natural setting of bats but would prevent bats access to the sap to reduce the risk of NiV transmission. In a previous study we observed that date palm sap harvesters (*gachhis)* occasionally used skirts made from bamboo to cover the sap stream and the sap collection pot as a physical barrier against bats' access (23). This bamboo skirt was inexpensive, easy to prepare, was accepted by *gachhis* (26) and proved to be an effective barrier to prevent bats' access to date palm sap (24). The present study aimed to develop and pilot behaviour change interventions targeting *gachhis* and to evaluate if the interventions encouraged *gachhis* to make and use skirts.

Materials and methods

Settings

We conducted this study in four villages, two from Faridpur and two from Rajshahi Districts. Both districts are located in the region where Nipah outbreaks have previously occurred. In Faridpur we selected villages with more than 10 *gachhis* for a broader range of informants. In Rajshahi the sap collection villages usually had more than 500 *gachhis*. Thus, we selected only one part of each village (*para*) to limit the number of informants for logistical reasons.

Study design

In the first phase of this study (9 November to 23 December 2008) the field team delivered two types of interventions that we categorized as higher- and lower-intensity interventions. We designated one village from Faridpur and one *para* of a village from Rajshahi as higher-intensity and the other village from Faridpur and the other *para* in Rajshahi as lower-intensity intervention areas. We consulted and planned with villagers and arranged seven community meetings and four skirt-making training sessions in higher-intensity intervention areas, and four community meetings and two skirt-making training sessions in lower-intensity intervention areas in locations suggested by the villagers. We spent 280 person-hours for four weeks (two weeks in each place) in higher- and half the amount of time (140 person-hours) in lower-intensity intervention areas.

In community meetings we discussed bats' presence in trees during sap collection, the signs and symptoms and mortality and morbidity of NiV infection, its transmission through date palm sap, and promoted bamboo skirts as an effective preventative method. We suggested that *gachhis* use skirts only on trees that were used for raw sap consumption. We displayed seven photographs and a poster containing general information about NiV, its transmission, and the application of bamboo skirts to prevent bat access. We showed a map that indicated the locations of NiV outbreaks in Bangladesh. Local residents read the text of the poster aloud and discussed the content of the photographs and poster. We showed them samples of skirts to help people understand the use of skirts as a physical barrier to bats.

We conducted skirt-making sessions where *gachhis* could learn to make skirts. To moderate the skirt-making sessions in Faridpur, we hired a *gachhi* from our previous field site who made and used skirts to share his experience. We affixed posters in prominent community places, such as the bazaar, mosque, schools and at *gachhis'* houses.

Beginning one month after the intervention we followed up with all *gachhis* once a month for three months (from 5 January to 19 March 2009) until the end of the sap-harvesting season to assess if they prepared and used skirts. We used a semi-structured questionnaire with open-ended questions on making and using skirts, reasons for making and using skirts, and advantages and disadvantages of skirt use. We asked them to show us skirts they had made and observed the use of skirts directly in the trees when *gachhis* reported using skirts. In addition, we conducted in-depth interviews with *gachhis* and tree owners to understand their motivation to accept or reject the intervention.

Sampling

We identified all the *gachhis* (*n* = 156) from our study areas and included them in the intervention and prioritized to reach them in each follow-up (Table 1). We conducted in-depth interviews with 46 *gachhis* and 10 tree owners who made skirts for *gachhis*. In Rajshahi we enrolled a systematic sample of every fifth *gachhi* on our list for in-depth interview.

Data analysis

During the intervention period, we wrote down our field experiences at the end of each day and reviewed them regularly to assess the need to modify our strategies. We recorded in-depth interviews on voice recorders and transcribed them verbatim in Bengali. Two researchers reviewed five in-depth interviews from each field site to make a code list. We coded our data manually. We looked for the relationship among codes to group them into categories and identified similarities and differences among intervention areas.

We entered our monthly follow-up data in Excel (Microsoft 2003). We coded the open-ended questions. We calculated the mean for demographic characteristics of our informants and reported the range. We measured the proportion of skirts made and used the variable as the outcome for this study.

Ethical consideration

We took informed consent before conducting the survey and in-depth interviews with *gachhis* and tree owners. The ethical review committee of the International Centre for Diarrhoeal Disease Research, Bangladesh reviewed and approved the study protocol.

Results

Informants' profile and background

The average *gachhi* was 39 years old, had four years of formal education and harvested 50 trees (Table 2). The *gachhis* from Faridpur were older, less educated, harvested more trees and owned fewer trees (Table 2). They sharecropped a number of trees, mostly with the agreement to share half of the collected raw sap with the tree owners. In Rajshahi we identified 21 *gachhis* employed by the tree owners. They harvested 50 trees a day, made molasses and earned an average of US$43 per month.

Some of the elderly *gachhis* were familiar with the use of skirts to interrupt bats' access to the sap. A *gachhi* at a community meeting in Rajshahi reported,

> Earlier people collected sap from a few trees in Rajshahi and used skirts to prevent bats when they want to drink raw sap from mid-February to mid-March. Now people collect sap from more trees and do not use skirts anymore.

Another *gachhi* from Faridpur saw his father using jute stalk skirts to protect sap from bats about 20 years ago. Only one *gachhi* from a lower-intensity intervention village in Rajshahi had been using polythene skirts for several years that he had learnt about from his

grandfather. Villagers from Faridpur District had heard about NiV infection though they did not know about the mode of transmission of NiV prior to the intervention.

Making skirts and materials used

Most participants (74%; 115/156) reported that they made skirts with bamboo (84%; 97/115) and seven other types of materials (Table 3). An individual *gachhi* made a range of one to eight skirts (Table 3). During in-depth interviews, bamboo skirt-makers said that they had bamboo stands. Bamboo is durable and therefore the skirt could be used in the next season. It costs approximately US$0.07 to US$0.28 and took one and a half hours to make a bamboo skirt. Those who grew *dhoincha* and jute used these stalks and reported that it was easier and less time-consuming (30 minutes each) to make skirts from these materials than bamboos. Some *gachhis* preferred polythene as they obtained it when they bought fertilizer for agriculture. Making a skirt with polythene, cloth or jute bags required only 10 minutes to add ropes to permit tying the skirt to the tree. Apart from bamboo, people considered the price of other materials too minimal to be calculated. However, *gachhis* were very busy with sap collection and suggested that tree owners could make skirts if they want to drink raw sap. Ten tree owners made skirts and provided them to *gachhis* to use on their (tree owners') trees marked for raw sap consumption. During in-depth interviews one tree owner explained,

> I made a skirt because the *gachhi* is very busy with collecting sap for several tree owners. If a *gachhi* makes skirts for all the tree owners that he collects sap for, he would end up making 10 to 20 skirts – that is a lot of work for a *gachhi*. I made my skirt with jute stalk because jute stalk and jute rope are available in every house as we harvest jute. So, I did not spend money for the materials. I made the skirt in my free time so there was no labour cost involved.

Skirt use

In total 72% (113/156) of *gachhis* who received an intervention reported ever using a skirt; 83% from higher- and 65% from lower-intensity intervention areas (Table 4). In the first follow-up 69% of *gachhis* from higher- and 35% of *gachhis* from lower-intensity intervention areas reported using skirts (Table 4). Most of the *gachhis* from Faridpur District as well as *gachhis* and tree owners from the Rajshahi higher-intensity intervention area made skirts just after receiving the intervention. In the lower-intensity intervention area in Rajshahi tree owners were not motivated to make skirts. During that period *gachhis* from this area prioritized molasses-making because of its high price and reported drinking raw sap less frequently.

In the second follow-up, 55% of *gachhis* reported using skirts. *Gachhis* explained that as the season had advanced the sap became sweeter and they made and used skirts to drink it raw. They were also encouraged seeing others using skirts. Three *gachhis* who did not make skirts reported borrowing skirts before drinking raw sap. However, 17 *gachhis* from the Rajshahi higher-intensity intervention area stopped using skirts by the second follow-up. Most of them (10/17) said that they did not use skirts because the weather was warmer, which caused sap to become cloudy and less sweet when drunk raw. Seven *gachhis* reported

that they stopped drinking raw sap. During the second follow-up the field team observed that people from Rajshahi were engaged in time- and labour-intensive onion cultivation that might have left less time to use skirts.

During the third follow-up, 34% of *gachhis* still harvesting sap (n = 135) used skirts. In both study areas between the second and the third follow-ups the use of skirts declined. *Gachhis* explained that at the end of the season the warmer weather made the sap too sour to drink in the morning. Thus, people from Rajshahi drank raw sap collected within a few hours of sunset (8 p.m. to 10 p.m.). They did not use a skirt before drinking this sap though they reported that bats often visited the trees in the evening. In this study only 15% (24/156) of *gachhis* reported using a skirt consistently throughout the study period.

Explanations for tree selection and skirt use

Gachhis who used skirts (n = 113) reported that they applied skirts only in those trees that they used for raw sap consumption. Because of skirt use they preferred to collect sap for raw consumption from trees that produced larger quantities of sweeter sap, and trees close to their house to avoid difficulties in transporting the collection pot.

They mentioned multiple reasons for using skirts in trees that were used for raw sap consumption. Forty-nine percent said that they used skirts because they drink raw sap. Other reasons for using skirts included preventing disease (37%), and to get clean sap that was free from bird and bat stool (16%). Among the 43 *gachhis* who did not use skirts, 68% mentioned that they did not use the skirts because they did not drink raw sap, 12% said that they were too busy to make a skirt, and 8% reported that their trees were too short to be visited by bats. Twelve percent said that (4% each) they did not receive the intervention messages, were not motivated and did not believe that skirts could prevent disease. During in-depth interviews *gachhis* explained their reasons for not using skirts. A *gachhi* from Rajshahi said:

> I did not make or use bamboo skirts as my family members stopped drinking raw sap. I was busy with other work and I didn’t get time to make a skirt. If you ask me to use polythene, I will use it as I don’t need much time to make a cover out of polythene.

Advantages and disadvantages of skirt use

Gachhis who used skirts (n = 113) reported several advantages of using skirts, including: the sap was cleaner and thus of better quality (69%), bats could not drink sap (39%), more sap was collected (9%), and they could avoid disease (7%). Although most skirt users (65%) said that there was no disadvantage associated with skirt use, 21% of skirt users found that rats or squirrels cut the rope of the skirt, and 12% reported that it was difficult and time-consuming to hang the skirt. Five percent said that the skirt was stolen, skirts displaced the sap flow, hindered the *gachhis*’ ability to climb the tree safely and using the skirt made the shaved part of the tree swell. In in-depth interviews eight *gachhis* expressed their disappointment when they found rat faeces in the sap from skirt-covered trees.

Discussion

Culturally suitable interventions with community participation have been successful in diverse settings to address various health issues (27). Our study is an additional example of promoting a culturally specific intervention with community participation to prevent an emerging infectious disease (28). We consulted the community to define intervention strategies and include them in our initiative to prevent NiV infection by protecting date palm sap with a bamboo skirt that already existed and was occasionally used. Future initiatives to prevent Nipah transmission should strengthen the partnership between local communities and the researchers and emphasis on active community participation so that communities could take the leading role in decision-making for disease prevention (29).

Our intervention could reduce exposure to NiV through increasing the use of skirts for safe drinking of raw date palm sap. The *gachhis* who did not make and use skirts sometimes embraced the intent of the intervention as they stopped drinking raw sap, though we did not directly discourage raw sap consumption. We found this during in-depth interviews and did not quantify how frequently it occurred. The initial uptake of skirt use was high, especially during the time when most raw date palm sap was consumed. The proportion of *gachhis* who covered their trees later in the season was lower, in part because raw date palm sap consumption decreased. Only a small proportion of participants continued to use skirts throughout the season. Future research should measure more specifically the decline in skirt use associated with people refraining from drinking raw sap. Even if all the *gachhis* who made a skirt used it every day, the vast majority of trees would remain uncovered. The *gachhis* collected sap from several trees (mean = 50) and made only a few skirts (in average 1.7 skirts each), hence only a small proportion (3%) of trees were protected against bats. Future research should explore if the observed 3% coverage is sufficient to provide protected fresh sap to village consumers.

Adopting the skirt intervention is a multi-step process that includes skirt-making, use and then continuing skirt use throughout the season and in subsequent seasons. We need to assess if *gachhis* continue using skirts in future sap collection seasons. The benefit of skirt use to prevent disease might not be sufficiently compelling to maintain regular use because Nipah is a rare disease. Most people who are not using skirts will not suffer Nipah infection. It might be important to explore and emphasize the additional economic benefits of skirt use (e.g. greater quantity and improved quality of sap resulting in higher profit) that might motivate *gachhis* to use skirts regularly. Although we promoted bamboo skirts, people used other available materials including jute stalk, *dhoincha*, and polythene to reduce the costs and time in skirt preparation. These materials effectively interrupted bat access to the sap (24). Promoting these materials might increase the use of skirts before drinking raw sap.

Our study has several limitations. During follow-up we used questionnaires with some open-ended questions that we coded and classified later for analysis. The diverse answers to these questions were difficult to classify under single headings, potentially influencing the interpretation of data. Ultimately, the goal of our intervention was to prevent consumption of NiV-contaminated raw date palm sap. We measured the making and use of skirts as a proxy for a change in this outcome, but given the changing pattern of raw date palm sap

consumption over the harvesting season and diversity in raw sap consumption practices between *gachhis* and intervention areas, our measurements are poor indicators of this ultimate goal. Given the complicated dynamics of raw sap consumption, future intervention evaluations should directly measure changes in the proportion of raw sap drunk from a protected tree.

This study is part of a broader effort to prevent spillover of dangerous zoonotic diseases from wildlife to people in Bangladesh, a high-risk country for emerging zoonoses (30). Bats are responsible for a substantial portion of newly recognized emerging zoonoses in several locations (3). G*achhis* reported that rodents also contaminate sap, which could represent a source for zoonotic transmission of hantavirus pulmonary syndrome and South American haemorrhagic fevers (31). Preventing bat access will prevent not only Nipah but also other pathogens that could be transmitted through date palm sap. Prevention of close contact through sharing food sources could also reduce the risk of emerging infections. Preventing such exposure requires in-depth understanding of the social and economic forces that bring people into close contact with animals, and developing context-specific strategies to interrupt this transmission.

Although this pilot intervention did not demonstrate high levels of sustained use of skirts, it did demonstrate a willingness of many harvesters to deploy this approach during the highest-risk season. However, the intensive nature of this intervention would be prohibitively expensive in a large public health intervention. Indeed, even the lower-intensity intervention required 70 person-hours per village and so would be too labour-intensive to be implemented on a large scale. Future efforts should focus on lowering the cost of delivering the behaviour change interventions and evaluating effectiveness by focusing on reducing population exposure to potentially contaminated fresh date palm sap.

Acknowledgments

We are grateful to our study participants for their time, cooperation and invaluable information. We are thankful to AKM Dawlat Khan, Sumaya Binte Masud, Shamim Azad and Rouha Anamika Sarkar for their assistance in data collection. We are also thankful to Elizabeth Oliveras for reviewing the earlier draft of the manuscript.

Funding

This study was funded by the Centers for Disease Control and Prevention (CDC), CoAg Grant Number was: 5-U01-CI000298-03. icddr,b acknowledges with gratitude the commitment of CDC to the Centre’s research efforts.

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Table 1

Number of *gachhis* included in the intervention and follow-up during November 2008 to March 2009 in Faridpur and Rajshahi Districts of Bangladesh.

Districts	Intensity of intervention		First follow-up	Second follow-up	Third follow-up	In-depth interview
	Higher	Lower				
No. of *gachhis* in Faridpur	13	11	22	21	23	24
No. of *gachhis* in Rajshahi	51	81	121	125	112	22
Total number	64	92	143	146	135	46

Glob Health Promot. Author manuscript; available in PMC 2015 December 01.

Table 2

Mean [minimum–maximum] of characteristics of *gachhis* by intensity of intervention during November 2008 to March 2009 in Faridpur and Rajshahi Districts of Bangladesh.

Characteristic	Higher-intensity intervention areas	Lower-intensity intervention areas	Faridpur District	Rajshahi District	Total from both districts
Age (years)	39 [14–70]	39 [13–70]	47 [33–67]	37 [13–70]	39 [13–70]
Education (years)	3 [0–12]	4 [0–15]	2 [0–10]	4 [0–15]	4 [0–15]
No. of trees harvested	58 [6–160]	44 [1–200]	96 [15–200]	41 [1–150]	50 [1–200]
No. of trees owned	40 [0–150]	33 [0–120]	12 [0–50]	40 [0–150]	36 [0–150]
No. of trees sharecropped	18 [0–160]	11 [0–195]	85 [0–195]	1 [0–30]	14 [0–195]

Table 3

Proportion of *gachhis* who reported making skirts using different types of material during November 2008 to March 2009 in Faridpur and Rajshahi Districts of Bangladesh.

Information on skirt-making	***Gachhis made skirt***	***(%)***
Higher-intensity intervention (*n* = 64)	53	(83)
Lower-intensity intervention (*n* = 92)	62	(67)
Total (*n* = 156)	115	(74)
Number of skirts		
One skirt	72	(63)
Two skirts	27	(23)
Three	6	(5)
Four	6	(5)
Five	0	(0)
Six	1	(1)
Seven	2	(2)
Eight	1	(1)
Materials used		
Bamboo	97	(84)
Polythene	12	(10)
Dhoincha	7	(6)
Jute stalk	7	(6)
Date palm branches	2	(2)
Jute bag/cloths	2	(2)
Shorpa	1	(1)
Mosquito net	1	(1)
Number of materials		
One	102	(89)
Two	12	(10)
Three	1	(1)

Table 4

Proportion of *gachhis* who reported using skirts by area, age and education during November 2008 to March 2009 in Faridpur and Rajshahi Districts of Bangladesh.

Total number of *gachhis* surveyed	Gachhis used skirts	(%)
By intensity		
Higher-intensity (*n* = 64)	53	(83)
Lower-intensity (*n* = 92)	60	(65)
By district		
Faridpur (*n* = 24)	20	(83)
Rajshahi (*n* = 132)	93	(70)
By follow-up		
1st follow-up (*n* = 143)	71	(50)
2nd follow-up (*n* = 146)	80	(55)
3rd follow-up (*n* = 135)	46	(34)
By follow-up in higher-intensity area		
1st follow-up (*n* = 61)	42	(69)
2nd follow-up (*n* = 59)	33	(56)
3rd follow-up (*n* = 51)	13	(25)
By follow-up in lower-intensity area		
1st follow-up (*n* = 82)	29	(35)
2nd follow-up (*n* = 87)	47	(54)
3rd follow-up (*n* = 84)	33	(39)
By age group		
13–29 (*n* = 38)	27	(71)
30–49 (*n* = 72)	61	(85)
>50 (*n* = 29)	16	(55)
By education (years of schooling)		
None (*n* = 62)	48	(77)
1–5 (*n* = 38)	29	(76)
6–10 (*n* = 34)	24	(71)
11+ (*n* = 5)	3	(60)