A behaviour change communication intervention trial to reduce the risk of Nipah virus spillover in Bangladesh

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Dekan

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Summary

Introduction

Nipah virus infection is a bat-borne zoonosis transmitted to humans through consumption of raw date palm sap contaminated by *Pteropus* bats. In Bangladesh, raw sap is a delicacy. The objective of this study was to measure the effectiveness of a behaviour change communication intervention to prevent Nipah virus transmission. We also measured the cost of the Nipah virus prevention intervention and estimated the potential cost of scaling it up to districts where spillover has been identified in the past.

Methods

We developed and implemented a behaviour change communication intervention to reduce the risk of Nipah virus transmission testing two different messages, using community mobilization, interpersonal communication, posters and television as communication channels to reach community residents.

During the 2012-14 sap harvesting seasons, we targeted one district that we denominated as the "no raw sap" area, recommending stopping drinking raw date palm sap. During the 2013-14 sap harvesting season, we targeted a different district denominated as the "only safe sap" area, promoting the use of a traditional method locally called *bana*, used by sap harvesters (*gachhis*), to cover the sap with a barrier that interrupts bats' access to sap, recommending drinking only *bana*-protected sap.

We conducted baseline and endline surveys to measure the proportion of people reached by our intervention and their change of behaviour. Before implementing the intervention during the 2012-13 sap harvesting season, the evaluation team collected baseline survey data from community residents in the "no raw sap" area, and a control area. Before the 2013-14 sap harvesting season, the team collected baseline data among community residents and *gachhis* in the "only safe sap" area, and the control area again. After the intervention, from March 31 to April 21, 2014, the team collected endline survey data among community residents and *gachhis* from the two intervention areas and the control. In all areas, the team also observed raw sap consumption and *bana* usage among *gachhis*. We calculated the implementation cost of our intervention and

also estimated future scaling up cost covering the 30 districts where Nipah virus spillover has been identified.

Results

The evaluation team interviewed a total of 6220 community residents and 665 *gachhis* during baseline and endline surveys. They also observed 214 *gachhis* harvesting and selling sap.

Survey data suggest that community residents' and *gachhis'* knowledge about Nipah virus/a disease from raw sap, significantly increased in both intervention areas from baseline to endline. This increase was markedly higher in the intervention areas than the control area.

In the "no raw sap" area, reported raw sap consumption decreased markedly between baseline and endline, from 43% to 18%, and from 57% to 40%, in the control area. The difference in the intervention area was not significantly larger than the control. Our observation data suggest that the proportion of observations of at least one person consuming raw sap at the *gachhi's* place declined more in the "no raw sap" area (46% to 22%) than in the control (61% to 53%; difference in difference 95% CI -45%, 15% and p=0.30). In addition, exposure to individual intervention communication elements in the "no raw sap" area was not associated with reported avoidance of raw sap consumption.

In the "only safe sap" area reported overall raw sap consumption decreased markedly, between baseline and endline, from 60% to 44%, and from 49% to 40%, in the control area. The difference in the intervention areas was not significantly larger than the control. Reported consumption of unprotected sap declined in the "only safe sap" (59% to 26%) and the control (36% to 29%) areas. The decline in the intervention area, however, was significantly larger than the control (-26% difference in difference analysis, 95% CI -33%, -18%, p<0.001). Restricting the analysis to residents who consumed sap, reported consumption of *bana*-protected sap significantly increased in the intervention area (3% to 43%) while it hardly changed in the control (26% to 27%). In the "only safe sap" area respondents with direct exposure to at least one intervention

communication element: were more likely to report consuming raw sap from a protected source than those with no exposure (25% vs. 15%, OR 2.0, 95% CI 1.5-2.6, p<0.001).

In the "only safe sap" area, *gachhi*-reported *bana* usage increased from 11% to 90% between baseline to endline. In the control, an unexpectedly high proportion of *gachhis* reported *bana* use during baseline, though it decreased during endline (66% to 57%). The intervention group's increase was significantly higher than the change in the control. However, our observation data suggest a higher percentage of *gachhis* using *banas* in the control (55%) than in the "only safe sap" area (31%).

In terms of implementation costs, the intervention's cost was US$30,000 in the "no raw sap" area and US$55,000 in the "only safe sap" area. The highest cost was conducting meetings and interpersonal communication efforts. The lowest cost was broadcasting the public service announcements on local TV channels.

To scale up a similar intervention in 30 districts where Nipah virus spillover has occurred would cost between 2.6 and 3.5 million US$ for one season. Placing the posters would cost US$96,000, and only broadcasting the public service announcement through local channels in the same region would cost US$26,000.

Discussion and conclusion

The results from the "no raw sap" area suggest that convincing people to abstain from drinking a traditional delicacy are difficult to achieve. Promoting the use of *banas*, an existing preventive method, in the "only safe sap" area seems to be an effective approach to modify raw sap drinking behaviour. To reduce the risk of Nipah virus transmission, a future "only safe sap" approach intervention should focus on increasing direct exposure to the communication elements to help prevent Nipah virus infection. Broadcasting the TV public service announcement would be a low cost next step to advance Nipah virus prevention, supplemented with posters and targeted interpersonal communication in districts with a high risk of Nipah virus spillover.

Zusammenfassung

Einführung

Infektionen mit dem Nipah-Virus, einer Zoonose, werden durch die Fledermausgattung *Pteropus* über den Verzehr von frischem, unverarbeiteten Dattelpalmensaft, der zuvor von den Fledermäusen kontaminiert wurde, auf den Menschen übertragen. In Bangladesch ist dieser Saft in natürlichem Zustand eine Delikatesse. Das Ziel dieser Studie war es, die Wirksamkeit einer Intervention mittels Verhaltensänderung durch Kommunikationsstrategien („behaviour change communication“) zu evaluieren, Übertragungen von Nipah-Viren zu verhindern. Zusätzlich haben wir die Kosten dieser präventiven Intervention betrachtet und basierend darauf die zukünftigen Kosten für die Implementierung dieser Maßnahme in Distrikten, in den zuvor Übertragungen auf den Menschen aufgetreten sind, berechnet.

Methoden

Wir entwickelten und implementierten eine „behaviour change communication“ Intervention, um das Risiko von Nipah-Virus-Übertragungen zu reduzieren. Hierzu haben wir zwei verschiedene Aufklärungsstrategien entwickelt, die die folgende Elemente, um die Bevölkerung mit unserem Programm zu erreichen, beinhalteten: Mobilisierung der Bevölkerung, interpersonelle Kommunikation, Plakate und Fernsehen als Kommunikationskanäle.

Während der beiden Erntezeiten für Dattelpalmensaft in den Jahren 2012/13 und 2013/14 haben wir in einem Distrikt die Strategie verfolgt, dass die Bevölkerung den Konsum von rohem Dattelpalmensaft komplett einstellt. Wir haben diese Strategie als „no raw sap“ Kampagne („ kein roher Saft“) bezeichnet. Während der Erntezeit im Jahr 2013/14 haben wir eine weitere Strategie in einem anderen Distrikt implementiert, wo wir die Verwendung einer traditionellen Methode zum Schutz des Dattelpalmensaftes propagierten. Bei dieser Methode wird der direkte Zugang zum Saft durch einen Schutz aus Bambusstäben (lokal als *bana* bezeichnet) versperrt. Diese Strategie haben wir als „only safe sap“ Kampagne („nur geschützter Saft“) bezeichnet, da wir weiterhin den Verzicht auf rohen Saftes propagierten, dennoch den Konsum von rohem Saft, der

durch ein *bana* vor Kontamination geschützt war, als weitere Option zur Reduktion von Nipah-Virus-Übertragungen zuließen.

Um den Anteil der durch unsere Interventionen erreichten Personen und deren Verhaltensänderung zu evaluieren, führten wir zu Beginn und am Ende der Studie je eine Befragung durch. Vor der Implementierung der Intervention im Jahr 2012/13 erhob das Evaluationsteam bevölkerungsbezogene Daten im Distrikt mit der „no raw sap" Kampagne und einem Distrikt, in dem wir keine Intervention implementierten und als Vergleichsgruppe („Kontrolle") verwendeten. Das Team erhob im Jahr 2013/14 weitere Daten für die Allgemeinbevölkerung und für *Gachhis* – dies sind Arbeiter, die den Dattelpalmensaft sammeln – im Distrikt mit der „only safe sap" Kampagne und erneut im Distrikt der Vergleichsgruppe.

Nach Abschluss der Intervention erhoben wir vom 31. März bis zum 21. April 2014 nochmals Daten von der Allgemeinbevölkerung und den *Gachhis* in allen drei Distrikten, den beiden Interventionsdistrikten und dem Kontrolldistrikt. Zusätzlich erhoben wir Beobachtungsdaten zum Konsum von rohem Dattelpalmensaft und zum Gebrauch von *banas* unter den *Gachhis*. Wir berechneten die Kosten für die Implementierung unserer Intervention und berechneten basierend auf diesen Daten die zukünftigen Kosten für die Ausweitung der Intervention in bis zu 30 Distrikten, in denen bisher Nipah-Virus-Übertragungen beobachtet wurden.

Ergebnisse

Das Evaluationsteam erhob Daten von 6220 Teilnehmern aus der Allgemeinbevölkerung und von 665 *Gachhis* während aller Erhebungen. Sie erhoben Beobachtungsdaten bei 214 *Gachhis* bzgl. Gebrauch von *banas* und Verkauf von rohem Dattelpalmensaft.

Unsere erhobenen Daten deuten darauf hin, dass das Wissen über Nipah-Virusinfektionen, eine Krankheit, die über rohen Dattelpalmensaft übertragen wird, in der Allgemeinbevölkerung und unter den *Gachhis* während der Studiendauer zugenommen hat. Dieser Anstieg war in den beiden Distrikten mit einer Intervention deutlich höher als in der Kontrollgruppe.

Im "no raw sap" Distrikt verringerte sich der Konsum von rohem Saft deutlich von 43% auf 18%, während in der Kontrollgruppe der Anteil der Bevölkerung, die rohen Dattelpalmensaft konsumiert, nur von 57% auf 40% sank. Dennoch war dieser Unterschied nicht statistisch signifikant. Unsere Beobachtungsdaten zeigen, dass der Anteil der Beobachtungen, bei denen mindestens eine Person vor Ort rohen Saft verzehrte, im "no raw sap" Distrikt (46% bis 22%) stärker zurückging als im Kontrolldistrikt (61% bis 53%; 95% Konfidenzintervall [95% KI] der difference-in-difference Analyse: -45%, 15% mit p = 0,30). Darüber hinaus war die Exposition gegenüber einzelnen Elementen unserer Intervention im "no raw sap" Distrikt nicht mit dem berichteten Verzicht auf Konsum assoziiert.

Der im Distrikt "only safe sap" berichtete Gesamtverzehr von rohem Saft verringerte sich deutlich von 60% auf 44% gegenüber 49% auf 40% im Kontrolldistrikt. Auch dieser Unterschied war nicht statistisch signifikant größer. Der berichtete Konsum von ungeschütztem Saft sank sowohl in der „only safe sap“ Gruppe (von 59% auf 26%) als auch in der Kontrollgruppe (von 36% auf 29%), jedoch war der Rückgang in der Interventionsgruppe signifikant größer (-26% in der difference-in-difference Analyse, 95% KI: -33%, -18% mit p <0,001). Bei der separaten Betrachtung der Teilnehmer, die Saft konsumiert hatten, zeigte sich, dass der Konsum von mit *bana* geschütztem Saft signifikant anstieg (von 3% auf 43%), während der Konsum sich in der Kontrollgruppe kaum änderte (von 26% auf 27%). Im "only safe sap" Distrikt berichteten die Teilnehmer, die mit mindestens einem Element unserer Intervention in direkten Kontakt kamen, häufiger, dass sie rohen Saft, der während der Ernte geschützt war, konsumiert haben (25% gegenüber 15%, Odds ratio 2,0, 95% KI 1,5-2,6, p<0.001).

Im "only safe sap" Distrikt erhöhte sich die Nutzung von *banas* von 11% auf 90% im Laufe der Intervention. In unserem Kontrolldistrikt berichteten zu unserer Überraschung ein Großteil der *Gachhis* zu Beginn unserer Studie die Verwendung von *banas* (66%), der allerdings im Verlauf der Studie auf 57% sank. Die Verwendung in der Interventionsgruppe war signifikant höher als in der Kontrollgruppe. Allerdings deuten unsere Beobachtungsdaten daraufhin, dass *Gachhis* der Kontrollgruppe viel häufiger diesen Schutz vor Kontaminatinon auch verwendeten (55%) als in der Interventionsgruppe (31%).

Die tatsächlichen Implementierungskosten für die „no raw sap“ Kampagne betrugen 30.000 US-Dollar und für die „only safe sap“ Kampagne 55.000 US-Dollar. Die höchsten Kosten entstanden bei der Durchführungen von Treffen und bei interpersonellen Kommunikationsstrategien. Vergleichsweise niedrige Kosten enstanden bei der Ausstrahlung unserer Aufklärungsfilme über lokale Fernsehsender.

Eine ähnliche Intervention in 30 Distrikten, in den bereits Nipah-Virus-Übertragungen aufgetreten sind, würde zwischen 2,6 und 3,5 Millionen US-Dollar pro Jahr kosten. Aufhängen von Plakaten würde 96.000 US-Dollar kosten, nur die Ausstrahlung unserer Aufklärungsfilme über lokale Sender 26.000 US-Dollar.

Diskussion und Schlussfolgerung

Die Ergebnisse der "no raw sap" Kampagne deuten darauf hin, dass es schwierig ist, die Menschen davon zu überzeugen, auf den Kosnum dieser lokale Delikatesse komplett zu verzichten. Dagegen scheint die „only safe sap“ Kampagne, die die Verwendung von *banas* als präventive Maßnahme propagiert, ein wirksamer Ansatz zu sein, um das Konsumverhalten von rohem Saft zu verändern. Um das Risiko von Nipah-Virus-Übertragungen zu verringern, sollte eine zukünftige "only safe sap" Kampagne darauf abzielen, die direkte Exposition mit den Interventionselementen zu erhöhen, um Nipah-Virusinfektionen vorzubeugen. Die Ausstrahlung der Aufklärungsfilme im Fernsehen wäre ein kostengünstiger nächster Schritt, um die Nipah-Virus-Prävention zu stärken. Diese könnte zusätzlich mit Plakaten und gezielter interpersoneller Kommunikation in Distrikten mit einem hohen Risiko von Nipah-Virus-Übertragung ergänzt werden.

List of abbreviations

AKK	Amara Kaj Kori
CI	Confidence Interval
DVD	Digital Video Disk
FHI 360	Family Health International 360
GDP	Gross Domestic Product
H1N1	Hemagglutinin Type 1 and Neuraminidase Type 1
IBM-WASH	Integrated Behavioural Model for Water, Sanitation, and Hygiene
icddr,b	International Centre for Diarrhoeal Disease Research, Bangladesh
IEDCR	Institute of Epidemiology, Disease Control and Research
NASA	National Aeronautics and Space Administration
NGO	Non-Governmental Organization
NiV	Nipah Virus
OR	Odds Ratios
PR	Prevalence Risk Ratios
Swiss TPH	Swiss Tropical and Public Health Institute
TV	Television
USAID	United States Agency for International Development
US$	United States Dollar
VPKA	Voluntary Paribak Kalyan Association

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1. Introduction

1.1. Nipah an emerging zoonosis

Nipah virus is a highly pathogenic emerging zoonotic Paramyxovirus. Although the virus' wildlife reservoir are large *Pteropus* fruit bats (Middleton, Morrissy et al. 2007), they do not get clinically ill by Nipah virus infection (Middleton, Morrissy et al. 2007) but can spread the infection to other animals and humans (Chua 2003). Infected bats can shed the virus through saliva and urine (Reynes, Counor et al. 2005, Wacharapluesadee, Lumlertdacha et al. 2005, Middleton, Morrissy et al. 2007). Nipah virus survives in fruit juice or bat's urine for days (Fogarty, Halpin et al. 2008). In humans, the infection can cause severe and often fatal disease (Hossain, Gurley et al. 2008, Luby, Gurley et al. 2009, Luby, Hossain et al. 2009, Luby 2013). Once infected with Nipah virus, humans can transmit the virus to other humans (Gurley, Montgomery et al. 2007, Homaira, Rahman et al. 2010, Sazzad, Hossain et al. 2013).

1.2. Nipah in Malaysia and Singapore

The first human Nipah virus infection was identified in 1998 in Malaysia, where domestic pig farmers had direct contact with sick pigs (Parashar, Sunn et al. 2000). During that time, a total of 283 Nipah human cases were identified and 109 (39%) of those where fatal (Chua 2003). As a result of pigs imported from Malaysia (Paton, Leo et al. 1999), the infection spread to abattoir workers in Singapore. This outbreak lasted from September 1998 to May 1999 (Paton, Leo et al. 1999, Chua 2003), resulting in over 900,000 culled pigs to control the outbreak (Uppal 2000). The Malaysia outbreak was linked to fruit trees at large commercial farms, where bats dropped partially eaten contaminated fruits and pigs ate them, got the infection, and later transmitted the infection to their caregivers (Field, Young et al. 2001, Chua 2003).

1.3. Nipah virus infection in Bangladesh and India

The first recognized Nipah virus outbreak in Bangladesh was identified in 2001. Since then, several outbreaks have occurred in Bangladesh and occasionally in India (Luby 2013). Person to person transmission has been identified during outbreaks in both

countries (Chadha, Comer et al. 2006, Gurley, Montgomery et al. 2007, Homaira, Rahman et al. 2010, Sazzad, Hossain et al. 2013). The most common signs and symptoms include fever, altered mental status, headache, cough, respiratory difficulty, vomiting and convulsions (Hossain, Gurley et al. 2008). After the onset of the illness, patients can die within a median of six days (Hossain, Gurley et al. 2008). Case fatality of Nipah virus infection in South Asia has been over 70% (Hossain, Gurley et al. 2008, Luby, Gurley et al. 2009). The incubation period for person to person transmission was a median of nine days after exposure to the sick patient (Hossain, Gurley et al. 2008). Nipah patients who survived can experience long term neurological impairment (Sejvar, Hossain et al. 2007).

Outbreak investigations in Bangladesh have repeatedly identified the consumption of fresh date palm sap as a risk factor to acquire Nipah virus infection (Luby, Rahman et al. 2006, Rahman, Hossain et al. 2012, Chakraborty, Sazzad et al. 2016) though consumption of fermented date palm sap can also cause Nipah virus infection (Arankalle, Bandyopadhyay et al. 2011, Chakraborty, Sazzad et al. 2016). Date palm sap is harvested during the cold season, November to March, by shaving the bark of the date palm tree (*Phoenix sylvestris*) and collecting the sap into a clay pot overnight (Luby, Rahman et al. 2006, Halim, Chowdhury et al. 2008, Nahar, Sultana et al. 2010). Nipah outbreaks have occurred from December to May, overlapping with the date palm sap collection season (Luby, Gurley et al. 2009).

Image 1: Date palm sap collection in Bangladesh

1.4. Nipah virus prevention initiatives

1.4.1. Outbreak surveillance

Outbreak surveillance for Nipah virus was initiated to identify and respond to outbreaks, to control further transmission of the infection. Bangladesh is a lower middle income country that cannot afford to establish thorough population-based surveillance of outbreaks. The national public health Institute of Epidemiology, Disease Control and Research (IEDCR), Dhaka, Bangladesh, the organization in charge of outbreak identification and response, developed a low-cost media-based surveillance system to identify outbreaks (Ao, Rahman et al. 2016). Under this system, printed newspapers and television channels are regularly scanned for health related news. Once a severe outbreak, such as Nipah virus, is identified, a response team is promptly deployed to the area, taking affected patients to local government health facilities (mostly to tertiary hospitals), occasionally establishing an isolation ward for highly infectious diseases like Nipah. For example, during the 2004 Faridpur Nipah outbreak and the 2011 Lalmonirhat outbreaks, isolation wards and room were established to separate Nipah patients (personal communication outbreak investigation team).

IEDCR investigates the outbreak and disseminates prevention messages to the affected community to create awareness about the disease, risk factors and prevention. Nipah prevention messages include recommending to residents of the Nipah affected community not to drink raw date palm sap and to avoid close physical contact with Nipah patients. The messages are disseminated using interpersonal communication and loudspeaker announcements. Targeting the broader population, IEDCR also circulates Nipah messages via newspapers and television during outbreak seasons.

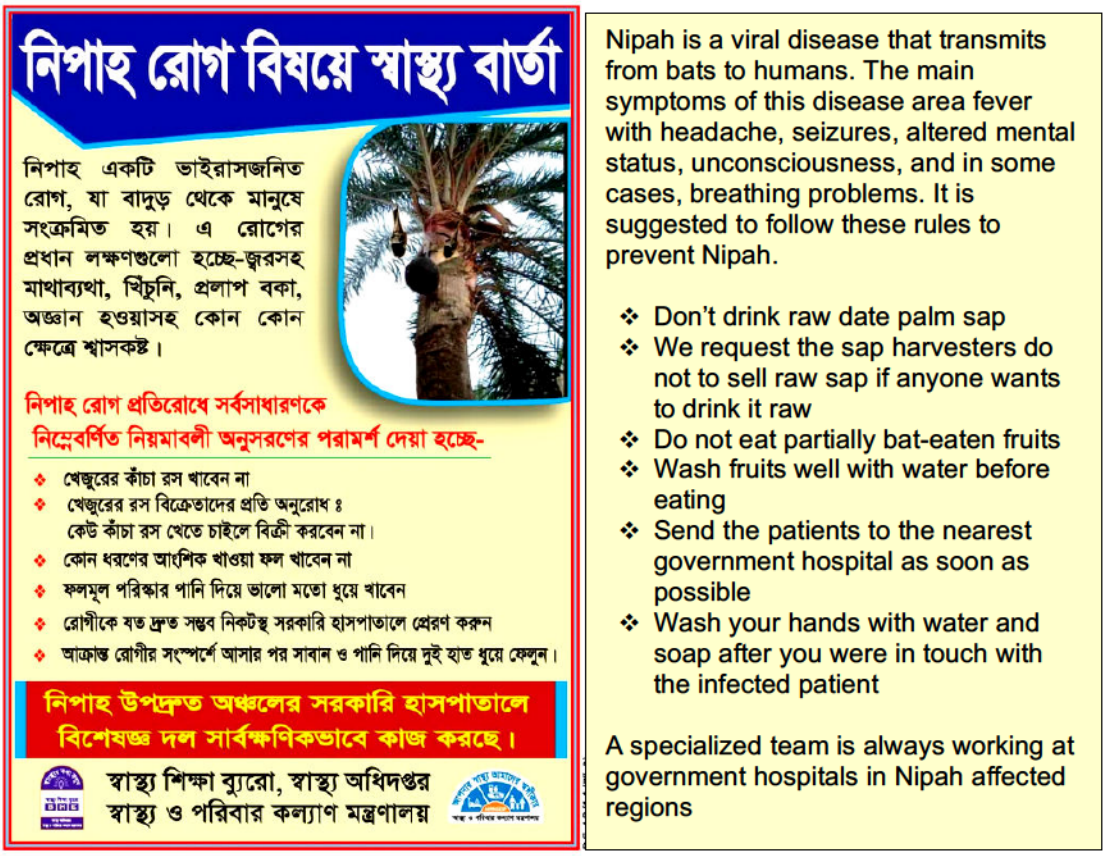

Image 2: Government's Nipah messages in Bengali newspaper

1.4.2. Hospital-based intervention to control outbreaks

Several outbreak investigations suggested that caregivers of Nipah patients and health care workers can get infected in hospital settings through physical contact, e.g. while taking care or examining patients without precautions such as use of gloves and masks (Chadha, Comer et al. 2006, Gurley, Montgomery et al. 2007, Sazzad, Hossain et al. 2013). This person-to-person transmission can occur through Nipah contaminated respiratory secretion reaching the respiratory tract of an uninfected person (Luby 2013). Several pilot intervention studies have been conducted to improve the hygiene behaviour of health workers and caregivers in Bangladeshi hospitals, to avoid such transmission by improving hand hygiene or use of gloves and mask (Gurley, Islam et al. 2013, Parveen, Sultana et al. 2015) and setting isolation corners in three tertiary hospitals in three districts (personal communication to Shahana Parveen). Although these studies suggest that, with focused attention, hygienic behaviour can reduce the risk of Nipah transmission in hospital settings, the cultural norms of taking care of

family members demanding close physical contact (Blum, Khan et al. 2009), as well as maintaining hand hygiene in hospitals with limited resources (Gurley, Islam et al. 2013, Rimi, Sultana et al. 2014) remains a challenge.

1.4.3. Community-based intervention

Since consumption of raw sap has been repeatedly identified as a risk factor for Nipah virus infection, the International Centre for Diarrhoeal Disease Research, Bangladesh (icddr,b), with the support of the Centers for Disease Control and Prevention (CDC), conducted exploratory studies to understand sap collection and consumption practices in Bangladesh (Nahar, Sultana et al. 2010), where drinking fresh date palm sap is a cultural delicacy (Luby, Rahman et al. 2006). Many people drink this sweet sap, fresh from the collection pots in the morning (Nahar, Sultana et al. 2010). Most of the sap is boiled to make molasses. Some people also drink fermented sap, which is locally called *tari* (Nahar, Sultana et al. 2010).

Sap collection is a seasonal occupation for sap harvesters (*gachhis*), who are mostly poor rural agricultural labourers (Halim, Chowdhury et al. 2008, Nahar, Sultana et al. 2010). Collecting sap during winter months supports their livelihood and generates additional income to fulfil other household needs (Nahar, Sultana et al. 2010). *Gachhis* consider bats as a nuisance (Luby, Rahman et al. 2006, Nahar, Sultana et al. 2010). Bat contaminated sap can have an unpleasant smell (Nahar, Sultana et al. 2010). Sap contaminated with bat faeces, or by a bat drowning in the sap, can reduce its value (Nahar, Sultana et al. 2010). Thus, they occasionally use a barrier, locally called *bana*, to interrupt bats' access to the sap.

Image 3: Raw date palm sap right after collection

Image 4: Molasses being made from raw date palm sap

Image 5: Use of bamboo-made *bana* to cover the shaved part of the date palm tree and collection pot

The Nipah research team of icddr,b and CDC conducted several other pilot intervention studies to understand the acceptance of *bana* within the community (Nahar, Mondal et al. 2013, Nahar, Mondal et al. 2014) and the effectiveness of *banas*, by observing bats' behaviour using infrared camera photography to assess if *banas* could interrupt bats access to the sap (Khan, Hossain et al. 2010, Khan, Gurley et al. 2012). The local community accepted the *banas* (Nahar, Mondal et al. 2013, Nahar, Mondal et al. 2014). Infrared photography found that bats visited unprotected date palm trees, drank sap and urinated in the sap pot. These studies also found that *banas* are effective at interrupting bats' access to the sap (Khan, Hossain et al. 2010, Khan, Gurley et al. 2012). Another community-based pilot intervention study demonstrated that, as an additional effect of a *bana* promotion intervention, many people stopped drinking raw sap (Sultana, Mondal et al. 2013).

2. Objectives

Based on our findings, we developed a behaviour change communication intervention targeting two Nipah affected districts, promoting the government's recommendation of not drinking raw sap, as well as asking people to drink only *bana*-protected sap.

2.1. General objective one

To evaluate the effectiveness of a behaviour change communication intervention in changing raw sap consumption behaviour, to reduce human consumption of Nipah contaminated sap, and to reduce raw sap consumption from unprotected trees in a Nipah virus affected region of Bangladesh.

2.2. General objective two

To assess the implementation of the intervention, calculate the intervention cost and estimate costs for a future scaled-up intervention covering the districts with observed Nipah spillover.

2.3. Specific objectives

a) To measure at pre and post intervention impact on:

- i) Awareness level of prevention of Nipah virus infection
- ii) The proportion of respondents reporting that they consume raw sap, those that stopped consuming raw sap, and those that consume protected sap
- iii) The proportion of sap harvesters (*gachhis*) who use *banas* to prevent bats' access to date palm sap.
- iv) The proportion of trees from which *gachhis* collect raw sap for consumption that are protected with *bana*
- v) Proportion of respondents reporting that they were exposed to the intervention

b) To measure

i) The intervention development and implementation cost

ii) An intervention development and implementation cost covering 30 districts where Nipah virus spillovers have been identified

3. Methods

We designed and implemented a community-based behaviour change communication intervention to reduce the risk of Nipah virus transmission in Bangladesh. Our intervention aimed to create awareness of the Nipah virus threat and its cause, and to change behaviour to reduce the risk of Nipah transmission. It consisted of two messages: in one study area, herein referred to as the "no raw sap" area, we advised people to stop consumption of raw sap. The intervention ran during the 2012-14 sap harvesting seasons. In another study area, herein referred to as the 'only safe sap" area, in addition to asking people not to drink raw sap we also advised people to drink only *bana*-protected sap if they wanted to drink sap. It ran during the 2013-14 sap harvesting season. We also advised sap harvesters to use *banas* in trees used for raw sap consumption. We selected a third area as a control to compare our interventions.

3.1. Theoretical framework

We designed an intervention to deal with systemic, structural, institutional and behavioural issues associated with disease transmission and control that might be useful to make an intervention sustainable (Manderson 1998). Thus, we planned to involve the local community using a participatory approach to ensure community engagement. We collaborated with local non-governmental organizations (NGOs) that closely work with local communities. They hired people at the union level (small administrative unit consisting of a few villages). The study team trained them on Nipah virus infection, prevention, and interpersonal communication, to implement the intervention at the community level. These trained people worked as trainers to those who remained in the community as resource persons, talking about Nipah virus infection and prevention. We also incorporated local opinion leaders to support the intervention, and to help local facilitators with the community mobilization effort. Targeting opinion leaders and the community, the facilitators organized community meetings and interpersonal

communication sessions. Community mobilization is defined as a "capacity building process through which community individuals, groups or organizations plan, carry out, and evaluate activities on a participatory and sustained basis to improve their health and other needs, either on their own initiative or stimulated by others" (Howard-Grabman and Snetro 2003). Community mobilization has been the focus of successful interventions, and it is also considered an empowerment process (Rosato, Laverack et al. 2008).

In the "only safe sap" area, in addition to asking residents to avoid drinking raw date palm sap, we offered the option to drink *bana*-protected sap and promoted the use of *banas* to interrupt bats' access to the sap. The *bana* method is a local technology, based on local knowledge, that is practical, affordable, accepted by sap harvesters from Bangladesh (Nahar, Mondal et al. 2013, Nahar, Mondal et al. 2014), and it is effective (Khan, Hossain et al. 2010, Khan, Gurley et al. 2012). Local knowledge refers to knowledge that is "practical, collective and strongly rooted in a particular place" (Geertz 1983). Local communities can substantially contribute to solve environmental problems using their local knowledge (Corburn 2003).

To facilitate the design of our intervention, as well as its evaluation, we adopted a model from The Integrated Behavioural Model for Water, Sanitation, and Hygiene (IBM-WASH) model (Dreibelbis, Winch et al. 2013). This integrated model acknowledges factors at various levels and also acknowledges the role of technology - in this case the *banas* to interrupt bats' access. This also summarizes the key factors affecting the use of *banas* and reduction of sap consumption. The model consists of three dimensions: contextual, psychosocial, and technological factors that operate at five-levels: structural, community, household, individual, and behavioural.

Table 1: The Integrated Behavioural Model for Nipah prevention (adapted from The Integrated Behavioural Model for Water, Sanitation, and Hygiene (IBM-WASH) for the "only safe sap" intervention

	Contextual	**Psychosocial**	**Technology**
Societal/ structural	• Government of Bangladesh has recommended to avoid consumption of raw date palm sap since the 2009/2010 season, but this recommendation is neither widely known nor followed	• Leadership, advocacy at the national government level to promote Nipah virus prevention • Affected communities understand the risk, but most communities are not affected. Thus, there is little social communication regarding prevention	• Promoting local technology to interrupt bats' access to sap
Community	• Drinking raw sap is a delicacy in rural communities • Villagers live in resource constrained settings thus interventions need to be affordable	• Bats are considered a nuisance that spoils sap • Clean sap is considered as the best quality sap because it has better taste	• Arranging *bana*-making sessions in the community
Interpersonal/ household	• Family members have the responsibility to avoid Nipah virus since it is a deadly disease	• Bat-contaminated sap can cause deadly disease that affects other household members • Death has devastating implications for a household	• Making *banas* is very easy, even children can make *banas*
Individual	• Individual (all age groups, male-female, poor and rich) drink raw sap	• Drinking raw sap without *bana* protection can cause disease	• Ask sap harvesters to use *banas* on raw sap consumption trees • Can make *banas* and provide to sap harvesters
Behavioural/ habitual	• Stop drinking sap • Drink sap from a protected source	• Can prevent disease • Can prevent death	• *Banas* are easy to use

3.2. Study area

We selected three Nipah affected districts: Rajbari and Faridpur for the intervention, and Kushtia as the control area (Figure 1). We refer to Rajbari as the "no raw sap" area and to Faridpur as the "only safe sap" area. Rajbari and Kushtia as well as Rajbari and Faridpur Districts border each other. Thus, from each district we selected two upazillas (sub districts) that do not border other study areas, to avoid affecting the study outcome. We did not select the study areas randomly. We selected these sub districts based on factors such as similar population density, percentage of males and females, average household size, literacy rate and sap harvesting and consumption practices.

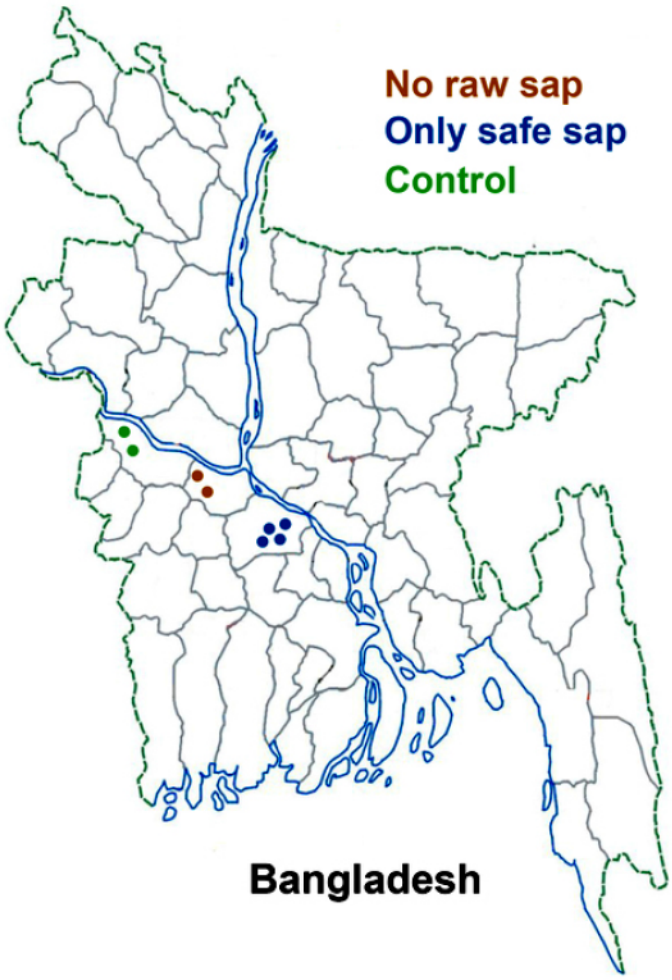

Figure 1: Study areas in Bangladesh map

For the "no raw sap" area, we selected two Rajbari District's upazillas (sub-districts): Pangsha and Kalukhali, comprising 17 unions and 348 villages, with a population of 361,000 (Bangladesh Bureau of Statistics 2012), excluding villages that did not have any date palm trees, sap harvesters, or those that no longer exist due to river erosion, for a total of 342 villages.

As the "only safe sap" area, we selected two Faridpur District's upazillas (sub-districts), Nagarkanda and Sadarpur, plus adjacent villages receiving the TV messages, for a total of 409 villages in 21 unions. The population of the intervention area is 335,000.

However, we conducted the intervention in 381 villages because some villages in the selected districts did not have date palm trees. We included adjacent villages receiving our TV messages to make sure the intervention was fully implemented in those areas where we were running a communication campaign. As control area we selected two Kushtia District's upazillas (sub-districts), Mirpur and Bheramara, comprising 18 unions and 276 villages with a population of 530,000.

3.3. Study design – an intervention

Our intervention consisted of community mobilization, interpersonal communicational and mass media. With technical support from FHI 360, Unitrend, a local advertising agency, developed posters, a calendar, a yearly planner, stickers and a TV public service announcement. They also designed sweatshirts to be used as an incentive for sap collectors using *banas*.

In Rajbari District, the "no raw sap" area, we implemented the intervention during two consecutive sap harvesting seasons: a full intervention from December 26, 2012 to March 29, 2013, and a TV-only intervention from November 16, 2013 to January 31, 2014. In Faridpur District, the "only safe sap" area, we implemented the intervention during one sap harvesting season: from October 3, 2013 to January 31, 2014, including a *gachhi* training component.

We hired two local NGOs, one from each district, to implement the intervention. As a first step, the NGOs conducted a quick survey in their localities. They began with census data (Bangladesh Bureau of Statistics 2012), and then confirmed the actual number of villages from local administrative offices. They visited villages and talked to villagers to get an estimate on the number of households, to identify opinion leaders, local sap harvesters and the existence of trees in the villages. This information was useful to decide the number of meetings required per study site.

A behaviour change communication expert from FHI 360 trained the study team from icddr,b and a PhD student from Swiss Tropical and Public Health Institute (Swiss TPH). This trained team provided training to NGO staff on interpersonal communication, organizing and conducting meetings with opinion leaders and community residents, and

on key intervention messages. In the "only safe sap" area, the NGO hired a *gachhi* experienced in making *banas* to teach their staff how to make and use *banas*.

In both intervention areas, the NGOs conducted approximately one opinion leaders and one community meeting per 500 households. They provided calendars or yearly planners with Nipah prevention messages to opinion leaders and affixed Nipah prevention posters in public places, prior to conducting the meetings. In the "only safe sap" area, the NGO staff also visited *gachhis* and delivered Nipah prevention messages using interpersonal communication, teaching them how to make and use *banas*. They also provided stickers to the *gachhis* to identify the sap collection pots containing *bana*-protected sap. After the first round of visits (three weeks) the NGO staff conducted follow-up visits to meet *gachhis* not found during their first visit, and to award sweatshirts to those *gachhis* who used *banas*.

We identified local satellite television operators covering the intervention areas. We provided broadcast-quality public service announcements in the form of DVDs to be broadcast in local TV channels.

Table 2: Communication channels and materials used to implement the intervention between 2012 to 2014

	No raw sap area	**Only safe sap area**
Opinion leader meetings	281	381
Community meetings	304	220
Calendar/yearly planner	1500	5000
Posters	3000	7000
TV public service announcements	First year 650 times Second year 440 times	440 times
Gachhi meetings and trainings		1,160
Gachhi incentives		1,100 sweat shirts
Stickers		6000

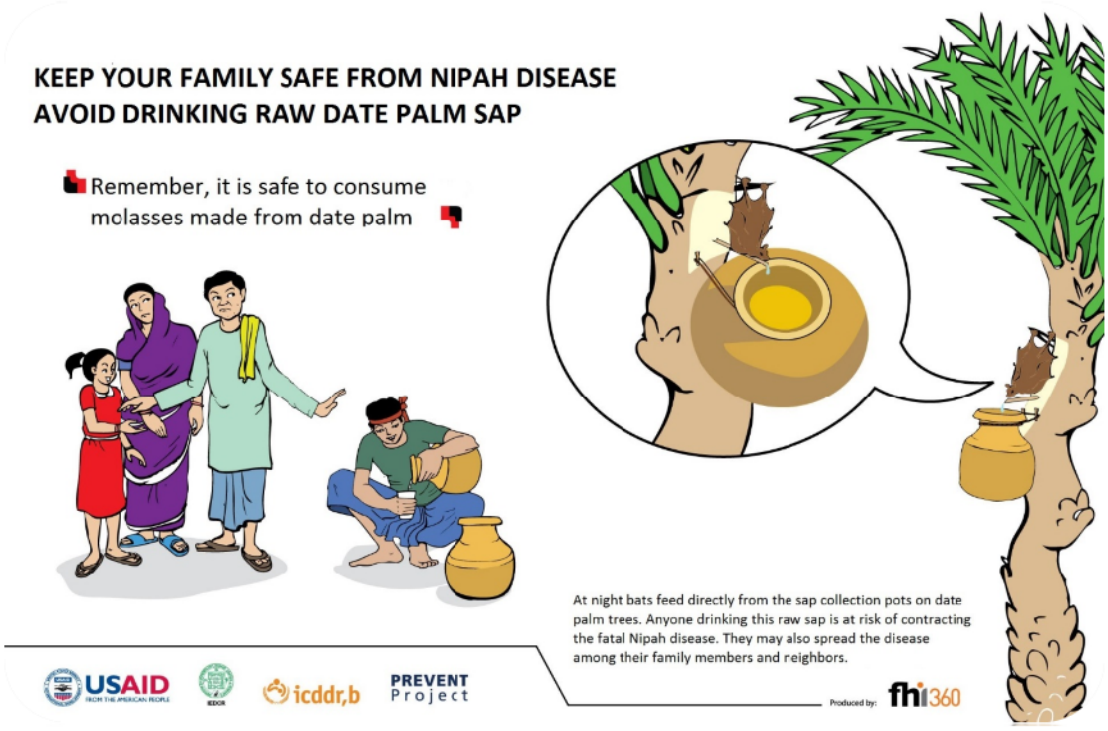

Image 6: Poster used in the "no raw sap" area (English translation)

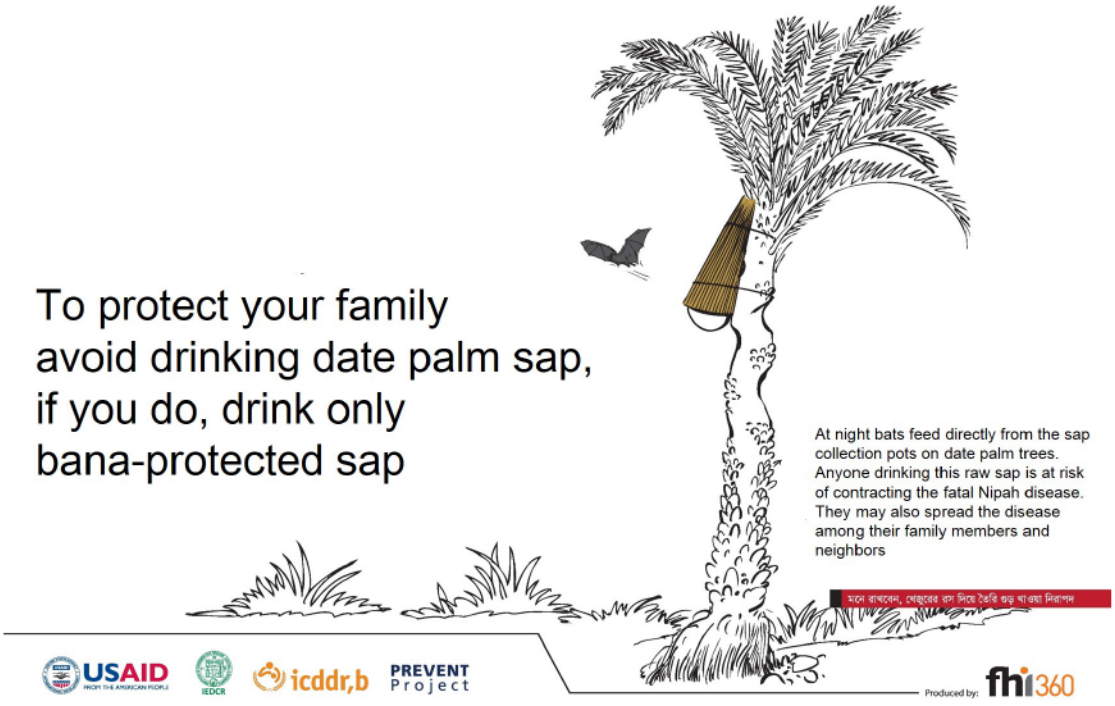

Image 7: Poster used in the "only safe sap" area (English translation)

Image 8: Photo of community meeting

Image 9: Photo from the TV public service announcement

3.4. Study assessment

To assess the effect of our intervention, we conducted baseline and endline surveys among community residents and sap harvesters. In addition, the evaluation team observed sap harvesters collecting and selling sap during the sap collection seasons.

3.4.1. The survey

During the 2012-13 sap harvesting season, the evaluation team conducted baseline surveys from November 21 to December 7, 2012, among community residents in Rajbari, the "no raw sap" area, and Kushtia, the control area.

During the 2012-13 sap-harvesting season, the evaluation team collected baseline data, from July 31 to September 11, 2013, among community residents and *gachhis* in Faridpur, the "only safe sap" area, and Kushtia, the control area. We did not conduct a baseline with *gachhis* in the "no raw sap" area, because the intervention did not include a component aimed at changing *gachhis'* behaviour in that area.

Two months after the "no raw sap" and "only safe sap" intervention, the evaluation team collected endline survey data, from March 31 to April 21, 2014, among community residents and *gachhis* from the intervention and control areas.

3.4.2. Observation

The evaluation team observed sap selling points in the "no raw sap" intervention and control areas between December to February during the 2012-13 and 2013-14 seasons to observe the sap selling and consumption behaviour. Between December, 2013 and February, 2014, the evaluation team observed sap selling points in the "only safe sap" and control areas to observe the use of *banas* and sap consumption behaviour. Every two weeks, the evaluation team conducted observations in at least five different sites per area: the "no raw sap," the "only safe sap, and the control areas. They randomly selected 10 *gachhis* per area and observed them performing their job, arriving at the household before *gachhis* started picking up sap collection pots from trees in the morning. They observed these activities between 5.25 am and 9.45 am. They observed and recorded the number of trees harvested and trees covered by *banas*, the number of

persons that consumed and bought raw sap to take home. The team estimated the amount of sap by observing the size of the pots and consulting with the *gachhis*.

3.4.3. Sample size calculation for the survey

For our primary objective we intended estimating the impact of the intervention defined as the difference in proportions between intervention and control group in the pre-test and post-test period. To calculate our sample, we used data from a study investigating village-level risk factors for Nipah spillover in Bangladesh. This study reported that 56% of people consume raw sap and the intra-class correlation was 0.45 between villages (Stephen P. Luby, unpublished data).

Assumptions: (sampling for the community males or females)

- 56% of people (men/women) in the intervention districts and 56% of men/women in the control district consumed raw and/or fermented sap pre-intervention
- 36% of men/women in the intervention districts and 51% of men/women in the control district consumed raw and/or fermented sap post-intervention
- 15% of absolute reduction in raw sap consumption practices between intervention and control group in a difference in difference analysis (0.56-0.36) - (0.56-0.51) =0.15=>15%. This effect size was based on a previous intervention study carried out in 2010-2011 which showed that 17% of *gachhis* and 41% of tree owners stopped drinking raw sap (sap drinking by the general population was not measured).
- 80% power
- 95% confidence
- 2.8 design effect, assuming an intra-class correlation of 0.45
- Zero correlation between intervention and control groups and 0.5 correlations within pre and post period.

Formula used for sample size calculation

The specified formula for calculating sample size with detectable difference d is given as,

$$n = \frac{(z_\alpha + z_\beta)^z var}{d^z}$$

$$var = deff(\sigma_1^2 + \sigma_2^2 + \sigma_3^2 + \sigma_4^2 - 2\rho_{12}\sigma_1\sigma_2 - 2\rho_{13}\sigma_1\sigma_3 + 2\rho_{14}\sigma_1\sigma_4 + 2\rho_{23}\sigma_2\sigma_3 - 2\rho_{24}\sigma_2\sigma_4 - 2\rho_{34}\sigma_3\sigma_4)$$

where,

the four group is denoted as 1 (pre-test intervention group), 2 (post-test intervention group), 3 (pre-test control group) and 4 (post-test control group),

σ_i^2 is the variance of i-th group,

ρ_{ij} is the coefficient of correlation between group i and group j,

deff is the design effect which is calculated using $1 + (k - 1)\,\rho$ where ρ is the intra-class correlation and k is the number of units per village.

We used software 'R' for sample size calculation. Based on this calculation, 372 observations in each gender group, from 75 villages would be sufficient to detect the expected change. If the pre-post correlation is 0.3, our calculated sample size allowed us to detect a difference of 20%. We interviewed 6 men and 6 women from each village to allow for a 15% refusal/absence rate, for a total of 450 men and 450 women from each study area, per baseline or endline.

<u>Assumptions: sampling for the sap harvesters/*gachhis*</u>

- 1% of *gachhis* in intervention districts and 1% of *gachhis* in the control district used *bana* pre-intervention
- 17% of *gachhis* in intervention district and 2% of *gachhis* in the control district used *bana* post-intervention.
- 15% of absolute increase of *bana* usage among *gachhis* between intervention and control groups. This effect size was chosen based on the results of earlier small trials introducing *banas* to *gachhis*, which gave rates of 26% of *gachhis* using *bana* at least once, with 7% of *gachhis* still using *banas* the following year.

- 80% power
- 95% confidence
- 1.9 design effect, assuming an intra-class correlation of 0.45
- Zero correlation between intervention and control groups and 0.5 correlations within pre and post period

Based on the calculation 53 observations in each group from 27 villages would be sufficient to detect the expected change. Considering a 20% non-response rate 63 observations were needed. However, we increased the sample size to 150 (2 *gachhis* from each village (out of 75) since we will visit 75 villages for our community baseline and endline surveys.

3.4.4. Survey procedure – community

Among men, the team interviewed the main income earner of a household. Among women, the team interviewed the wife of the main male income earner in the household. To select the first male respondent randomly, the team identified the closest household to where the most recent birth in the village occurred. Similarly, to select the first female respondent randomly, the team identified the closest household to where the most recent wedding occurred. To conduct the interviews, the field team approached the selected household. If the desired respondent was available and provided informed consent, they interviewed the person. They conducted face-to-face interviews with men and women using two separate pre-tested standardized questionnaires. If the person was not available, they revisited the household twice within the next 24 hours. After that time-period, if not available, the respondent was skipped and not replaced.

After interviewing a respondent, the field team skipped the next closest 20 households and then approached the 21st for consent and enrolment of a respondent. They repeated this procedure until the required number of households per gender per village had participated in the survey. People were excluded if someone else in the household had already been enrolled.

The team asked both men and women about their knowledge of Nipah virus infection and their own raw sap consumption. Since women spend more time at home, where sap consumption usually occurs, the team only asked women about the amount of raw sap consumed per-week by household members. To collect the information on the amount of raw sap consumed, the team asked the women respondents how many people in the household drank raw sap, how many days a week and how many glasses of raw sap they usually consumed during the previous sap collection season.

3.4.5. Survey procedure for *gachhis*

The evaluation team asked community respondents to identify *gachhis* in their village and listed their names, phone numbers, and household locations. The survey team randomly talked to one *gachhi* to confirm accuracy and finalize the list. From the final list, we used a Kish grid (Kish 1965), to select *gachhis* for interview.

3.5. Ethics

The team obtained written informed consent prior to collecting data. Human subject review committees at icddr,b and FHI 360 approved the study protocol. The study protocol was registered as a clinical trial on clinicaltrials.gov (NCT01811784).

3.6. Organization of the results section

The first section of our results is the published manuscript representing the baseline data from the "no raw sap" and control areas. In it, we discussed peoples' raw sap consumption habits and its association with knowledge of Nipah virus. Next is the manuscript discussing the results of the intervention impact. The final section of the results presents the cost of the intervention and estimated cost of a future scale up.

4. Raw sap consumption habits and its association with knowledge of Nipah virus in two endemic districts in Bangladesh

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4.1. Abstract

Human Nipah virus (NiV) infection in Bangladesh is a fatal disease that can be transmitted from bats to humans who drink contaminated raw date palm sap collected overnight during the cold season. Our study aimed to understand date palm sap consumption habits of rural residents and factors associated with consumption. In November-December 2012 the field team interviewed adult respondents from randomly selected villages from Rajbari and Kushtia Districts in Bangladesh. We calculated the proportion of people who consumed raw sap and had heard about a disease from raw sap consumption. We assessed the factors associated with raw sap consumption by calculating prevalence ratios (PR) adjusted for village level clustering effects. Among the 1,777 respondents interviewed, half (50%) reported drinking raw sap during the previous sap collection season and 37% consumed raw sap at least once per month. Few respondents (5%) heard about NiV. Thirty-seven percent of respondents reported hearing about a disease transmitted through raw sap consumption, inclusive of a 10% who related it with milder illness like diarrhea, vomiting or indigestion rather than NiV. Respondents who harvested date palm trees in their household were more likely to drink sap than those who did not own date palm trees (79% vs. 65% PR 1.2, 95% CI 1.1-1.3, $p<0.001$). When sap was available, respondents who heard about a disease from raw sap consumption were just as likely to drink it as those who did not hear about a disease (69% vs. 67%, PR 1.0, 95% CI 0.9-1.1, $p=0.512$). Respondents' knowledge of NiV was low. They might not have properly understood the risk of NiV, and were likely to drink sap when it was available. Implementing strategies to increase awareness about the risks of NiV and protect sap from bats might reduce the risk of NiV transmission.

4.2. Introduction

Nipah virus (NiV) infection is an emerging zoonosis that causes severe disease in both animals and humans. Several human Nipah virus outbreaks have been reported in Bangladesh since 2001 with a case fatality of 73% (Luby, Gurley et al. 2009). Multiple lines of evidence support a causal relationship between raw date palm sap consumption and human infection with Nipah virus. *Pteropus* bats, the reservoir of Nipah virus (Halpin, Hyatt et al. 2011), occasionally shed Nipah virus in their saliva (Reynes, Counor et al. 2005, Wacharapluesadee, Lumlertdacha et al. 2005, Middleton, Morrissy et al. 2007). Infrared photography demonstrates *Pteropus* bats in Bangladesh frequently directly contaminate raw date palm sap with their saliva (Khan, Hossain et al. 2010, Rahman, Hossain et al. 2012). Laboratory studies demonstrate that Nipah virus survives for several days in date palm sap (de Wit, Prescott et al. 2014). Laboratory animals exposed to date palm sap spiked with Nipah virus develop Nipah infection (de Wit, Prescott et al. 2014). Finally, several outbreak investigations in Bangladesh have found that people with Nipah virus infection are more likely to have drunk raw date palm sap than controls (Luby, Rahman et al. 2006, Luby, Hossain et al. 2009, icddr,b 2010, Rahman, Hossain et al. 2012). Person-to-person transmission of human NiV has also been identified (Gurley, Montgomery et al. 2007, Homaira, Rahman et al. 2010, Sazzad, Hossain et al. 2013), a finding that has broader public health implications including the risk of a pandemic (Luby 2013).

Raw date palm sap is harvested during the cold season, from November to March, by shaving the bark of the tree (Homaira, Rahman et al. 2010). Often using a small wooden pipe, sap is collected into a clay pot and made available for people to drink raw (Luby, Rahman et al. 2006, Homaira, Rahman et al. 2010). Bats frequently visit the harvested date palm trees and lick the sap stream that flows from the shaved part of the tree to the collection pot (Khan, Hossain et al. 2010). *Pteropus* bats can shed NiV through their saliva and urine (Reynes, Counor et al. 2005, Wacharapluesadee, Lumlertdacha et al. 2005, Middleton, Morrissy et al. 2007) and can contaminate the date palm sap.

Since 2005, the messages "do not drink raw sap" or "avoid drinking raw sap" have been disseminated in outbreak affected communities in response to NiV outbreaks. Due to repeated NiV outbreaks associated with raw date palm sap consumption (Luby,

Rahman et al. 2006, Rahman, Hossain et al. 2012), beginning in 2011, the Institute for Epidemiology, Disease Control and Research (IEDCR) of the Government of Bangladesh adopted an official strategy to discourage drinking raw date palm sap to prevent the transmission of NiV from bats to humans. The message was communicated via national newspapers and loudspeaker announcements in NiV affected areas.

We conducted an assessment to measure the existing raw sap consumption behavior and knowledge about NiV in two endemic districts. We intended this measurement as a baseline to help assess the effectiveness of a subsequent intervention. The objective of this analysis was to describe raw date palm sap consumption habits among rural community residents, grouping them by gender, district of residence, education and ownership of date palm trees, to determine if those factors and knowledge about NiV were associated with raw sap consumption.

4.3. Methods

In this paper we presented baseline data of an intervention trial selecting Rajbari as an intervention district and Kushtia as a control district. From each district, we purposely selected two sub-districts using specific criteria. We chose rural sub-districts that did not border each other (between the intervention and control areas) to avoid spillover that could affect the study outcome. In Rajbari, we chose sub-districts with TV coverage via local satellite operators to be able to broadcast a public service announcement on close-circuit television. Finally, we looked for sub-districts where human population and date palm tree densities were similar. Although Rajbari and Kushtia districts experienced NiV outbreaks in the past, after our selection we found that our selected sub-districts had not experienced any recognized outbreak.

Based on the sample size calculation to evaluate the impact of an intervention, we randomly selected 75 villages per district (two sub-districts from each district) from the list of villages from the 2011 census (Bangladesh Bureau of Statistics 2012) for a cross sectional survey. We planned to enrol 450 respondents per gender per district, for a total of 1,800 respondents altogether, allowing for a 15% refusal/absent rate. In each village, we interviewed six men and six women to understand their date palm sap consumption habits and their knowledge about NiV transmission.

The data collection team conducted the survey between 21 November and 7 December 2012. Among men, the team interviewed the main income earner of a household. Among women, the team interviewed the wife of the main male income earner in the household. To select the first man respondent randomly, the team identified the closest household to where the most recent birth in the village occurred. Similarly, to select the first woman respondent randomly, the team identified the closest household to where the most recent wedding occurred. To conduct the interviews, the field team approached the selected household. If the desired respondent was available and provided informed consent, they interviewed the person. They conducted face-to-face-interviews with men and women using two separate pre-tested standardized questionnaires. If the person was not available, they revisited the household twice within the next 24 hours. After that time-period, if not available, the respondent was skipped and not replaced.

After interviewing a respondent, the field team skipped the next closest 20 households and then approached the 21st for consent and enrolment of a respondent. They repeated this procedure until the required number of households per gender per village had participated in the survey. People were excluded if someone else in the household had already been enrolled.

The team asked both men and women about their knowledge about NiV infection and their own raw sap consumption. Since women spend more time at home, where sap consumption usually occurs, the team only asked women about the amount of raw sap consumed per-week by household members. To collect the information on the amount of raw sap consumed, the team asked the women respondents how many people in the household drank raw sap, how many days a week and how many glasses of raw sap they usually consumed during the previous sap collection season.

4.4. Data analysis

We calculated the proportion of men and women and all household members drinking raw sap during the last sap collection season, the frequency and amount consumed per capita and source of raw sap consumed. We calculated the amount of raw sap consumed assuming that each glass of sap was 250 ml. We compared sap consumption practices

by gender and study area/district using a t-test, adjusted for cluster effects (Davidson and MacKinnon 1993). To investigate if there was an association between raw sap consumption and gender, district, education, ownership of date palm trees and having heard of NiV, we restricted the analysis to the availability of raw sap. Thus, we excluded people who reported not drinking raw sap because of unavailability. We calculated prevalence risk ratios (PR) using a log linear model and 95% confidence interval (CI) adjusted for village level clustering.

4.5. Ethical consideration

The team obtained written informed consent prior to conducting the survey. Ethical Review Committee of icddr,b and Office of International Research Ethics of FHI 360 reviewed and approved the protocol.

4.6. Results

4.6.1. Background information of respondents

During the survey, the field team enrolled 1,777 (99%) of the 1,800 targeted participants, equally distributed among districts and by gender. The mean age of the respondents was 40 years. Men respondents were older than women respondents (mean 45 vs. 34 years). Less than half (42%) completed primary school education. More respondents in Kushtia District completed primary education compared to Rajbari District. More women respondents in both districts completed primary education than men respondents (Table 3).

4.6.2. Knowledge about NiV

More than one third (37%) of respondents reported hearing about a disease that resulted from raw sap consumption, 17% of respondents heard about a disease transmitted from bats to people and 5% of respondents had heard of a disease named "Nipah" (Table 3). Respondents who mentioned about a disease resulting from raw sap consumption related it with a number of illnesses like diarrhea and vomiting (10%), *gastric* (1%) and other health problems in addition to a deadly disease (12%) and NiV (2%).

Table 3: Demographic characteristics, knowledge about Nipah and raw sap consumption habits in the previous sap collection season by gender and district

Characteristics	Gender[§]		District[§§]		Total
	Men (N=889) n (%)	Women (N=888) n (%)	Rajbari (N=892) n (%)	Kushtia (N=885) n (%)	(N=1,777) n (%)
Mean Age (Standard Deviation)	45 (14.2)	34 (9.8) †††	40 (13.8)	39 (13.1)	40 (13.4)
Completed primary education	338 (38)	413 (47) †††	341 (38)	410 (46) †††	751 (42)
Knowledge about NiV					
Heard about a disease that can be transmitted from bats to people	159 (18)	150 (17)	176 (20)	133 (15)†	309 (17)
Heard about a disease from raw sap consumption	320 (36)	341 (38)	322 (36)	339 (38)	661 (37)
Heard the name "Nipah" disease	29 (3)	60 (7) †††	47 (5)	42 (5)	89 (5)
Individual level consumption					
Ever drank raw sap	851 (96)	829 (93)	857 (96)	823 (93)	1,680 (95%)
Drank raw sap last season	495 (56)	396 (45) †††	382 (43)	509 (57) †††	886 (50)
Raw sap drinking frequency during last season					
At least once or twice a month	281 (32)	383 (43) †††	284 (32)	380 (43)	664 (37)
Once or twice a season	214 (24)	8 (1) †††	96 (11)	126 (14)	222 (12)
Source of raw sap drank during the last season					
Purchased from neighbouring *gachhi* or tree owner	199 (22)	148 (16)	159 (18)	188 (21)	347 (20)
Own household trees	105 (12)	81 (9)	99 (11)	87 (10) ††	186 (10)
Gift	81 (9)	112 (13) †††	91 (10)	102 (11)	193 (11)
Market	97 (11)	29 (3) †††	43 (5)	83 (10) †	126 (7)
Mobile vendor	75 (8)	56 (6)	22(2) †††	109(12) †††	131 (7)

Household level raw sap consumption					
A least one person in the household consume raw sap in the last season*	-	472 (53)	194 (44)	278 (63)	472 (53%)
Mean number of household members (95% confidence interval) *		4.5 (4.43, 4.69)	4.8 (4.61, 5.02)	4.3 (4.15, 4.47)	4.5 (4.43, 4.69)
Mean number of household members who drank raw sap in the sap drinking household (95% confidence interval) *	-	3.5 (3.31, 3.62)	3.5 (3.21, 3.73)	3.5 (3.26, 3.66)	3.5 (3.31, 3.62)
Per capita raw sap consumption at household per week in the peak month during the last season (in litres) *					
Mean (95% confidence interval) and [range]	-	0.6 (0.55,0.62) [0.14, 5.3]	0.6 (0.55, 0.67) [0.14, 5.3]	0.6 (0.52, 0.62) [0.14, 2.6]	0.6(0.55,0.62) [0.14, 5.3]
Use of any raw sap at household level in the last season					
Drank raw sap	546 (61)	481 (54) †	457 (51)	570 (64) †††	1,027 (58)
Made molasses	94 (11)	77 (9)	112 (13)	59 (7)	171 (10)
Shared with neighbours and relatives	74 (8)	70 (8)	73 (8)	71 (8)	144 (8)
Sold raw sap	15 (2)	6 (1)	11 (1)	10 (1)	21 (1%)
Feed sap to animals	10 (1)	6 (1)	9 (1)	7 (1)	16 (1)
Made *tari*	0 (0)	1 (0)	0 (0)	1 (0)	1 (0)

* Calculated from the response of women respondents
§ P value was calculated by comparing men and women (by gender)
§§ P value was calculated by comparing Rajbari and Kushtia District (by district)
†P value < 0.05, ††P value < 0.01, †††P value< 0.001; P-values were cluster adjusted

More respondents from Rajbari (20%) mentioned hearing about a disease that can be transmitted from bats to people than respondents from Kushtia (15%); more women (7%) reported hearing about a disease named "Nipah" than men (3%) (Table 3).

4.6.3. Individual habits of raw sap consumption

Half of the respondents (50%) reported drinking raw sap during the previous sap collection season, 37% of respondents consumed raw sap at least once per month. Twenty percent of all respondents purchased raw sap from *gachhis* in their neighborhood. More men drank raw sap than women (56% vs. 45%) and more respondents from Kushita District (57%) drank raw sap than respondents from Rajbari District (43%) during the previous sap collection season (Table 3).

4.6.4. Household use of raw date palm sap

Respondents reported that their household members primarily used raw date palm sap for consumption, followed by making molasses and sharing raw sap with neighbors and relatives (Table 3). On average, households consisted of 4.5 members and 3.5 members drank raw sap in the previous sap collection season. For households reporting any consumption in the previous sap collection season, per capita mean raw sap consumption averaged about half a liter per week during the peak month of sap collection, i.e. mid December to mid-February.

4.6.5. Reason for not drinking raw sap

The primary reason that respondents gave for not drinking raw sap during the previous sap collection season was because the sap was unavailable or they did not enjoy drinking it (Table 4). Only 6% of respondents mentioned that they did not drink sap because they heard about "Nipah" or heard about a disease from drinking raw sap that caused death.

Table 4: Respondents reported caused for not drinking raw date palm sap during previous sap collection season from Rajbari and Kushtia Districts, 2012

Causes for not drinking raw sap during the last sap collection season*†	**Total (N=794) n (%)**
Sap was not available	470 (59)
Did not like to drink	158 (20)
Did not purchase	51 (6)
Risk of disease	47 (6)
Heard about "Nipah" or heard death after drinking raw sap	45 (6)
Too expensive	33 (4)

* Number of people who did not consume raw sap in the previous season was used as the denominator
† Open ended responses with multiple responses

4.6.6. Associations with raw sap consumption

When raw sap was available men were somewhat more likely than women to drink it (74% vs. 62% PR 1.1, 95% CI 1.1-1.2, p<0.001) (Table 5). Kushtia District residents were somewhat more likely than Rajbari District residents to drink raw sap (72% vs. 62 % PR 1.1, 95% CI 1.1-1.2, p=0.002). Respondents whose households owned date palm trees harvested during the previous sap collection season drank sap more frequently than those respondents whose household did not own trees drank (79% vs. 65% PR 1.2, 95% CI 1.1-1.3, p<0.001). Neither respondents' education nor their knowledge about NiV was associated with raw sap consumption (Table 5).

Table 5: Characteristics associated with raw sap consumption among those living in villages that had access to date palm sap during previous sap collection season from Rajbari and Kushtia Districts, 2012

Characteristic	Consumption of raw sap %	Prevalence ratio (95% CI)	P value*
Gender			
Women	62 (391/635)		
Men	74 (494/672)	1.1 (1.1-1.2)	<0.001
District			
Rajbari	62 (379/608)		
Kushtia	72 (506/699)	1.1 (1.0-1.2)	0.002
Education			
<5 years	68 (500/732)		
5 to 9 years	66 (276/418)	0.9 (0.8-1.0)	0.441
10 to 12 years	69 (109/157)	0.9 (0.8-1.1)	0.799
Household own date palm trees			
No	65 (705/1,079)		
Yes	79 (180/228)	1.2 (1.1-1.3)	<0.001
Heard about NiV transmission			
Heard about a disease that can be transmitted from bats to people			
No	68 (730/1,066)		
Yes	64 (155/241)	0.9 (0.8-1.0)	0.303
Heard about a disease from raw sap consumption			
No	67 (531/792)		
Yes	69 (353/514)	1.0 (0.9-1.1)	0.512
Heard of "Nipah" disease			
No	68 (836/1,230)		
Yes	64 (49/77)	0.9 (0.7-1.1)	0.482

* Cluster adjusted

4.7. Discussion

Rural Bangladeshi residents like drinking raw date palm sap. In our study, half of the respondents reported drinking it during the last sap collection season putting them at risk of contracting NiV. Those who did not drink raw sap, attributed it mostly to its unavailability. Since NiV kills most of the people infected (Luby, Gurley et al. 2009), outbreaks often receive media attention (News Editor 2011, Afrin 2013, Staff Correspondent 2013). The Government of Bangladesh has taken efforts to communicate the risk associated with raw date palm sap consumption through newspaper announcements as well as in the outbreak-affected communities using interpersonal and loudspeaker communication. However, respondents' understanding of NiV is still low and only a small proportion of people had heard about NiV and its consequences. Reducing consumption of raw date palm sap would reduce the risk of NiV transmission. Concentrating on raising awareness about the disease and its associated risk, as well as disseminating information on a regular basis for several years may help increase the likelihood of long-term change (Contento, Balch et al. 1995).

Men in our study were somewhat more likely to drink raw sap than women. In rural Bangladesh men have higher mobility in the locality and more access to money than women (Kabeer 2001). As a result, they might have more options to drink sap. Similarly, respondents who had harvested trees at home were more likely to consume sap, presumably because it was easily available to them, at minimal or no cost. The result is similar to other food-focused studies that suggest that people consume more unhealthy food when it is readily available (Mehta and Chang 2008, Li, Harmer et al. 2009, Olstad, Raine et al. 2012).

In our study, when sap was available, knowledge about the potential risk of NiV in this population did not influence raw sap consumption behavior, indicating a gap between knowledge and NiV risk perception. This behavior can be compared with raw milk consumption in the United States. Although many states restrict the sale of unpasteurized or raw milk to prevent foodborne disease outbreaks, some people still consume raw milk (Lejeune and Rajala-Schultz 2009, Oliver, Boor et al. 2009, Longenberger, Palumbo et al. 2013). In the Portland, Oregon area, during an outbreak of *Escherichia coli* O157: H7 infection caused by raw milk consumption, messages

were widely disseminated about the life threatening risk of raw milk consumption, however, sale of the raw milk continued until the dairy selling that milk was forced out of the retail business (Keene, Hedberg et al. 1997). Milk consumers were sceptical about the inherent hazard (Keene, Hedberg et al. 1997). A study among farm families in Pennsylvania suggests that farmers consume raw milk primarily because of the taste and availability (convenience) and because it is a traditional practice, less expensive than retail pasteurized milk (Jayarao, Donaldson et al. 2006).

NiV is a relatively newly identified disease and few people in our study sites have heard enough about it to understand the risk it represents. Those who heard about it might not be fully aware of NiV infection consequences, since many of them only related raw sap consumption with gastrointestinal distress like diarrhea and vomiting. They may not be concerned because they have been drinking sap for many years, and not experiencing any serious consequences, thus they may not consider themselves at risk. When people are concerned about their health, they consider themselves at risk and intend to change and make efforts towards change (Tamers, Allen et al. 2014). NiV is a disease with low probability of occurrence but with a high fatality rate, similar to other common exposure that occasionally result in human fatality. Lightning strikes, for example, affects people engaged in common outdoor activities. Although it is a well characterized risk, and recommended practices could reduce risks, many people ignore expert advice and consequently a small proportion are hit and killed by lightning each year (Duclos and Sanderson 1990). Similar to the behavior of people who drink raw date palm sap, people who put themselves at risk of lightning strike, may not properly understand the risk, or may not consider themselves at risk since lightning does not strike people frequently.

A number of factors influence consumption of foods that have well understood adverse health effects (Nestle, Wing et al. 1998, Mehta and Chang 2008, Hattersley, Shrewsbury et al. 2009, Li, Harmer et al. 2009, Zoellner, Estabrooks et al. 2012, Gase, Robles et al. 2014). For example, people consume sugar-sweetened beverages that contribute to obesity because those are easily available and inexpensive, advertised or promoted (Hattersley, Shrewsbury et al. 2009, Zoellner, Estabrooks et al. 2012, Gase, Robles et al. 2014). Behavioral intention consistent with negative and positive

evaluation towards performing a behavior, perceived behavior control, and subjective norms based on how others approve or disapprove the behavior can influence peoples' choice of drinking sweetened beverages (Zoellner, Estabrooks et al. 2012). Though some of them know the health consequences, they do not perceive themselves as vulnerable to weight gain and they see others drinking it (Hattersley, Shrewsbury et al. 2009). Similarly, drinking raw date palm sap is widely acceptable and people see others drinking it. Even if they know about the risk, it is a seasonal delicacy craved during the sap-collection season and they may not perceive themselves as potential victims of NiV. Thus, it might be difficult to change people's behavior so that they decide to stop drinking raw sap altogether.

A potentially useful strategy would be to create awareness of NiV and to provide an option of drinking safer sap. Similar to substituting high-sugar soda with diet soda, an approach that allows people to drink sap while avoiding the risk of infection may be effective at reducing exposure to NiV. To keep sap clean during collection, local sap harvesters occasionally use a skirt-like barrier called *bana*, made from locally available materials, that covers the sap flow and the collection pot to interrupt bats' access (Homaira, Rahman et al. 2010). The method was effective in protecting sap from bats (Khan, Gurley et al. 2012). Pilot studies to promote them found that *banas* were well accepted by sap harvesters. Many of them made and used *banas* on date palm trees used for raw sap consumption (Nahar, Mondal et al. 2013, Nahar, Mondal et al. 2014). In additon to raising NiV awareness, promoting *banas* might help people make a healthy decision on the risk of consuming raw date palm sap, understanding that there is a way to reduce risk without having to avoid consuming it.

In addition to reducing NiV transmission, the use of *banas* on trees for raw sap consumption could help reduce the risks of other diseases that could be transmitted through bats. Bats are the reservoir of several zoonoses that can affect both humans and other animals (Calisher, Childs et al. 2006, Wong, Lau et al. 2007). In our study, some respondents reported vomiting and diarrhea after drinking raw sap. This suggests that bats might contaminate sap with other pathogens. For example, fruit bats in Bangladesh carry *Salmonella* (Islam, Mikolon et al. 2013) and presumably other enteropathogens.

Our study has limitations. From this survey we received only some reports of fermented sap preparation and consumption, though it is one of the routes of NiV transmission to humans (Arankalle, Bandyopadhyay et al. 2011, icddr,b 2012). Drinking alcohol is proscribed in Islam and therefore it is a sensitive issue to report. Thus, from our study we cannot predict how many people consume, or how frequently they consume, fermented sap. Understanding more about practices related to sap fermentation and consumption could guide us to incorporate this issue in future intervention messages.

We do not fully understand why some people drank raw sap after knowing the risk of getting NiV or why residents of Kushtia were more likely to drink sap than residents of Rajbari. These would be useful topics for further exploration.

NiV is a serious disease that often kills people infected (Luby, Gurley et al. 2009) and because it can be transmitted from person to person (Gurley, Montgomery et al. 2007, Homaira, Rahman et al. 2010, Sazzad, Hossain et al. 2013) there is some risk that, during human infection, the virus could evolve to become more easily transmissible from person-to-person, increasing the risk of a pandemic (Antia, Regoes et al. 2003). The large and increasing population density in Bangladesh means more human interactions, more mobility and therefore increased opportunities for person-to-person transmission that would further increase this global risk. Reducing the risk of NiV spillover by developing effective and practical interventions is in the interest of the global community. Such interventions will require more than simply informing people on the risk of drinking raw date palm sap, but even just informing them would be a sound first step.

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5. A controlled trial to reduce the risk of human Nipah virus exposure in Bangladesh

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5.1. Abstract

Human Nipah virus (NiV) infection is a fatal disease in Bangladesh, transmitted by drinking raw date palm sap contaminated by *Pteropus* bats. We assessed the impact of a behavior change communication intervention on reducing consumption of potentially NiV-contaminated raw sap. During the 2012-2014 sap harvesting seasons, we implemented the intervention in two areas, comparing results with a control area, disseminating a "do not drink raw sap" message in one area, and in the other, an "only safe sap" message encouraging drinking sap protected from contamination by a barrier that stops bats. Post-intervention, respondents' knowledge about a disease from raw sap consumption increased over 40% more in both intervention areas than the control. Reported raw sap consumption decreased in all areas but the reduction was not significantly greater in the intervention compared to the control. However, respondents directly exposed to the "only safe sap" message were more likely to report consuming raw sap from a protected source than those with no-exposure (25% vs. 15%, OR 2.0, 95% CI 1.5-2.6, $p<0.001$). Although the intervention increased knowledge in both intervention areas, the "only safe sap" intervention reduced exposure to potentially NiV contaminated sap, and should be considered for future dissemination.

5.2. Introduction

Zoonotic infections can kill people, spread globally, and have a devastating social and economic impact on affected regions (Anderson, Fraser et al. 2004, Girard, Tam et al. 2010, Dawood, Iuliano et al. 2012, UNDG 2015, WHO 2016). Intervention strategies aimed at interrupting spillover of zoonotic infections could reduce the risk of disease occurrence and its consequences.

Nipah virus (NiV) infection, a zoonotic disease transmitted from infected *Pteropus* bats to humans, is often fatal and can cause neurological sequelae among survivors (Chua, Goh et al. 1999, Reynes, Counor et al. 2005, Wacharapluesadee, Lumlertdacha et al. 2005, Middleton, Morrissy et al. 2007, Sejvar, Hossain et al. 2007, Luby, Hossain et al. 2009). Since 2001, NiV outbreaks have been identified almost every year in Bangladesh (Luby 2013). People can acquire NiV from drinking bat-contaminated raw date palm sap (Luby, Rahman et al. 2006, Luby, Gurley et al. 2009, Rahman, Hossain et al. 2012, Hegde, Sazzad et al. 2016). Once a person is infected with NiV, they can transmit it to other people (Gurley, Montgomery et al. 2007, Homaira, Rahman et al. 2010, Sazzad, Hossain et al. 2013).

In Bangladesh, date palm sap harvesters, locally called *gachhis,* collect raw sap during cold months, from November to March, by shaving the bark of the tree and hanging a pot to collect sap overnight (Luby, Rahman et al. 2006, Nahar, Sultana et al. 2010). In 2009 the Government of Bangladesh began discouraging people from drinking raw sap to prevent NiV.

Traditionally, *gachhis* occasionally used skirt-like barriers called *banas* to cover the shaved area, the sap flow and the collection pot to stop bats, rodents, birds and insects from accessing the sap (Nahar, Sultana et al. 2010). *Banas* can interrupt bats' access to the sap, potentially preventing NiV spillover, and were acceptable to *gachhis* when promoted (Khan, Hossain et al. 2010, Khan, Gurley et al. 2012, Nahar, Mondal et al. 2013, Nahar, Mondal et al. 2014). Some people stopped drinking raw sap after they learned about NiV (Sultana, Mondal et al. 2013). To reduce the risk of NiV transmission, we implemented a behavior change intervention in two areas, promoting

not drinking raw sap in one area, and encouraging drinking only *bana*-protected sap in the second area. This study assessed the impact of this intervention.

5.3. Methods

5.3.1. Study sites

We selected two NiV endemic districts, Rajbari and Faridpur for the intervention, using Kushtia district as a control. These three neighboring districts experienced repeated NiV outbreaks, and have similar population density, household size, literacy rate (Table 6), (Bangladesh Bureau of Statistics 2012, Nahar, Asaduzzaman et al. 2017). Date palm sap is harvested and consumed raw in these districts. From each district, we selected two adjacent sub-districts that did not share borders with the other intervention and control districts (Nahar, Paul et al. 2015a). From Faridpur we excluded 145 hard to reach villages from the river islands because they had no *gachhis* and no electricity, and could not run TV public service announcements, a key component of our intervention. Our study areas included 342 villages in Rajbari, 381 in Faridpur and 276 in Kushtia. The approximate population of these sub-districts were 361,000 in Rajbari, 335,000 in Faridpur and 530,000 in Kushtia (Bangladesh Bureau of Statistics 2012).

Table 6: Demographic characteristics of the "no raw sap" and the "only safe sap" intervention and control areas

Characteristic	Rajbari District	Faridpur District	Kushtia District
Sub-districts	Pangsha and Kalukhali	Nagarkanda and Sadarpur	Mirpur and Bheramara
Area	"No raw sap"	"Only safe sap"	Control
Population density (sq.-km)	945	871	1192
Sex ratio (men/women)	50% / 50%	49% / 51%	50% / 50%
Average household size	4.3	4.6	4.1
Literacy rate	49.8%	44.7%	45.3%

5.3.2. Study design

We assessed two different community-based behavior change communication messages to improve knowledge about NiV and ultimately change behavior. We disseminated a "no raw sap" message for two seasons, discouraging community

residents from drinking raw date palm sap (Figure 2). Because we were delayed in securing Government of Bangladesh approval, we disseminated an "only safe sap" message for only the second season. This message targeted community residents and *gachhis*, discouraging drinking raw sap but offering the option of drinking *bana*-protected sap. In both areas local NGOs implemented the intervention by convening meetings, and placing posters with key messages in public places with heavy traffic of people (Table 7). In the "only safe sap" area, NGO staff also showed *gachhis* to make and use *banas* to protect their community from NiV and encouraged people to inquire if raw sap was collected using a *bana,* before purchasing it. We broadcast TV public service announcements on closed-circuit local television in both intervention areas, about five times daily, during the intervention period.

Table 7: Audience, key messages and targeted behaviour for the "no raw sap" and "only safe sap" intervention areas implemented during 2012 to 2014 in Bangladesh

Area	Audience	Key Message	Behaviour
No raw sap	Community	To avoid Nipah disease stop drinking raw sap	Stop drinking raw date palm sap
Only safe sap	Community	To avoid getting Nipah disease stop drinking raw date palm sap	Stop drinking raw date palm sap
		If you want to drink raw sap drink only *bana*-protected sap	Drink only *bana*-protected sap
		If you consume raw sap, ask if it is *bana*-protected sap	Make sure the sap you consume is *bana*-protected
Only safe sap	*Gachhis*	Protecting palm sap trees with *banas* protects your community from the deadly Nipah disease.	Use *banas* on those trees used for raw sap consumption

To assess the effect of the intervention, we conducted baseline and endline surveys using pre-tested standardized questionnaires for face-to-face-interviews, and observed *gachhis* collecting sap, and sap selling points (Figure 2).

During the 2012-13 sap harvesting season, the evaluation team collected baseline survey data from community residents in Rajbari, the "no raw sap" area, and Kushtia, the control area. After the survey, the intervention consisted of meetings with opinion leaders and community residents, posters and TV public service announcements, from December 26, 2012 to March 29, 2013. During the 2013-14 sap harvesting season, we continued with a limited intervention, only broadcasting the public service announcement from mid-November, 2013 to January, 2014, reminding residents of the risk of drinking raw sap. The evaluation team observed *gachhis* collecting and selling raw sap in the "no raw sap" intervention and control areas, between December and February during the 2012-13 and 2013-14 seasons. We did not conduct a baseline with *gachhis* in the "no raw sap" area because the message did not target them.

Before the 2013-14 sap harvesting season, the evaluation team collected baseline data among community residents and *gachhis* in Faridpur, the "only safe sap" area; and Kushtia, the control area (Figure 2). After the survey, we implemented the intervention from October, 2013 to January, 2014, including opinion leaders' meetings, community residents' meetings, posters and public service announcements. NGO workers also trained *gachhis* on making *banas*, encouraging its use on trees which sap was collected for raw consumption, provided stickers that *gachhis* could use to identify *bana*-protected sap pots, and offered sweatshirts as an incentive to use *banas*. Between December 2013 and February 2014, the evaluation team visited *gachhis* to observe them collecting and selling sap and to witness *bana* usage.

After our intervention ended in both areas, from March 31 to April 21, 2014, the evaluation team conducted endline surveys among community residents and *gachhis* from the intervention and control areas (Figure 2).

Figure 2: Study activities in the "no raw sap," "only safe sap," and control areas between 2012 to 2014 in Bangladesh

Study areas	Activities	2012		2013									2014			
		Nov	Dec	Jan	Feb	Mar	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
No raw sap	Intervention															
	Observation															
	Survey															
Only safe sap	Intervention															
	Observation															
	Survey															
Control	Observation															
	Survey															

During baseline and endline surveys the evaluation team interviewed separate samples of adult men and women (Nahar, Paul et al. 2015a). They collected data on respondents' sap consumption behavior during the previous sap collection season, their exposure to the intervention communication channels, and message recall from elements of the intervention. They interviewed *gachhis* on their NiV knowledge, number of trees harvested, use of *banas* and raw sap selling practices.

5.3.3. Sample size calculation

Our intervention aimed for a 15% absolute reduction of proportion of people reporting raw sap consumption in the intervention areas, compared to the control area. For a difference in difference analysis, we calculated the desired sample size as 372 men and 372 women from 75 villages per area, per survey. We followed a probability proportionate to size sampling procedure using 2011 census information on total population per village to select villages from each area. From each village, we selected independent samples of men from six households, and women from six other households, targeting 450 households per gender per area, allowing for a 15% refusal rate. We followed the same procedure for baseline and endline sampling.

To measure changes in *gachhi* behavior, targeting a 15% absolute increase in reported *bana* usage between the intervention and control groups in a difference in difference analysis, we calculated the desired sample size as 53 *gachhis* (from 27 villages) in the intervention and control areas. Since the evaluation team would have already visited 75 villages during the community surveys, we increased the sample to 150, two *gachhis* per village, per area per year.

The evaluation team asked community respondents to identify *gachhis* in their village and listed their names, phone numbers, and household locations. They randomly talked to one *gachhi* to confirm accuracy and finalize the list, using a Kish grid, a method for sample selection (Kish 1949), to select *gachhis* for interviews.

5.3.4. Observational data collection

Every two weeks, the evaluation team conducted observations in at least five different sites per intervention and control areas, randomly selecting 10 g*achhis* per area, from the initial *gachhi* list. They observed their activity between 5:25 and 9:45 am, when they collected and sold raw sap, stopping when *gachhis* sold all their sap or started making molasses. They observed and recorded the number of trees harvested, trees covered by *banas*, amount of raw sap collected and consumed, and the number of persons consumed or purchased raw sap to take home. They estimated the amount of sap collected, consumed by observing the size of the pots and consulting with the *gachhis*.

5.3.5. Data analysis

We compared respondents' knowledge about NiV and practices about sap harvesting and consumption between baseline and endline surveys. We assessed the relationship between intervention exposure and behavioral outcomes using a logistic regression model calculating odds ratios (OR). We adjusted for clustering within villages when calculating 95% confidence limits and p–values. We used difference in difference analysis to compare changes from baseline to endline between the control and intervention groups.

Using the observation data, we calculated the median amount of raw sap collected and consumed; the mean number of people who consumed and purchased raw sap; and the proportion of observations during which at least one person consumed raw sap. These helped us determine differences between intervention and control areas in the amount of sap collected and consumed, and if there were any changes in the "no raw sap" area during the two-season intervention. We used difference in difference analysis to understand the changes in observed behavior among the control and the "no raw sap" intervention groups, from the 2012-13 to the 2013-14 sap season. We calculated the proportion of *gachhis* using *banas* and selling *bana*-protected sap for raw consumption, to understand the effect of the "only safe sap" intervention on *bana* usage.

5.3.6. Ethical consideration

The team obtained written informed consent prior to collecting data. Human subject review committees at icddr,b and FHI 360 approved the study protocol. The study protocol was registered as a clinical trial on clinicaltrials.gov (NCT01811784).

5.4. Results

The evaluation team interviewed a total of 6220 community residents and 665 *gachhis* during baseline and endline surveys.

5.4.1. Knowledge about the disease

Community residents' and *gachhis'* knowledge about NiV, a disease from raw sap, significantly increased in both intervention areas from baseline to endline. This increase was markedly higher in the intervention areas than in the control area. A larger proportion of *gachhis* reported knowing about NiV than community residents both at baseline and endline (Table 8).

5.4.2. Community practices in the "no raw sap" area

Reported raw sap consumption decreased markedly between the 2012 baseline and 2014 endline, from 43% to 18%, among residents of the "no raw sap" area, and from 57% to 40%, among residents of the control area (Table 9). The difference in the intervention area was not significantly larger than the control (-7%, 95% CI -15%, 1%, p=0.07). Reported raw sap purchasing from local *gachhis* and tree owners declined from 34% to 18% in the intervention area, a decline that was not significantly larger than in the control (-11%, 95% CI -22%, 1%, p=0.07). Collecting raw sap from your own trees or purchasing from market or mobile vendors for raw consumption did not change significantly among any group.

Table 8: Reported community and *gachhi* knowledge on NiV at baseline and endline from the "no raw sap" and "only safe sap" intervention and control areas, Bangladesh 2012 to 2014

Heard about a disease associated with date palm sap consumption and bats	Intervention area		Control area		Difference in difference analysis [95% CI]
	n (%)	n (%)	n (%)	n (%)	
"No raw sap" intervention and control areas community					
	¶Baseline 2012 N=892	Endline 2014 N=897	¶Baseline 2012 N=885	Endline 2014 N=896	
A disease that people can get from drinking raw date palm sap	322 (36)	688 (77) †††	339 (38)	279 (31) †	(48) ††† [38, 57]
A disease that can be transmitted from bats to people	176 (20)	541 (60) †††	133 (15)	181 (20) †	(35) ††† [27, 43]
Heard of Nipah disease	47 (5)	276 (31) †††	42 (5)	58 (6)	(24) ††† [19, 28]
"Only safe sap" intervention and control areas community					
	#Baseline 2013 N=879	Endline 2014 N=879	#Baseline 2013 N=892	Endline 2014 N=896	
A disease that people can get from drinking raw date palm sap	405 (46)	667 (76) †††	371 (42)	279 (31)†	(40) ††† [30, 49]
A disease that can be transmitted from bats to people	338 (39)	620 (71) †††	217 (24)	181 (20)	(36) ††† [26, 45]
Heard of Nipah disease	97 (11)	307 (35) †††	77 (9)	58 (6)	(26) ††† [20, 31]
"Only safe sap" intervention and control areas *gachhi*					
	#Baseline 2013 N=110	Endline 2014 N=150	#Baseline 2013 N=105	Endline 2014 N=150	
A disease that people can get from drinking raw date palm sap	57 (52)	135 (90) †††	56 (53)	61 (41)	(50) ††† [35, 66]
A disease that can be transmitted from bats to people	50 (45)	135 (90) †††	50 (48)	67 (45)	(47) ††† [31, 63]
Heard of Nipah disease	10 (9)	113 (75) †††	24 (23)	24 (16)	(73) ††† [59, 86]

¶P-value was calculated by comparing baseline-2012 data with endline-2014 data
#P-value was calculated by comparing baseline-2013 data with endline-2014 data
† P value < 0.05, ††P value < 0.01, †††P value< 0.001; *P-values were cluster adjusted

5.4.3. Community practices in the "only safe sap" area

Reported overall raw sap consumption decreased markedly, between the 2013 baseline and the 2014 endline, from 60% to 44% among residents of the intervention area, and from 49% to 40%, in the control area. The difference was not significantly larger than the control (-7%, CI -14%, 2%, p=0.12). Reported consumption of unprotected sap declined in the intervention area (59% to 26%) and the control (36% to 29%). This decline was significantly larger than the control (-26%, 95% CI -33%, -18%, p<0.001) (Table 9).

Restricting the analysis to residents who consumed sap, reported consumption of *bana*-protected sap significantly increased in the "only safe sap" area (3% to 43%) while it hardly changed in the control (26% to 27%). In addition, reported inquiries about *bana* use before purchasing sap significantly increased in the intervention area but decreased in the control. Reported raw sap purchased from local *gachhis* significantly declined in the intervention (39% to 30%) and control (38% to 25%) areas. However, reported buying sap from local *gachhis* increased among residents who reported consuming *bana*-protected sap (13% to 31%). This increase was significantly larger in the intervention area than in the control (27%, 95% CI 3%, 50%, p<0.05) (Table 9).

Table 9: Reported community raw sap consumption behaviour at baseline and endline from the "no raw sap" and "only safe sap" intervention and control areas, Bangladesh 2012 to 2014

Community sap consumption behaviour	Intervention area community		Control area community		Difference in difference analysis [95% CI]
	n (%)	n (%)	n (%)	n (%)	
"No raw sap" intervention and control areas community					
	¶Baseline 2012 N=892	Endline 2014 N=897	¶Baseline 2012 N=885	Endline 2014 N=896	
Respondents' individual raw sap consumption during previous sap harvesting season					
Consumed raw sap	380 (43)	163 (18) †††	506 (57)	354(40) †††	(-7) [-15, 1]

Sources of raw sap among those who drank raw sap during previous sap harvesting season‡					
	N=380	N=163	N=506	N=358	
Purchased from local *gachhi*/ tree owner	130 (34)	30 (18) †††	151 (30)	89 (25)	(-11) [-22, 1]
Own household trees	99 (26)	40 (25)	87 (17)	55 (15)	0
Gift	91 (24)	73 (45) †††	102 (20)	126 (35) †††	(6) † [-4, 16]
Purchased in market/ mobile vendor	65 (17)	23 (14)	192 (37)	104 (29)	(4) [-5, 14]
"Only safe sap" intervention and control areas community					
	#Baseline 2013	Endline 2014	#Baseline 2013	Endline 2014	
	N=879	N=879	N=892	N=896	
Respondents' individual raw sap consumption during previous sap harvesting season					
Consumed raw sap	530 (60)	391 (44) †††	440 (49)	358 (40) ††	(-7) [-14, 2]
Consumed unprotected raw sap	515 (59)	224 (26) †††	325 (36)	260 (29) ††	(-26) ††† [-33, -18]
Raw sap consumption behaviour among those who drank raw sap during previous sap harvesting season)‡					
	N=530	N=391	N=440	N=358	
Consumed *bana* protected raw sap	15 (3)	167 (43) †††	115 (26)	98 (27)	(38) ††† [29, 48]
Asked at least once about *bana* usage before sap purchase	35 (7)	148 (38) †††	119 (27)	73 (20)	(38) ††† [26, 49]
Sources of raw sap among those who drank raw sap during previous sap harvesting season‡					
Purchased from local *gachhi*/ tree owner	206 (39)	119 (30) †	169 (38)	89 (25) †††	(5) [-5, 15]
Own household trees	159 (30)	116 (30)	61 (14)	55 (15)	(-2) [-11, 8]
Gift	114 (22)	107 (27) †	110 (25)	126 (35) ††	(-4) [-13, 5]
Purchased in market/ mobile vendor	97 (18)	62 (17)	124 (28)	104 (29)	(-3) [-14, 7]
Sap purchasing behaviour among those who consumed sap from *bana*-protected trees					
	N=15	N=167	N=115	N=98	
Purchased from local *gachhi*/ tree owner	2(13)	52(31) †††	41(36)	26(27)	(27) † [3, 50]

‡ Open ended responses

¶ P-value was calculated by comparing baseline-2012 data with endline-2014 data

P-value was calculated by comparing baseline-2013 data with endline-2014 data

† P value < 0.05, †† P value < 0.01, ††† P value< 0.001; * P-values were cluster adjusted

5.4.4. *Gachhi*-reported date palm tree harvesting and *bana* use

In the "only safe sap" area, between the 2013 baseline and 2014 endline, the total number of trees harvested and those harvested for raw sap consumption significantly declined. In the control, there were fewer harvested trees than in the intervention area, but the number remained constant throughout the study. The 2014 endline data suggest a higher number of harvested trees in the "no raw sap" area than the control (Table 10).

In the "only safe sap" area, *gachhi*-reported *bana* usage increased from 11% to 90% between the 2013 baseline and 2014 endline. In the control, an unexpectedly high proportion of *gachhis* reported *bana* use during the 2013 baseline, though it decreased during the 2014 endline (66% to 57%). The increase in the intervention area was significantly higher than in the control (Table 10).

5.4.5. Observation of protected and unprotected raw sap consumption and *bana*-usage

Comparing the 2012-13 and the 2013-14 sap harvesting seasons, in the "no raw sap" area, the observed amount of raw sap collected increased (median 36 vs. 50 liters) while it decreased in the control (median 48 vs. 14 liters). The proportion of observations of at least one person consuming raw sap at the *gachhi's* place declined more in the "no raw sap" area (46% to 22%) than in the control (61% to 53%; difference in difference 95% CI -45%, 15% and p=0.30). During the 2013-14 sap harvesting season, the evaluation team observed a higher number of harvested trees in the intervention area than the control. They observed a higher percentage of *gachhis* using *banas* in the control than in intervention villages (Table 11).

Table 10: Reporting of *gachhis* on their harvested trees and *bana* usage during baseline and endline data collection from the "no raw sap," "only safe sap" and control areas, Bangladesh 2013 to 2014

Information on harvested trees and *bana* usage	**"No raw sap" intervention**[§]	**"Only safe sap" intervention area *gachhi***		**Control area *gachhi***		Difference in difference analysis "the "only safe sap" and control group [95% CI]	Difference of "only safe sap" endline and control endline 2014 [95% CI]	Difference of "no raw sap endline and control endline 2014 [95% CI]
	Endline 2014 N=150 n (%)	Baseline 2013 N=110 n (%)	Endline 2014 N=150 n (%)	Baseline 2013 N=105 n (%)	Endline 2014 N=150 n (%)			
	Number of trees harvested during previous sap harvesting season							
Median (IQR)	30 (8, 60)	65 (29, 100)	40 (19, 80) ††	7 (4, 16)	6 (2, 15)	(-29) ††	(34) ††† [26, 42]	(24) ††† [12, 36]
	Harvested trees used for raw consumption during previous sap harvesting season							
Median (IQR)	10 (2, 40)	60 (25, 100)	19 (5, 40) †††	6 (3, 10)	5 (2, 10)	(-40) †††	(14) ††† [8, 20]	(5) †† [0, 10]
	***Gachhis* used *banas* during previous sap harvesting season**							
Gachhis used *banas*	47 (31)	12 (11)	135 (90) †††	69 (66)	85 (57)	(88) ††† [73, 102]	(33) ††† [23, 43]	(-25) ††† [-38, -12]
	Mean proportion of harvested trees used for raw consumption, covered by banas, during previous sap harvesting season							
Trees always covered by *banas*	30%	7%	68%†††	60%	53%	(68) †††	(15) †††	(-23) †††

[§] No baseline with *gachhis*

[‡] Open-ended responses with multiple answers allowed, †P value < 0.05, ††P value < 0.01, †††P value< 0.001, * P values were cluster adjusted

Table 11: Observation of date palm sap harvesting, consumption and selling at *gachhis'* households at 5.25 am to 9.45 am until *gachhis* finished the raw sap selling and/or start making molasses during 2012-13 and 2013-14 sap harvesting seasons

Observation findings	¶ "No raw sap" intervention		# "Only safe sap" intervention	Control		Difference in difference analysis of the "no raw sap" and control group [95% CI]
	2012-13 sap season N=46	2013-14 sap season N=46	2013-14 sap season	2012-13 sap season N=36	2013-14 sap season N=38	
Amount of sap (in liters) collected, median (IQR)	36 (20, 56)	50 (40, 80)	39 (27, 60)	48 (24, 105)	14 (8, 40) †††¶, †††#	49††† [25, 73]
Number of trees harvested (observed), median (IQR)§	-	16 (12, 27)	16 (11, 24)		7 (3, 13) †††¶, †††#	
	Consumption and purchase of raw sap during observation					
At least one person consumed raw sap during observation	21 (46%)	10 (22%)	15 (31%)	22 (61%)	20 (53%)††¶, †#	-15 [-45, 14]
Gachhi who served sap for raw consumption used *bana*‡	-	0	8 (53%)	-	12 (60%)††¶	
Mean number of persons consumed raw sap‡ (SD) (protected or unprotected)	3.14 (2.22)	3.20 (2.20)	3.00 (2.83)	5.45 (3.78)¶††	2.95 (1.85)	1 [-0.5, 2.6]
Mean number of persons purchased raw sap and took it home‡‡(SD)	1.85 (1.21)	1.56 (1.33)	1.65 (0.93)	3.77 (2.98)¶†	2.25 (2.00)	1.4† [0.3, 2.4]
Amount of raw sap (in litres) consumed by the people at *gachhi's* household, median (IQR) (people who purchased or did not purchase)	1(1, 2)	0.88 (0.5, 1.25)	1 (0.5, 2.75)	2(1, 4)	1 (0.5, 1.75)	0.5 [-0.3, 1.3]
	Uses of *bana* on observation day					
Proportion of *gachhis* using *banas*§	-	2(4%)	15 (31%)	-	21(55%) †††¶, ††#	-

5.4.6. Association of exposure to the intervention with raw sap consumption

During the 2014 endline, more respondents from the "only safe sap" area than the "no raw sap" area reported direct exposure to any element of the intervention (41% vs. 30%) as well as more indirect exposure by learning from others (36% vs. 28%) (Appendix 4).

In the "only safe sap" area, respondents with direct exposure to at least one intervention element were more likely to report consuming raw sap from a protected source than those with no exposure (25% vs. 15%, OR 2.0, 95% CI 1.5-2.6, $p<0.001$) (Table 12). Similarly, there were noticeable differences among respondents exposed to an individual element and those with no exposure. Respondents who attended community meetings were more likely to report consuming raw sap (54% vs. 43% OR 1.5, 95% CI 1.0-2.3, $p=0.02$) than those who did not. They were also more likely to report consuming raw sap from a protected source than those who did not attend community meetings (38% vs. 16%, OR 3.1, 95% CI 2.1- 4.6, $p<0.001$). In addition, respondents who saw a poster were more likely to report consuming raw sap from a protected source than those who did not, (26% vs. 16%, OR 1.8, 95% CI 1.3-2.5, $p<0.001$). Respondents who watched the public service announcements were more likely to report consuming raw sap from a protected source than those who did not (27% vs. 18%, OR 1.7, 95% CI 1.0-2.7, $p<0.05$) (Table 12). By contrast, exposure to individual elements of the "no raw sap" intervention was not associated with reported avoidance of raw sap consumption.

Table 12: Association of exposure to interventions with reported consumption of raw date palm sap during pervious sap harvesting season in the intervention areas - endline 2014.

Exposure to intervention	"No raw sap" intervention area N=897			"Only safe sap" intervention area N=879								
				Raw sap			Unprotected raw sap			Protected raw sap		
	Consumption of raw sap n (%)	Odds ratio (95% CI)	P*	Consumption of raw sap n (%)	Odds ratio (95% CI)	P*	Consumption of raw sap from unprotected source n (%)	Odds ratio (95% CI)	P*	Consumption of raw sap from protected source n (%)	Odds ratio (95% CI)	P*
	Attended community meeting											
No	147/807 (18)	Ref		334/774 (43)	Ref		215/774 (28)	Ref		127/774 (16)	Ref	
Yes	16/90 (18)	0.97 (0.6-1.7)	0.916	57/105 (54)	1.56 (1.1-2.3)	0.025	17/105 (16)	0.50 (0.3-0.8)	0.010	40/105 (38)	3.1 (2.1-4.6)	0.000
	Saw a poster											
No	130/707 (18)	Ref		264/607 (43)	Ref		173/607 (28)	Ref		97/607 (16)	Ref	
Yes	33/190 (17)	0.93 (0.6-1.4)	0.753	127/272 (47)	1.14 (0.8-1.5)	0.402	59/272 (22)	0.70 (0.5-1.0)	0.061	70/272 (26)	1.8 (1.3-2.5)	0.000

	Saw TV public service announcement											
No	150/798 (19)	Ref		339/770 (44)	Ref		207/770 (27)	Ref		138/770 (18)	Ref	
Yes	13/99 (13)	0.65 (0.4-1.2)	0.167	52/109 (48)	1.16 (0.8-1.7)	0.442	25/109 (23)	0.81 (0.5-13)	0.362	29/109 (27)	1.7 (1.0-2.7)	0.048
	Directly exposed to any communication channel (community meeting or poster or TV PSA)											
No	114/629 (18)	Ref		224/518 (43)	Ref		153/518 (30)	Ref		76/518 (15)	Ref.	
Yes	49/268 (18)	1.01 (0.7-1.5)	0.959	167/361 (46)	1.13 (0.9-1.5)	0.346	79/361 (22)	0.67 (0.5-0.9)	0.013	91/361 (25)	2.0 (1.5-2.6)	0.000
	Indirectly exposed to the new information through word of the mouth (no direct exposure to community meeting or poster or TV PSA)											
No	111/649 (17)	Ref		250/558 (45)			145/558 (26)			111/558 (20)	Ref.	
Yes	52/248 (22)	1.29 (0.8-2.0)	0.259	141/321 (44)	0.97 (0.7-1.2)	0.783	87/321 (27)	1.1 (0.8-1.5)	0.729	56/321 (17)	0.9 (0.6-1.2)	0.314

* Cluster adjusted

5.5. Discussion

Respondents' knowledge of NiV transmission in both intervention areas markedly increased, while there was no significant increase in the control. Reported raw sap consumption declined in both intervention and control areas. Reported *bana* usage and consumption of *bana*-protected sap increased in the "only safe sap" area. Direct exposure to the intervention was significantly associated with drinking sap from a protected source in the "only safe sap" area.

The primary outcome in the "no raw sap" intervention area was to reduce raw sap consumption. We expected a 15% absolute reduction of the proportion of people reporting raw sap consumption in the intervention area, and observed a 25% absolute reduction, but we also observed an unexpected 17% reduction in the control, thus the reduction in the intervention area was not significantly different than control. Our observational data found no change in the mean number of persons consuming raw sap at the *gachhis* place nor in the amount consumed, suggesting that the decrease in the number of people reporting sap consumption may have been due to social desirability or courtesy bias (Wood, Egger et al. 2008, Cairncross, Hunt et al. 2010). We also did not find any association between exposure to the intervention and decline in raw sap consumption. Overall, the evaluation does not provide compelling evidence that the "no raw sap" message markedly reduced raw sap consumption.

In the "only safe sap" area there was no reported or observed reduction of raw sap consumption. However, reported consumption of *bana*-protected sap, inquiring about the use of *bana* prior to sap purchasing, and drinking *bana*-protected sap from local *gachhi* significantly increased in comparison to the control. Direct exposure to the intervention was associated with increased consumption of raw sap overall, but associated with increased consumption of protected sap and reduced consumption of unprotected sap.

In the "only safe sap" area, reported *bana* usage significantly increased and exceeded the 15% absolute increase projection though observed *bana* usage was much lower than that reported by *gachhis*. This higher reporting might be due to social desirability or courtesy bias. Although we interviewed three times more *gachhis* than the required

sample, there was an over 25% absentee rate among *gachhis*, which might have affected the reported results. However, in the "only safe sap" area, the observed proportion of *gachhis* using *banas* during the intervention period was about three times higher than the reported *bana* usage at baseline, suggesting that *bana* use increased because of the intervention.

The "no raw sap" message did not achieve the expected outcome. Exposure to community meetings and posters occurred one year prior to conducting the survey, probably affecting recall. Although we re-broadcast the public service announcement the second year, exposure to it, during two seasons, was not related to behavior change. This might be because a two-season intervention was not enough to eliminate an existing food behavior such as drinking raw sap. People acquire eating behaviors over a lifetime, and changing them requires alterations in habits with long term interventions (Nestle, Wing et al. 1998). Although many respondents reported ceasing drinking raw sap, continuous intervention efforts may be required to ultimately modify the raw sap consumption behavior. When raw sap is available, it might be difficult for people to abstain from drinking it (Nahar, Paul et al. 2015a) since drinking raw sap from one's own household trees remained constant among intervention and control groups over time.

Even though the "only safe sap" message was disseminated for one season, reported community and *gachhi* behaviors were in line with the expected outcomes. The intervention offered the option of continuing an existing food behavior rather than completely eliminating a preferred food item. The use of *banas* and drinking *bana*-protected sap was an already existing practice among some *gachhis*, though it may be occasional (Nahar, Sultana et al. 2010). The cultural environment where a person grows up has a strong influence on the types of choices made, and social interaction can have a great effect on people's views of foods and their eating behavior (Nestle, Wing et al. 1998, Shepherd and Shepherd 2002). Thus, having the option to drink safe sap might be more acceptable.

The "only safe sap" message is a harm-reduction approach that recognizes abstinence as an ideal outcome but accepts alternatives that reduce harm (Marlatt 1996). These

approaches have proven useful for reducing other public health risks, such as HIV transmission through needle sharing among drug users (Aspinall, Nambiar et al. 2014). Harm reduction studies demonstrate that modest changes to behaviors are easier to achieve than more substantive changes (Luby, Hoodbhoy et al. 2005, Plautz and Meekers 2007, Kirby 2008). We know that some people still drink raw sap even after learning about the risk of NiV (Nahar, Paul et al. 2015a). Asking them to drink only safe sap is less demanding than asking them to stop drinking sap altogether (Luby, Rahman et al. 2006). It also targeted *gachhis* who are the source of sap and could be held responsible for NiV transmission, giving them a safe option to provide sap. Thus, disseminating an "only safe sap" message may be a more pragmatic strategy to reduce the risk of NiV transmission.

Our study has limitations. Neither the community nor our evaluators were blinded to the intervention. Our primary outcome was measured through reported behavior. Although social desirability bias may have induced respondents to under-report their sap consumption practice and over-report *bana* usage (Wood, Egger et al. 2008, Cairncross, Hunt et al. 2010), there is little reason to expect more social desirability bias in the "only safe sap" than in the "no raw sap" area. To interpret our reported data, we looked at changes in knowledge and observation data though the number of observed outlets was small and the presence of our observer might have altered some behavior. Nevertheless, the association between exposure to specific elements of the intervention and reported safe sap behaviors, suggests behavior change resulted from the "only safe sap" message but not from the "no raw sap" message.

Our intervention and control areas were not comparable in terms of number of date palm trees harvested and pre-existing behaviors related to *bana* usage. Without any intervention, raw sap consumption decreased among community respondents in the control area, and this decline remains unexplained. There might be other characteristics specific to the districts that contributed to different practices in different years, rather than the intervention. However, the changes in the "only safe sap" area likely resulted from the intervention, because of the association between exposure and behaviors and the significant changes identified in the difference in difference analysis between intervention and control groups on a number of outcomes.

We did not fully understand why a high proportion of *gachhis* from the control area used *bana* at baseline and endline. Perhaps, since *gachhis* from the control area harvested a small number of trees, they have less work related to tree harvesting and more time to make *banas*. In our earlier work, even without intervention, some *gachhis* reported to occasionally using *banas* to collect more, cleaner sap (Nahar, Sultana et al. 2010, Nahar, Mondal et al. 2014). Other *gachhis* recalled their previous experience seeing colleagues using *banas* more frequently when harvesting fewer trees (Nahar, Sultana et al. 2010, Nahar, Mondal et al. 2014). In the "only safe sap" area, the proportion of *gachhis* that used *banas* increased, thus increasing their workload, which may have resulted in the significant decline in the number of harvested trees after the intervention. Better understanding of control area *gachhis'* motivation to use *banas* without any intervention might provide useful insights to support the expansion of this intervention strategy.

Our measurements were unable to confirm if people reporting drinking protected sap, actually consumed protected sap. Their ability to reliably assess whether the sap was *bana*-protected or not likely depends on how well they know the *gachh*i. Future studies could investigate the effect of the message to ask for *bana*-protected sap from local *gachhis* (Table 2), and to observe actual use of *banas*.

The "only safe sap" message resulted in changes in reported behavior that may reduce the risk of NiV spillovers, thus, this intervention could be further promoted and evaluated. Prospective efforts to track raw sap consumption practices, and explore year-to-year variation in Bangladesh, would be particularly useful to guide government policy.

5.6. Acknowledgements

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6. A large-scale behaviour change intervention to prevent Nipah transmission in Bangladesh: Components and costs

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6.1. Abstract

Background

Nipah virus infection (NiV) is a bat-borne zoonosis transmitted to humans through consumption of NiV-contaminated raw date palm sap in Bangladesh. The objective of this analysis was to measure the cost of an NiV prevention intervention and estimate the cost of scaling it up to districts where spillover had been identified.

Methods

We implemented a behavior change communication intervention in two districts, testing different approaches to reduce the risk of NiV transmission using community mobilization, interpersonal communication, posters and TV public service announcements on local television during the 2012-14 sap harvesting seasons. In one district, we implemented a "no raw sap" approach recommending to stop drinking raw date palm sap. In another district, we implemented an "only safe sap" approach, recommending to stop drinking raw date palm sap but offering the option of drinking safe sap. This is sap covered with a barrier, locally called *bana*, to interrupt bats' access during collection. We conducted surveys among randomly selected respondents two months after the intervention to measure the proportion of people reached. We used an activity-based costing method to calculate the cost of the intervention.

Results

The implementation cost of the "no raw sap" intervention was $30,000 and the "only safe sap" intervention was $55,000. The highest cost was conducting meetings and interpersonal communication efforts. The lowest cost was broadcasting the public service announcements on local TV channels. To scale up a similar intervention in 30 districts where NiV spillover has occurred, would cost between $2.6 and $3.5 million for one season. Placing the posters would cost $96,000 and only broadcasting the public service announcement through local channels in 30 districts would cost $26,000.

Conclusion

Broadcasting a TV public service announcement is a potential low cost option to advance NiV prevention. It could be supplemented with posters and targeted interpersonal communication, in districts with a high risk of NiV spillover.

Key words

Nipah virus infection, Behavior change communication intervention, prevention, intervention cost, Bangladesh

6.2. Background

Nipah virus (NiV) infection is a fatal emerging zoonosis that can transmit from bats to humans and can cause further person-to-person transmission (Gurley, Montgomery et al. 2007, Luby, Hossain et al. 2009, Homaira, Rahman et al. 2010, Sazzad, Hossain et al. 2013). In Bangladesh, several NiV outbreaks have been identified since 2001, and raw date palm sap consumption has been repeatedly implicated as the pathway of transmission from bats to humans (Luby, Rahman et al. 2006, Rahman, Hossain et al. 2012). Raw sap is collected during cold months, from November to March, by shaving the bark near the top of the date palm tree (Luby, Rahman et al. 2006, Nahar, Sultana et al. 2010). During sap collection, bats often visit date palm trees and contaminate sap with their saliva and urine (Nahar, Sultana et al. 2010, Khan, Gurley et al. 2012). Interrupting bat-to-human transmission may reduce the risk of a potentially large outbreak.

Based on previous pilot studies on interrupting bats access to sap (Khan, Gurley et al. 2012, Nahar, Mondal et al. 2013, Nahar, Mondal et al. 2014), and on the Government of Bangladesh's recommendation to abstain from drinking raw sap, we developed and implemented a behavior change communication intervention using two different approaches to reduce the risk of NiV transmission. After the intervention, local residents' knowledge of NiV increased, and people reported changing their behavior to reduce the risk of NiV transmission through date palm sap (Nahar, Paul et al. 2015b). Thus, understanding the intervention development, process and logistics will help plan scaling it up. Calculating the approximate cost of the intervention, and the proportion of people to be reached, is useful to make investment decisions (Victora, Hanson et al.

2004, Lim, Gaziano et al. 2007, Muangchana, Riewpaiboon et al. 2012) between potential interventions to prevent not just NiV, but other emerging zoonoses.

The objective of our paper is to describe and calculate the cost of an already implemented behavior change communication intervention, and estimate the cost of scaling it up to districts where NiV spillover was identified in Bangladesh, using risk-based scenarios.

6.3. Methods

6.3.1. Study sites

We developed a behavior change communication intervention using two separate approaches, targeting rural areas from two NiV endemic districts: Rajbari and Faridpur, where date palm trees are harvested and residents drink raw date palm sap (Figure 3). We selected these districts because both have been repeatedly affected by NiV outbreaks, both are from the same geographical region, neighboring each other, and have similar raw sap collection and consumption practices. Within those districts, we selected two sub-districts that do not border each other to avoid interference between the interventions. The population of Rajbari and Faridpur study sites was approximately 361,000 and 335,000 respectively.

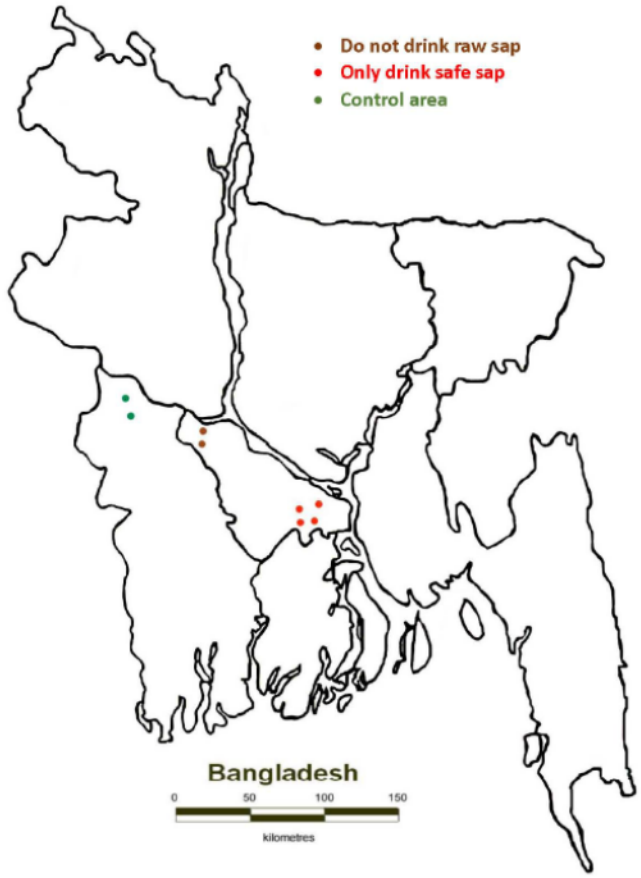

Figure 3: Map of Bangladesh showing the "no raw sap" and the "only safe sap" Nipah prevention intervention areas

6.3.2. The intervention and materials development

Following the Government of Bangladesh's recommendation of abstaining from drinking raw sap, we developed an intervention discouraging people from drinking raw date palm sap in Rajbari District, herein referred to as the "no raw sap" intervention. Some people continued to drink raw sap though they were aware of the risk (Nahar, Paul et al. 2015a), thus we developed an "only safe sap" intervention in Faridpur District, discouraging drinking raw sap but offering the option of drinking sap protected by a skirt-like barrier locally called *bana* (Image 10). During collection, *banas* can stop bats from accessing and contaminating the sap with NiV (Nahar, Sultana et al. 2010, Khan, Gurley et al. 2012).

Image 10: *Bana* to stop bats access to the raw date palm sap to prevent Nipah virus infection in the "only safe sap" area

We worked with a Bangladeshi communication organization to develop posters, calendars, yearly planners, stickers, sweatshirts and TV public service announcements. Our qualitative research data collection team pre-tested the materials conducting focus

group discussions with audiences similar to our target audience. Based on these results, we revised and fine-tuned the messages and illustrations. We also developed training guides for the staff implementing the intervention. The communication organization designed and printed the final training guides.

We developed the "no raw sap" intervention, including production of the communication materials, from June to October, 2012 and the "only safe sap" intervention from August to September, 2013 (Figure 4).

6.3.3. NGO selection

We visited local NGOs from both districts to assess their experience and capability to implement the interventions in the selected sub-districts. Using a competitive bidding process, we selected one local NGO from each district. We assessed their experience with similar interventions, knowledge of the areas to be covered and qualifications of their key personnel. We also compared the size of the organizations, as an indicator of their capacity to implement the intervention, and the budget required to carry it out.

The selected NGOs visited villages and talked to villagers to get an estimate on the number of households, and identify opinion leaders and local sap harvesters (*gachhis*). We provided training to the NGOs' staff on interpersonal communication, on organizing and conducting meetings with opinion leaders and community residents, and on key intervention messages.

6.3.4. The intervention implementation

In both intervention areas, the NGOs conducted one opinion leaders and one community meeting per 500 households approximately. Prior to conducting the meetings, the NGOs affixed NiV prevention posters in public places such as health centers, bazaars, and areas with heavy traffic of people. We provided calendars or yearly planners, with NiV prevention messages, to the opinion leaders, and broadcast-quality public service announcements, in the form of DVDs, to the local TV channels. In the "only safe sap" area, the NGO trained *gachhis* on making *banas*, and encouraged using them on trees used for raw sap consumption. We also provided sweatshirts as an incentive to those *gachhis* who made and used *banas*.

Date palm sap is harvested during cold months from November to March (Nahar, Sultana et al. 2010). We implemented a full "no raw sap" intervention from December 26, 2012 to March 29, 2013 in 342 villages in Rajbari District (Figure 4). During the next sap harvesting season, from November 16, 2013 to January 31, 2014, we only broadcast the TV public service announcement. We implemented a full "only safe sap" intervention from October 3, 2013 to January 31, 2014 in 381 villages in Faridpur District, including a *gachhi* training component. We started the "only safe sap" intervention slightly before the sap season because we needed to train *gachhis* on making and using *banas* before they started collecting sap.

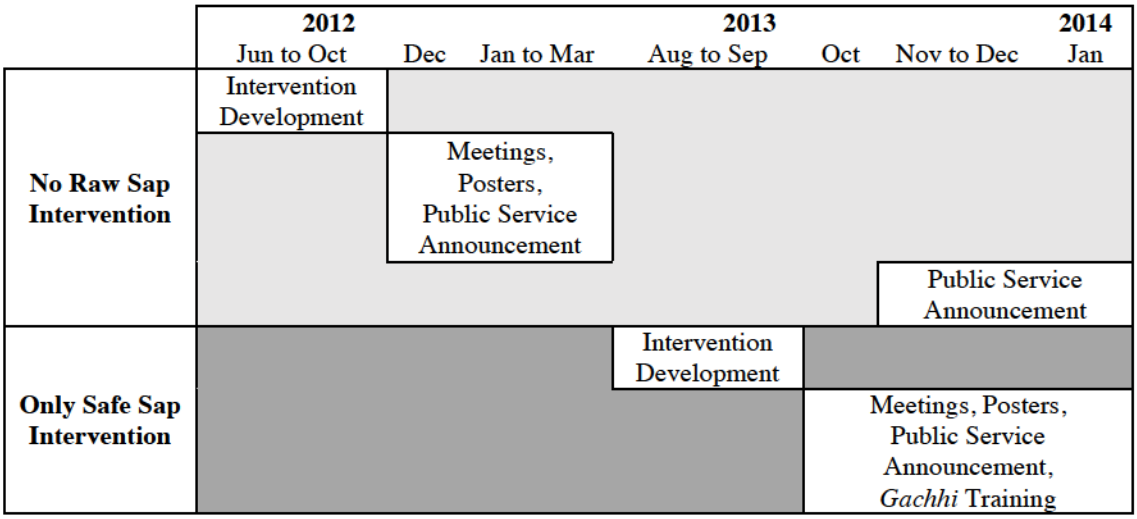

Figure 4: "No raw sap" and "Only safe sap" intervention development and implementation to reduce the risk of Nipah virus transmission in Bangladesh during the 2012-13 and 2013-14 date palm sap harvesting seasons

6.3.5. Assessment of the intervention implementation

During the intervention implementation period, we received NGO weekly reports with photographs of the meetings. Our monitoring team visited 143 randomly selected villages to confirm placement of at least one poster, watched the TV public service announcements at least in one tea stall, and observed one meeting per village incognito. Tea stalls with a television set exist in almost every village, and serve as gathering places where men drink tea, watch television and chat with others. Since most of the villagers do not have television at home, this communication channel was used to target men. We also recruited 15 tea stalls with television access in each study area to monitor

the number of times the TV public service announcement was broadcast daily. We collected written weekly reports from those tea stalls, indicating dates and times when the announcements were broadcast.

After the intervention, during April-May 2014, our quantitative data collection team interviewed 900 adult male and female respondents from 75 randomly selected villages from each "no raw sap" and "only safe sap" district. We described the sampling procedure for this study elsewhere (Nahar, Paul et al. 2015a). Our data collection team asked about NiV knowledge, sap consumption behavior, use of *banas* and exposure to the interventions. In this manuscript, we only present data about the respondents' direct exposure to the intervention.

6.3.6. Assessment of the cost of developing and implementing the intervention

We used an activity-based costing approach to compare health interventions (Fiedler, Villalobos et al. 2008, Murray, Tornambe et al. 2011, Muto, Tani et al. 2011, Rajabi and Dabiri 2012, Stefano and Filho 2013). We identified, costed out, and quantified all development and implementation activities. We reviewed timelines and deliverables to confirm activities performed, transport requisition emails, and budgets submitted to the donor. We calculated the cost per activity performed using person time, with the exception of NGO activities that were calculated using per activity cost instead of person time cost.

We separated the start-up cost from the intervention implementation cost (Table 13). The start-up cost covered the development of materials before the implementation, from the period of time between the decision to implement, to the start of its delivery to the beneficiaries (Johns, Baltussen et al. 2003). Because we developed some of the materials for both interventions, we were not able to completely separate the cost of developing all the materials for each intervention. Thus, we could not add the start-up cost to the implementation cost to determine the total cost per intervention.

Table 13: Description of activities and the cost of intervention development and implementation in Rajbari District 2012-14 and in Faridpur District 2013 14, to reduce the risk of Nipah virus infection in Bangladesh

Activities		**Cost included**
Intervention development /start-up cost	Concept note and protocol development	1. Staff cost - international and local experts 2. Cost of transportation 3. Cost of materials development, testing and production 4. Cost of venue for training the trainers
	Explore communication channels	
	Districts-selection field visit	
	NGOs selection	
	Communications organization selection	
	Intervention materials development	
	Materials testing	
	TV campaign production	
	Materials revisions	
	Training of trainers	
Intervention implementation	Production of print materials, stickers and sweatshirt	Production cost
	Copies of the TV materials	DVD cost
	Training of NGO staff	Cost of training (venue, per-diem, food and transportation of trainees). For *bana*-making training session; cost of bamboo, *bana*-making trainer
	Opinion leaders and community meetings, placement of poster, *gachhi* meetings and incentive program	Cost of NGO field implementation
	TV broadcasting	Cost of cable operators
	TV monitoring	Cost of monitoring tea stalls
	Intervention monitoring	Cost of the monitoring team

The implementation cost included NGO cost, mass media dissemination expenditures (local TV channel, DVDs copies and printing posters) and intervention monitoring cost. The cost of training NGO staff included training manuals, personnel, snack allowance, venue, electricity, photocopies, and transportation. In the "only safe sap" area, we also included the cost of bana-making materials and the allowance and transportation cost of a bana-making expert as part of the NGO staff training cost.

The cost of training the NGO staff and printing the materials would be incurred before any future implementation, thus we included them in the implementation cost.

We calculated the amount of money the NGOs spent as cost of the meetings and gachhi training. Since NGO staff affixed posters while visiting the villages for meeting purposes, the NGOs did not include the cost for placing posters separately in their reporting. To estimate this cost, we assumed that one person could visit four villages per day, to affix 10 posters per village, and estimated the cost of affixing one poster based on the daily salary, meal allowance and transportation costs. We deducted these costs from the meetings cost to calculate the cost per meeting. We calculated costs in US dollars, using a rate of 82.34 Bangladeshi takas per US$1, the conversion rate used on the original budget. We did not include the cost of the research study in this analysis.

6.3.7. Data analysis

We calculated the start-up cost first, followed by the implementation cost of the interventions. We calculated cost per meeting by dividing the total cost to conduct all meetings, provided by the NGOs, by the total number of meetings conducted; and the cost per *gachhi* training by dividing the total training cost provided by the NGOs by total number of *gachhis* trained.

From our survey data, we calculated the percentage of people directly reached or exposed to each communication channel used during the intervention (Nahar, Sultana et al. 2015). We found that a lower percentage of respondents from the "no raw sap" area reported that they were directly exposed to the intervention than the respondents from the "only safe sap" area (30% vs. 41%). Also a lower percentage of respondents reported exposure to each intervention component: TV public service announcement (11% vs. 12%), saw a poster (21% vs. 31%) and attend a meeting (10% vs. 12%) in the "no raw sap" area than the "only safe sap" area (Nahar, Sultana et al. 2015). We calculated the cost per person reached per channel by dividing the implementation cost by the total population (361,000 in the "no raw sap" area and "335,000 in the "only safe sap" area) times the percentage of people reached per channel.

$$\begin{matrix} Cost\ per\ person \\ reached\ per\ component \end{matrix} = \frac{Total\ implementation\ cost}{Total\ population\ x\ percentage\ of\ people\ reached}$$

We estimated the future start-up cost and intervention implementation cost in all 30 districts where at least one NiV spillover has been identified in the past. We added person-day cost for activities, including the cost of revising the intervention and materials, identifying cable operators, cost for transportation and phone communication.

Using different risk-based scenarios in all 30 affected districts where 117 NiV spillovers were identified from 2001 to 2015 (unpublished NiV surveillance data), we estimated future implementation costs based on the number of spillovers per district. A spillover is defined as at least one identified NiV case in the district and we separated the districts into three categories:

- six districts with six or more spillovers (48% of all spillovers)
- thirteen districts with two to five spillovers (43% of all spillovers)
- eleven district with one spillover, (9% of all spillovers)

We estimated the implementation cost at the district level, based on implementation expenditures during the 2012-2014 interventions.

To estimate the cost of the meetings for a future intervention, we estimated the number of rural households in all sub-districts using census data (Bangladesh Bureau of Statistics 2012). We projected conducting one opinion leaders meeting and one community meeting per every 500 rural households, using the cost-per-meeting from the "only safe sap" area. We projected the approximate number of *gachhis* using NGO data from the "only safe sap" area (3 *gachhis* per village or within 500 households). To estimate the cost of training the *gachhi*s we used the per-*gachhi* training cost from the "only safe sap" intervention. We assumed two cable operators per sub district to estimate the cost of broadcasting the TV public service announcement.

6.4. Results

6.4.1. Start-up cost of the 2012-2014 intervention

We incurred most of the start-up costs developing the intervention, including expenditures on national and international experts and local staff, materials' pre-testing,

revisions and production, districts and NGO selection, and training of trainers (Table 14). The second highest cost was the production of the TV public service announcements, followed by the cost of creating and producing the other communication materials.

6.4.2. Intervention activities

The NGOs conducted 281opinion leaders and 304 community meetings in the "no raw sap" area, and 381 opinion leaders and 220 community meetings in the "only safe sap" area. They affixed 3,000 posters in the "no raw sap" area and 7,000 posters in the "only safe sap" area. Local channels broadcast the TV public service announcements 5 times daily. In addition, in the "only safe sap" area, the local NGO conducted 1,160 *gachhi* training sessions on how to make and use *banas*.

6.4.3. Intervention implementation cost incurred during 2012-2014

Our implementation cost was lower in the "no raw sap" intervention than in the "only safe sap" intervention ($30,000 vs. $55,000) (Table 15). The cost of the intervention components, broadcasting the TV public service announcement ($313 vs. $674), promoting posters ($1,305 vs. $2,930) and conducting community meeting costs ($22,243 vs. $30,135) was lower in the "no raw sap" intervention than in the "only safe sap" intervention (Table 15).

The cost per person directly reached by at least one intervention component was also lower in the "no raw sap" area than in the "only safe sap" area (28 cents vs. 40 cents).

Table 14: Start-up cost (preparation cost) for intervention development, materials development, production of materials and training of trainers calculated using activity-based costing of an intervention to reduce the risk of Nipah virus infection conducted in two districts of Bangladesh in 2012-13 and 2013-14

Activities		**Total (US$) ***
Intervention development	Staff cost international experts	$131,000
	Staff cost local experts	$36,050
Cost of creating the campaign and preparing materials for production	Training manuals, TV public service announcements, posters, calendar, yearly planner, stickers, sweat shirts	$28,850
Materials pre-testing	FGDs with local community. Materials were tested twice for the "no raw sap" intervention to get the Government approval and materials were tested once for the only safe sap intervention	$1,893
TV materials production**	6-minute docudrama and 3-minute TV public service announcement for the "only safe sap" intervention.	$39,940
Last minute revision of the intervention materials	3-minute TV public service announcement for the "no raw sap" intervention, new poster, revised calendar and revised training manuals	$9,000
Training of trainers	International expert trained 7 local experts to train the NGO staff	$3,342
Field visit for districts and NGO selection	Transportation	$5,716
Grand total		$255,791
Grand total in Bangladeshi taka (BDT)		21,061,831

* 1US$=82.34

** The TV public service announcement cost includes initial production and two revisions. The cost of both TV public service announcements are combined because the original shooting included footage for both versions of the TV public service announcements

The cost to reach one person per communication channel was lower in the "no raw sap" area than in the "only safe sap" area: TV public service announcement was 0.8 cents vs. 1.7 cents, poster was 1.7 cents vs. 2.8 cents, and community meetings was 62 cents vs. 75 cents.

The cost of the *gachhi* training program in the "only safe sap" area, including the incentive of providing a sweatshirt to those observed using *banas* during follow up

visits, was $15,000. The per *gachhi* cost with incentive was $13. With no incentive was $7.6 (Table 15).

6.4.4. Estimated cost of the NiV-affected region for a future intervention

To scale up the intervention, we estimated the start-up cost at $60,000 (Table 16). Our future estimated implementation cost of meetings, posters and the public service announcement was the same for both the "no raw sap" and the "only safe sap" intervention (Table 17). However, the *gachhi* training component increased the cost of the "only safe sap" intervention. Thus, the implementation cost of a future intervention covering 30 districts would be $3.5 million using an "only safe sap" approach, and $2.6 million using a "no raw sap" approach (Table 17). The cost of printing and affixing the posters in 30 districts would be $96,000. Broadcasting the TV public service announcement in 30 districts would cost $26,000.

To implement an "only safe sap" intervention with community meetings, *gachhi* training, poster and the TV public service announcement in the six districts with 48% of all spillover would cost $715,000. To implement it in the second most affected area, thirteen districts with 43% of all spillover, would cost $1.5 million and in eleven districts with 9% of all spillover, would cost $1.3 million.

To implement a full "no raw sap" intervention with community meetings, posters and the TV public service announcement in the six most affected districts would cost $536,000. In the second most affected thirteen districts it would cost $1 million and another $970,000 to implement it in the other 11 districts.

Table 15: "No raw sap" and "only safe sap" intervention cost, implemented in 2012-2014 in Rajbari District and 2013-14 in Faridpur District to reduce the risk of Nipah virus infection, Bangladesh

Component	"No raw sap" intervention (population: 361,000)			"Only safe sap" intervention (population: 335,000)		
	Description	Total cost (US$)	Cost per person reached (US$)	Description	Total cost (US$)	Cost per person reached (US$)
TV public service announcement						
Cable operator cost	1 operator in 2 sub districts at $154 each season for two seasons	$308		11 operators in 2 sub districts at $59.5 per operator for one season	$654	
DVDs cost	5 DVD, per DVD $1	$5		20 DVD, per DVD $1	$20	
Total cost of TV public service announcement	11% people directly saw the TV public service announcement	$313	$0.008	12% people directly saw the TV public service announcement	$674	$0.017
Poster						
Printing cost	3000 posters at $0.15 per poster	$450		7000 posters at $0.119 per poster	$830	
Affixing cost	3000 posters at $.30 per poster	$900		7000 posters at $.30 per poster	$2,100	
Total cost of poster	21% people saw a poster	$1,305	$0.017	31% people saw a poster	$2,930	$0.028
NGO training						
Staff training	45 staff per training session, at $2,674 per training session	$2,674		56 staff per training session, at $2,674 per training session	$2,575	
Training manuals	1000 training manuals at $0.13 per manual	$125		1000 training manuals at $0.275 per manual	$275	
Total cost of NGO training		$2,799			$2,850	

Meeting cost						
Meetings	585 meetings at $37.48 per meeting	$21,928		601 meetings at $48.87 per meeting	$29,374	
Calendars/yearly planner	1500 yearly planner at $0.21 per calendar	$315		5000 calendar at $0.152 per calendar	$761	
Total cost of meetings	10% people attended meeting	$22,243	$0.62	12% people attended meeting	$30,135	$0.75
Intervention monitoring cost						
TV public service announcement monitoring	15 tea stalls per district at $1.3 per tea stall for two seasons	$40		15 tea stalls per district at $1.3 per tea stall for one seasons	$20	
Meeting monitoring	4 persons at $ 865per per person	$3,460		4 persons at $ 865per per person	$3,460	
Total cost of intervention monitoring		$3,500			$3,480	
Total cost with TV public service announcement, poster, meeting and monitoring (or a "no raw sap" intervention)	30% people directly reached the intervention	$30,205	$0.28			
***Gachhi* component**						
Training				1,160 *gachhis* at $7.6 per *gachhi* training	$8,846	
Stickers to identify *bana* protected sap				6,000 stickers, per $0.035	$210	
Incentive for *gachhis* who used *bana*				1,100 *gachhis* at $5.8 per sweatshirt	$6,346	
Total cost of *gachhi* component				1,160 *gachhis* reached	$15,402	$13
Grand total (with TV public service announcement, poster, meeting monitoring and *gachhi* training for an "only safe sap" intervention)				41% people directly reached the intervention	$55,471	$0.40
Grand total in Bangladeshi taka (BDT)		2,4487,080			4,567,564	

Table 16: Start-up cost to prepare a Nipah prevention intervention covering 30 Nipah-affected districts with at least one Nipah spillover, Bangladesh

Activities	**Person**	**Person-days**	**Estimated cost**
Developing intervention design	NiV and research and intervention expert (international)	10	$10,000
Contribute to intervention design and provide logistical support from the Government	NiV expert and intervention coordinator (from government)	10	Government contribution
Revising the intervention	Behaviour change communication experts	20	$20,000
To write protocol and review NGO proposals	Assistant scientist	44	$4,689
To identify and communicate with NGO and TV channel operators	Research officer*	154	$6,303
	Field Transportation**	140	$3,401
Revising the intervention materials (poster, calendar, PSA, training guide)	Revision of the intervention materials (if needed)		$15,000
Cost of phone communication	(Communicating local NGO, local TV channels)		$448
Total			$59,841
Total in Bangladeshi taka (BDT)			4,927,308

*At $609 per month salary, at $15 per diem per day

** At 2000 taka (approximately $24) per day to rent a motor cycle to explore NGO and TV channels, about 4 days in one district and half day inter-district travel

Table 17: Nipah prevention intervention implementation cost covering 30 Nipah-affected districts with at least one Nipah spillover, Bangladesh

Intervention element		**NiV spillover 6 or more (Total 56 spillover)**	**NiV spillover 2 to 5 (Total 50 spillover)**	**NiV spillover 1 only (Total 11 spillover)**	**NiV spillover all (Total 117 spillover)**
Component	Description	6 districts, consisted of 47 sub-districts with a rural population of 2,434,793 Cost (US$)	13 districts, consisted of 90 sub-districts with a rural population of 4,947,566 Cost (US$)	11 districts consisted of 76 sub-districts with a rural population of 4,276,269 Cost (US$)	30 districts with 213 sub-districts with a rural population of 11,658,628 Total cost (US$)
TV public service announcement					
Cable operator cost	2 operators per sub district at $60 each	$5,640	$10,800	$9,120	
DVD	2 per cable operator at $1 per DVD	$188	$360	$304	
Total cost of TV public service announcement		$5,828	$11,160	$9,424	$26,412
Poster					
Printing cost	10 posters per every 500 households at $0.11 per poster	$5,357	$10,885	$9,408	$25,650
Affixing cost	10 posters per every 500 households at $.30 per poster	$14,610	$29,685	$25,659	$69,954
Total cost of poster		$19,967	$40,570	$35,067	$95,604

NGO training					
Staff training	Approximately 1 NGO to cover two sub-districts, 3 staff from one NGO to train and maximum 50 staff per training session, at $2,850 per training session	$5,700	$8,550	$8,550	
Training manuals	60 training manuals per training session at $0.28 per manual	$34	$50	$50	
Total cost of NGO training		$5,734	$8,660	$8,660	$23,054
Meeting cost					
Meetings	1 opinion leader and 1 community meeting per 500 households at $50 per meeting	$487,000	$989,500	$855,300	
Calendars	10 per opinion leader meeting at $0.15 per calendar	$7,305	$14,843	$12,830	
Total cost of meetings		$494,305	$1,004,343	$898,130	$2,396,778

Intervention monitoring cost					
TV public service announcement monitoring	10 tea stalls per district at $1.3 per tea stall	$611	$1,170	$988	
Meeting monitoring	1 person in 1 district at $609 per month, at $15 (1200 taka) per diem per day, at $24 (2,000 taka) transport per day, $1.2 (100 taka) per day phone bill	$9,665	$20,942	$17,718	
Total cost of intervention monitoring		$10,276	$22,112	$18,706	$51,094
Total cost with TV public service announcement, poster, meeting and monitoring for a "no raw sap" intervention		$536,110	$1,086,845	$969,987	2,592,942$
Gachhi* training					
Training	3 *gachhis* per 500 households at $7.6 per *gachhi* training	$111,036	$225,606	$195,008	
Incentive	80% of *gachhis* at $5.8 per sweatshirt	$67,790	$137,738	$119,057	
Total cost of *gachhi* training		$178,826	$363,344	$314,065	$856,235
Grand total (with TV public service announcement, poster, meeting monitoring and *gachhi* training for an "only safe sap" intervention)		$714,936	$1,450,189	$1,284,052	$3,449,177
Grand total in Bangladeshi taka (BDT)		58,867,830	119,408,562	10,572,884	284,005,234

*We can get the cost of the "no raw sap" intervention excluding the cost of "*gachhi* training" component from the calculation.

6.5. Discussion

We spent $30,205 implementing the "no raw sap" intervention and $55,471 on the "only safe sap" intervention. To scale these interventions up to 30 districts in Bangladesh where human infections with NiV have been identified, we estimated a cost of $2.6 million US$ for the "no raw sap" and $3.5 million US$ for the "only safe sap" intervention. NiV usually affects impoverished rural communities in Bangladesh, thus, affected families often experience a severe social and financial crisis (Roy, Kane et al. 2001, Ronsmans, Chowdhury et al. 2010). NiV kills people and leaves survivors with permanent neurological sequelae, similar to those experienced by some survivors of Japanese encephalitis (Solomon, Dung et al. 2000, Sejvar, Hossain et al. 2007). Sixty-one percent of NiV cases affected males with a mean age of 27 (Luby, Hossain et al. 2009) who could be the main wage earners of the family. Most died (Luby, Hossain et al. 2009), and those that survived could not continue to work due to the neurological effects of NiV. In addition, NiV is a disease that requires special care. Hospitalization and illness episodes can last a week (Hossain, Gurley et al. 2008). The financial burden associated with hospitalization translates into reduced monthly food and children education expenditures, having to borrow money, taking loans with high interests, and selling assets (Alamgir, Naheed et al. 2010, Haque, Budi et al. 2013, Bhuiyan, Luby et al. 2014). Prevention could reduce the risk of disease transmission as well as save poor families from social degradation.

Despite the severity of Nipah illness, since an average of fewer than 20 NiV cases are identified annually in Bangladesh (Luby, Hossain et al. 2009), the cost of NiV prevention is unlikely to meet the traditional criteria for cost-effective interventions to prevent cases (WHO 2003). However, in addition to causing sickness and death, outbreaks have social consequences including fear, social unrest, violence and economic loss (Strong 1990, McGrath 1991, Kinsman 2012, UNDG 2015). For diseases with moderate to high perceived severity, such as pandemic influenza, SARS or Ebola, investing and intervening earlier in the outbreak can be cost effective (Fast, Gonzalez et al. 2015). NiV is a deadly disease that can transmit from person to person and represents a global pandemic threat (Daniels, Halpin et al. 2007, Luby 2013). Estimating NiV prevention costs is of interest to local and global health communities, helping to make informed decisions on funding interventions to prevent this disease. If

we prevent a large high-mortality NiV pandemic, an effective intervention would be remarkably cost-efficient.

Disaster preparedness reduces the impact of disasters and associated costs, compared to a scenario without preparedness (Kunz, Reiner et al. 2014). Initiatives to mitigate low probability, high catastrophic risks are not uncommon. NASA spends millions of dollars each year to track asteroids, though chances of dying from an asteroid impact are very low for the average person in the United States (Chapman and Morrison 2003). Investing in active surveillance activities for zoonotic infections, implementing effective ecological health interventions, improving modeling capabilities, increasing evaluations of health systems and public health needs and policies, and implementing better risk communication can improve the preparedness to respond to emerging infectious diseases (Jacobsen, Aguirre et al. 2016). For example, Taiwan established a nationwide emergency department, based on a syndromic surveillance system, that collaborated with 189 hospitals for better public heath response to improve their pandemic flu preparedness and disease control capabilities (Wu, Shih et al. 2008). Similarly, investing in preventing NiV could provide an important benefit.

Health intervention studies from Bangladesh, focusing on cost, find some similarities with our study (LeFevre, Shillcutt et al. 2013, Sarker, Ahmed et al. 2013, Islam, Sarker et al. 2015). A study on neonatal and child health reported a lower cost per person reached through local TV channels than other intervention components (Sarker, Ahmed et al. 2013). In our intervention, the cost of interpersonal communication was around 44 times higher than broadcasting the televised public service announcement in the "only safe sap" area. The estimated cost of posters was also low and could be integrated in future interventions.

Findings from our trial suggested more behavior change resulted from a one season "only safe sap" intervention than a two-season "no raw sap" intervention (Nahar, Sultana et al. 2015). This could be because the "only safe sap" intervention offered the option of drinking safe sap by promoting the use of *banas* among *gachhis*, an already existing behavior (Nahar, Sultana et al. 2010) that still allowed people to enjoy drinking sap. The *gachhi* training component might also have contributed to increased exposure

to the intervention. Although its estimated scale up cost was higher than the "no raw sap" intervention, for upcoming seasons, the "only safe sap" intervention should be considered.

Spending US$ 3.5 million annually on an "only safe sap" intervention would be prohibitively costly for a low-middle income country like Bangladesh that currently spends only $30.83 per capita per year for healthcare (World Bank 2016) and 2.8% of gross domestic product in total health expenditures (WHO 2016). The high cost of the meetings used in this intervention makes it impossible to scale up and sustain this intervention without external funding. Reducing meetings and interpersonal communication would reduce costs and so increase the feasibility of scaling it up. We could achieve a lower cost intervention by including community health workers (Ahmed, Alam et al. 2015) and health workers from the Expanded Program of Immunization (EPI), as well as health workers from NGOs such as BRAC (Rahman, Jhohura et al. 2015, Singh, Negin et al. 2015). They could conduct meetings in the areas immediately surrounding their offices, affix posters, provide leaflets, and disseminate messages to people receiving their services during the sap harvesting season, adding a minimal cost. In addition, eliminating the *gachhi* incentive for using *banas* would reduce the cost of the *gachhi* intervention by more than one third.

Our intervention findings provide a framework to calculate costs of a future intervention to prevent NiV. However, the following limitations of our findings require consideration. We did not include the intervention impact data in the results of this cost manuscript, therefore, we cannot calculate cost-effectiveness. The complexity of the impact data required a separate manuscript to be properly presented. Nevertheless, this cost analysis, conducted from a provider's perspective, enables future providers to weight the costs of taking on this intervention against those of other interventions (Batura, Pulkki-Brannstrom et al. 2014). Better understanding of the cost, from intervention providers and recipients, would provide an understanding of cost-related potential barriers and obstacles to implementing the intervention.

Although we calculated the separate cost of each intervention component, we cannot interpret the separate impact of each component. Since communication campaigns

often rely on a synergistic effect, all of its components may need to run in parallel for maximum impact (Lipovsek, Mukherjee et al. 2010, Krenn, Cobb et al. 2014, Koenker, Kilian et al. 2015). Therefore, although deploying only a single component markedly reduces cost, this body of work does not provide direct evidence that the standalone components will alter behavior.

To reduce costs, we proposed engaging government and other health workers to conduct meetings within their locality. Since, they already have other tasks to accomplish, small-scale pilot efforts could help identify practical strategies to integrate NiV prevention messages into health worker activities. The government already broadcast the "no raw sap" public service announcement during the 2015-16 season. Continuing to measure the prevalence of raw sap consumption as these messages are disseminated more widely can provide useful guidance on adjusting interventions and messages going forward.

6.6. Conclusion

Exploring low cost strategies to communicate prevention messages in frequently affected districts, such as broadcasting the public service announcement on local channels, combined with health workers visiting communities to spread messages and affix posters in districts with high risk of NiV spillover, may be an effective way to reduce the risk of NiV. Continuous monitoring efforts may help to further develop and refine the intervention components for more effective communication.

6.7. List of abbreviations

NiV: Nipah virus infection
NGO: Non governmental organization
TV: Television
DVD: Digital video disk

6.8. Declarations

6.8.1. Ethical approval and consent to participate

The Ethical Review Committee of icddr,b and FHI 360's Institutional Review Board reviewed and approved the study protocol. The data collection team obtained written informed consent from the respondents before conducting interviews.

6.8.2. Consent for publication

Not applicable

6.8.3. Availability of data and material

All relevant data have been presented in the main paper and an additional supporting file has been uploaded.

6.8.4. Competing interests

The authors declare that they have no competing interests.

6.8.5. Funding

Support for this study was provided by FHI360 with funds from USAID Cooperative Agreement GHN-A-00-09-00002-00.

6.8.6. Authors' contribution

Nazmun Nahar, Stephen P. Luby, and Rebeca Sultana contributed to study conception, design, data analysis and interpretation. Mohammad Asaduzzaman, Fernando Garcia, Emily S. Gurley, and Mahmudur Rahman were involved in designing the study, data analysis and interpretation. Repon C. Paul, Jaynal Abedin, and Hossain M. S. Sazzad were involved in data analysis and interpretation. Nazmun Nahar drafted the manuscript and Stephen P. Luby supervised her to develop the manuscript. All the co-authors critically reviewed the manuscript and provided approval for journal submission.

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7. Overall discussion and conclusion

We explored the effectiveness of two different messages to reduce exposure to the risk of Nipah virus spill over through consumption of raw date palm sap. The discussion is organized as follows: first we provided insights into the cultural and economic aspects of raw date palm sap consumption in Bangladesh and its implication for acceptable interventions. Then we discussed the need for an intervention to be acceptable, from a cultural point of view, while also addressing the needs from a public health perspective. Next we talked about the impact of the "no raw sap" and the "only safe sap" intervention, its costs, and projection of costs for a large-scale intervention and its implications. Finally, we summarized our findings, drew a conclusion of our findings and provided recommendations.

7.1. Cultural and economic aspects of raw sap consumption

Raw sap consumption is a risk factor for human Nipah virus infection in Bangladesh (Luby, Rahman et al. 2006, Rahman, Hossain et al. 2012, Chakraborty, Sazzad et al. 2016). Though stopping the consumption of raw sap would prevent the spillover of Nipah virus infection, it is difficult to change behaviour in a large scale, due to cultural aspects of raw sap consumption in rural Bangladesh. Drinking raw sap is a delicacy, a tradition. People have been drinking it for many years, for several generations (Luby, Rahman et al. 2006, Halim, Chowdhury et al. 2008, Nahar, Sultana et al. 2010). People like the sweet taste of raw sap, share it with others or send it as a gift to their relatives and friends (Nahar, Paul et al. 2017). It is a special seasonal drink only available during winter time. When a food is available and people are used to consuming it and like its taste, it is difficult to change their behaviour to stop its consumption (Mehta and Chang 2008, Li, Harmer et al. 2009, Olstad, Raine et al. 2012).

In addition to cultural aspects, collection of date palm sap contributes to the rural economy (Halim, Chowdhury et al. 2008, Nahar, Sultana et al. 2010). Sap harvesting is an occupation for poor *gachhis* who are mainly agricultural labourers. Sap harvesting is an additional source of income that supports their livelihood and other household economic expenditures for about five months in a year (Nahar, Sultana et al. 2010). Apart from raw consumption, a large quantity of date palm sap is boiled to make

molasses (Halim, Chowdhury et al. 2008, Nahar, Sultana et al. 2010). Consumption of molasses does not cause Nipah virus infection. Molasses has a high demand in Bangladesh and can be preserved for a long period of time. Thus, to prevent Nipah, restricting harvesting date palm sap is not an option since this is an income generating activity for a group of poor people that helps them earn their living.

7.2. Requirements of an intervention balancing culture, economy and public health

Our study suggest that awareness of the risk of Nipah virus infection does not result in all informed people stopping drinking raw sap (Nahar, Paul et al. 2015a). In such context, an intervention that will reduce the risk of exposure to Nipah virus infection while allowing drinking raw sap could provide a balance between public health benefits and cultural traditions which is comparable to a harm reduction approach that recognizes abstinence as an ideal outcome, but accepts alternatives that reduce harm (Marlatt 1996). Harm reduction strategies have a long history in public health indicating that modest changes to behaviours are easier to achieve than more substantive changes (Luby, Hoodbhoy et al. 2005, Plautz and Meekers 2007, Kirby 2008). In the "no raw sap" area we asked not to drink raw sap as the government recommends (Nahar, Asaduzzaman et al. 2017). We also disseminated the same message in the "only safe sap" area (Table 7), but we delivered an additional message providing the option of drinking *bana*-protected sap. That way, people can have the pleasure of enjoying the delicacy while allowing *gachhis* to earn a living by offering *bana*-protected palm sap as a safe option. This approach balances public health and cultural traditions with the economic needs of the *gachhis*.

7.3. Impact of interventions

After our intervention, people's knowledge about Nipah virus infection increased in both intervention areas, though consumption of raw sap declined in the intervention and control areas. This decline in the control area, without any intervention, made it difficult to interpret our data. Thus, we conducted difference in difference analysis of various outcomes among the control and intervention groups, from baseline to endline, to monitor changes over time in the absence of an intervention.

In the "no raw sap" area, we expected a 15% absolute reduction on the proportion of people reporting raw sap consumption and observed a 25% absolute reduction, but we also observed an unexpected 17% reduction in the control area, thus the reduction in the "no raw sap" area was not significantly different than the control in difference in difference analysis. Exposure to any element of the "no raw sap" intervention was not associated with any change in behaviour. These findings suggest that the "no raw sap" intervention did not achieve the objective of changing people's behaviour.

In the "only safe sap" area many people reported drinking *bana*-protected sap and many *gachhis* started using *banas*. These reported changes in behaviour were significant in the difference in difference analysis. Direct exposure to the "only safe sap" messages was associated with reduced reported consumption of unprotected sap or increased consumption of protected sap (Nahar, Paul et al. 2017). All these changes indicated that this intervention was successful in changing behaviour and can be included in future intervention initiatives (Nahar, Paul et al. 2017).

7.4. Costs and projection to scale up the intervention

Our intervention was supported by external funding. Both the "no raw sap" and the "only safe sap" communication campaigns were professionally developed, implemented, monitored and assessed. The implementation and dissemination costs of the "no raw sap" message for two seasons, and its associated cost-per-person to directly reach the target population was lower than disseminating the "only safe sap" messages for one season (Nahar, Asaduzzaman et al. 2017). We used the same tools/elements in both areas, but the "only safe sap" message required one additional component to reach *gachhis*, resulting in additional expenses that increased its cost.

For future interventions, we estimated a cost of 2.6 million US$ to disseminate a "no raw sap" communication campaign and 3.5 million US$ for an "only safe sap" campaign, to scale up the intervention to the 30 districts of Bangladesh where Nipah spillovers occurred, for one season (Nahar, Asaduzzaman et al. 2017). Although our intervention changed peoples' behaviour, it might not be possible for the government of Bangladesh to allocate this amount of financial support in their overall health budget to implement a similar intervention in all Nipah affected districts, thus external financial

and logistical support might be needed. In Bangladesh, Nipah might not be considered as one of the most important health issues to get priority and extensive attention from the government. The occurrence of Nipah is rare and the number of people that die from Nipah each year is still lower than deaths from infectious diseases (Streatfield, Khan et al. 2014). Since cost-effectiveness and sustainability remains critical to secure support, a low cost, easy to implement intervention might be more acceptable to the government and could be adopted by the local health system, as well as for external funding agencies to continue their support.

7.5. Suggestions to reduce the cost of future interventions

Looking for strategies to reduce the implementation cost, we estimated the cost of each component of the intervention. One potential strategy is to use the local satellite channels to broadcast the public service announcement in the 30 Nipah spillover districts, at a cost of only $26,000 (Nahar, Asaduzzaman et al. 2017). A supplementary channel, to reach people that do not watch television, is professionally designed posters targeting the high risk communities. We estimated the cost of printing and affixing posters in those 30 districts at about $ 96,000 (Nahar, Asaduzzaman et al. 2017).

The cost of community meetings and interpersonal communication is the highest among the channels used (Nahar, Asaduzzaman et al. 2017). To minimize this cost, we suggested involving community health workers from the public and NGO sectors to disseminate messages and information, using leaflets or affixing posters in their communities during date palm sap harvesting season. Since they are already paid by the government or NGOs, it may add only a small cost to include them in Nipah prevention activities. Small scale piloting studies during upcoming seasons can provide cost estimates and measure the effectiveness of involving community and NGO health workers.

7.6. Recommendation, future direction and conclusion

Our analysis suggests that the "no raw sap" message did not change people's behaviour on raw sap consumption. Although people learned about the risk of Nipah, they continued drinking raw date palm sap. The "only safe sap" message, however, resulted

in changes in reported behaviour. Those who were exposed to the "only safe sap" messages were less likely to drink unprotected sap or more likely to drink protected sap. In addition, many *gachhis* reported using *banas*. The promotion of an "only safe sap" message may reduce the risk of NiV spillovers (Nahar, Paul et al. 2017). This approach is also culturally appropriate, promotes an already existing practice and only requires moderate changes in behaviour. Thus, an "only safe sap" behaviour change communication intervention could be implemented in the future.

Future interventions may require revisions and modifications, based on the need to make it more relevant within the current situation. The Government of Bangladesh already broadcast the "no raw sap" public service announcement through national television during the 2015-16 sap harvesting season. An evaluation of the results of this effort might be useful in determining its effectiveness. This may also help to identify the best time to broadcast the public service announcement to reach more people. Regular monitoring and evaluation of an already implemented intervention as well as Nipah surveillance data can help us to understand what behaviour has been changed and what else needs to be modified for future interventions. For example, we have evaluated the intervention right after its implementation. It would be informative to evaluate this intervention after a few years to know how sustainable and effective it was, and what modifications are required.

We suggested several cost minimizing strategies for future interventions. Piloting the cost of a minimized-strategy intervention can provide insights to understand its effectiveness and help to come up with more realistic solutions to minimize cost.

Considering the devastating effects of other zoonotic pandemics such as swine flu and Ebola, the Nipah prevention intervention can be a priority for global health. The estimated number of deaths from the 2009 swine-origin pandemic influenza A H1N1 was over 200,000 globally (Dawood, Iuliano et al. 2012). The bat-borne Ebola outbreak in West Africa, started in December 2013, killed over 11,000 people and severely affected the socio-economic situation of the region (Leroy, Kumulungui et al. 2005, UNDG 2015, WHO 2016). Nipah virus outbreaks have been identified almost every year in Bangladesh (Luby, Hossain et al. 2009) and Nipah virus infection is an emerging

zoonosis that has the potential to become a global pandemic threat (Luby 2013). Our study suggests ways to proceed further with prevention initiatives. Continued efforts to reduce exposure to bat contaminated sap could not only protect the people of Bangladesh but reduce the risk of a global pandemic.

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Appendix 1

Supplementary table to the second manuscript

Reported community and *gachhi* exposure to information about NiV at baseline and endline from the "no raw sap" and "only safe sap" intervention and control areas, Bangladesh 2012 to 2014

Characteristics	Intervention area community		Control area community		Difference in difference analysis [95% CI]
	n (%)	n (%)	n (%)	n (%)	
"No raw sap" intervention and control areas community					
	¶Baseline 2012	Endline 2014	¶Baseline 2012	Endline 2014	
	N=892	N=897	N=885	N=896	
First time heard about a disease associated with date palm sap consumption and bats					
This year	22 (2)	74 (8) †††	13 (1)	61 (7) †††	0
One year back	102 (11)	237 (26) †††	149 (17)	94 (10) ††	(21) ††† [15, 28]
Two or more years back	247 (28)	418 (47) †††	219 (25)	193 (22)	(22) ††† [14, 30]
"Only safe sap" intervention and control areas community					
	#Baseline 2013	Endline 2014	#Baseline 2013	Endline 2014	
	N=879	N=879	N=892	N=896	
First time heard about a disease associated with date palm sap consumption and bats					
This year	126 (14)	405 (46) †††	113 (13)	61 (7) ††	(38) ††† [30, 45]
One year back	140 (16)	182 (21) †††	145 (16)	94 (10) ††	(10) †† [4, 17]
Two or more years back	235 (27)	124 (14) †††	170 (19)	193 (22)	(-16) ††† [-23, -8]

"Only safe sap" intervention and control areas *gachhi*					
	[#]Baseline 2013	Endline 2014	[#]Baseline 2013	Endline 2014	
	N=110	N=150	N=105	N=150	
This year	18 (16)	81 (54) [†††]	22 (21)	15 (10) [†]	(49) [†††] [34, 63]
One year back	10 (9)	38 (25) [†]	20 (19)	34 (23)	(12) [-1, 26]
Two or more years back	35 (32)	23 (15) [†]	26 (25)	42 (28)	(-19) [††] [-34, -4]

[¶]P-value was calculated by comparing baseline-2012 data with endline-2014 data; [#]P-value was calculated by comparing baseline-2013 data with endline-2014 data

[†]P value < 0.05, [††]P value < 0.01, [†††]P value< 0.001; [*]P-values were cluster adjusted

Appendix 2

Supplementary table to the second manuscript

Reporting of *gachhis* on receiving NiV information and behaviour related to raw sap, during baseline and endline data collection from the "no raw sap," "only safe sap" and control areas, Bangladesh 2013 to 2014

Characteristics	"No raw sap" intervention	"Only safe sap" intervention area *gachhi*		Control area *gachhi*		Difference of (Only safe sap" Difference 2014-2013) - (Control Difference 2014-2013) [95% CI]	Difference of "only safe sap" endline and control endline 2014 [95% CI]	Difference of "no raw sap endline and control endline 2014 [95% CI]
	Endline 2014 N=150 n (%)	Baseline 2013 N=110 n (%)	Endline 2014 N=150 n (%)	Baseline 2013 N=105 n (%)	Endline 2014 N=150 n (%)			
Frequency of bringing sap for raw consumption from harvested trees to household during previous sap harvesting season								
Very frequently	115 (77)	102 (93)	137 (91)	89 (85)	124 (83)	0	(9) † [0.1, 17]	(-6) [-16, 4]
Once a week	23 (15)	8 (7)	10 (7)	13 (12)	19 (13)	(-0) [-1, 9]	(-6) [-12, 1]	(2) [-6, 11]
Frequency of selling raw sap during previous sap harvesting season								
At least few times	102 (68)	90 (82)	109 (73)	64 (61)	81 (54)	(-2) [-18, 13]	(19) †† [6, 31]	(14) † [0.1, 27]

Learned about using *banas* from‡								
Family members	18 (12)	5 (5)	17 (11) †	35 (33)	34 (23)	(17) [4, 30]	(-11) † [-20, -2]	(-11) † [-20, -1]
Other *gachhis*	13 (9)	3 (3)	6 (4)	21 (20)	33 (22)	(-1) [-11, 10]	(-18) ††† [-26, -10]	(-13) † [-22, -4]
NGO workers	5 (3)	0	89 (59) †††	1 (1)	1 (1)	(59) ††† [50, 69]	(59) ††† [50, 67]	(3) [-0.5, 5]
Community meetings	3 (2)	0	37 (25) †††	0	0	(25) ††† [16, 33]	(24) ††† [17, 33]	(2) [-0.2, 4]
Poster	2 (1)	0	6 (4) †††	0	0	(4) [0, 8]	(4) † [0.3, 8]	(1) [-0.5, 3]
Television	2 (1)	0	5 (3) †††	4 (4)	4 (3)	(4) [-1, 9]	0	(-1) [-5, 2]
Self -taught	7(5)	5(5)	3(2)	14(13)	18(12)	(-1) [-10, 8]	(-10) †† [-16, -4]	(-7) † [-14, -0.3]
Neighbour	1 (1)	1 (1)	2 (1)	2 (2)	6 (4)	(-2) [-7, 3]	(-2) [-6, 1]	(-3) [-6, 0.1]
Tree owners	2 (1)	0	5 (3) †††	5 (5)	1 (1) ††	(7) [2, 12]	(2) [-1, 6]	(1) [-1, 3]

* Cluster adjusted ‡ Open-ended responses with multiple answers allowed, †P value < 0.05, ††P value < 0.01, †††P value< 0.001

Appendix 3

Supplementary table to the second manuscript

Observation of date palm sap harvesting, consumption and selling at *gachhis'* households at 5.25 am to 9.45 am until *gachhis* finished the raw sap selling and/or start making molasses during 2012-13 and 2013-14 sap harvesting seasons

Observation findings	**2012-13 sap season**		**2013-14 sap season**		
	"No raw sap" intervention area N=46	**Control area** N=36	**§ "No raw sap" intervention area** N=46	**# "Only safe sap" intervention area** N=48	Control area N=38
Amount of sap (in liters) used for molasses, median (IQR)	40 (32, 62)	23 (0, 71)	50 (37, 80)	32 (19, 53)	5 (0, 14) †††¶, †††#
Persons purchased raw sap and took it home for household use during observation					
At least one person purchased raw sap and took away to home	13 (28%)	22 (61%)††	9 (20%)	20 (42%)	12 (32%)
Gachhi who sold raw sap for household use used *bana*‡‡			1 (11%)	10 (50%)	6 (50%)
Amount of raw sap (in liters) bought and brought home, median (IQR) (among who purchased raw sap)	15 (6, 16)	17 (8, 24)	10 (8, 10)	15 (9, 20)	10 (6, 14)

§Items were not observed in 2012-13 season

¶P-value was calculated by comparing the "no raw sap" intervention area with the control area; #P-value was calculated by comparing the "only safe sap" intervention area with the control area

†P value < 0.05, ††P value < 0.01, †††P value< 0.001

‡Denominator was the *gachhis* household where raw sap consumption occurred

‡‡Denominator was the *gachhis* household where persons purchased raw sap and took away

Appendix 4

Supplementary table to the second manuscript

Endline data on community respondents' exposure to Nipah prevention intervention during 2012-2013 and 2013-2014 sap seasons from the "no raw sap" and the "only safe sap" intervention area, Bangladesh

Exposure to interventions	**Intervention community endline**	
	No raw sap N=897 n (%)	**Only safe sap** N=879 n (%)
Attended community meeting	90 (10)	105 (12)
Saw a poster	190 (21)	272 (31)
Saw TV public service announcement	99 (11)	109 (12)
Directly exposed to any communication channel (community meeting or poster or TV public service announcement)	268 (30)	361 (41)
Indirectly exposed to the new information through word of the mouth (no direct exposure to community meeting or poster or TV public service announcement)	248(28)	321(37)

Appendix 5

Questionnaire on Demographic information

Socio Economic Status

7.1. Occupation of the main income earner of household	1=Agricultural worker (cultivate in other's land with sharing crops) 2=Farmer having own land 3=Day labourer 4=Small shop owner (capital <=20,000) 5=Businessman (capital>20,000) 6=Homemaker 7=Rickshaw/van puller 8=Driver 9=Service 10=Dependent (aged) 11=Unemployed 12=Skilled worker 13=Gachhi [MvwQ] 88=Other (specify)_____
7.2. Number of members in your household?	☐☐
7.3. Number of living rooms in your household?	☐☐
7.4. What is the monthly expenditure of your household? (Don't know= 77777)	☐☐☐☐☐
7.5. What is the monthly income of your household? (Don't know= 77777)	☐☐☐☐☐
7.6. How much per month did you earn from harvesting date palm sap during the past season?	☐☐☐☐☐

Raw sap consumption information

1.1. How old are you? (Write in years)	☐☐
1.2. If you have any formal education, what class have you passed?	1=No schooling 2=Some primary 3=Finished primary 4=Some secondary 5=Finished secondary 6= Finished higher secondary
1.3. Does this household own date palm trees either here or elsewhere that were harvested during last season?	1= Yes 0=No → ***Skip to 1.57***
1.4. How many of the date palm trees belonging to people in this household were harvested during last season? *(Integer Response*	☐☐☐ *(Write 777 in case of don't know)*

1.5. During last season, how many of those trees were used for raw sap consumption by the household or sold in the market for consumption? *(Integer Response)*	☐☐☐ ***(If zero, skip to 1.57)*** *(Write 777 in case of don't know)*
1.6. Did you or anyone else in this household collect date palm sap for raw sap consumption from your household's trees during last season?	1= Yes 0=No → ***Skip to 1.28***
1.7. Who was it from this household who collected sap for raw sap consumption during last season? Was it yourself alone, yourself and others from the household, or others from this household but not yourself?	1= Respondent only (you alone) (2= Respondent and others 3= Others from household, not respondent
1.8. In which month did [you/others in your household] start collecting sap for raw sap consumption? *[Probe once]*	1= Arshin 2= Kartik 3=Agrahayan 4=Poush 5=Magh 6=Falgun 7=Choitro
1.9. During last season about how often did the household get sap for raw consumption from these household members?	1= Very frequently (daily or several times a week) 2= About once a week 3= Every few weeks 4= A few times 5= Not at all
1.10. During this last season did [you/he/they] use any *bana*/skirt to cover the shaved part of the tree and/or the sap collection pots?	1=Yes 0=No → ***Skip to 1.12***
1.11. Did you cover only shaved part of the tree or only sap collection pot or both shaved part of the tee and pot?	1=Only shaved part of tree 2=Only sap collection pot 3=Covered both → ***Skip to 1.15***
1.12. Have you or anyone of this household ever used any *bana*/skirt to cover the shaved part of the tree and/or the sap collection pots?	1=Yes 0=No → ***Skip to 1.27***
1.13. Did you cover only shaved part of the tree or only sap collection pot or both shaved part of the tee and pot?	1=Only shaved part of tree 2=Only sap collection pot 3=Covered both
1.14. What were the reasons this household did not use skirts this past season? (multiple answers)	1=Not drinking raw sap 2=Difficult to use skirts 3= Due to time constraints 4=The skirt was broken 5=The skirt was stolen 6=Do not see any more bats 7=Sap is not sweet enough for raw consumption 9= Did not know how to use 88=Other _____ ***Skip to 1.27***
1.15. Was this last season the first time that people from this household used skirt on the household's trees for raw sap consumption?	1=Yes → ***Skip to 1.17*** 0=No
1.16. For how many years has this household been using skirt (*integer response*)	☐☐

1.17. From where/whom did people in this household learn about using skirt? *[Multiple response acceptable]*	1= Family members 2= Other *gachhis* 3= NGO worker 4= Community meeting 5=Poster 6=Television in tea stall 7= Television at home 8= Tree owner 88= Other _____
1.18. From where did you obtain skirt for your sap collection trees during last season? *[Multiple response acceptable]*	1=Made at home 2=Collected from neighbouring 3=Collected from local market 8=Other _____ ***Skip to*** 1.20
1.19. From where/whom did people in the household learn to make skirt? *[Multiple response acceptable]*	1= Family members 2= Other *gachhis* 3= NGO worker 4= Community meeting 5=Poster 6=Television in tea stall 7= Television at home 8=Tree owner 88= Other _____
1.20. What material was used to make *bana*/skirts during last season? *[Probe once] (Multiple response acceptable)*	1=Bamboo 2=Dhoincha 3=Jute stalk 4=Polythene 8= Other _____
1.21. You said that your household harvested sap for raw consumption from ___ trees this past season. Correct? Now I am going to ask you how often the household used skirts on those trees during the time that sap was being collected for raw consumption – never, sometimes, most of the time, or always. How many of the household's sap collection trees that were being used for raw sap consumption were covered with skirts in last season?	
1.21.1. Never *(Integer Response)*	☐☐ *(Write 77 in case of don't know)*
1.21.2. Sometimes *(Integer Response)*	☐☐ *(Write 77 in case of don't know)*
1.21.3. Most of the time *(Integer Response)*	☐☐ *(Write 77 in case of don't know)*
1.21.4 Always *(Integer Response)*	☐☐ *(Write 77 in case of don't know)*
1.22. What benefit did the household get from using skirts? *[Probe once] (Multiple response acceptable)*	1=Got more sap 2=Got good quality sap 3=Got clean sap free from dirt 4=Could prevent disease 5=No benefits 8=Other _____

1.23. In which month did household members stop collecting sap for raw consumption?	1= Arshin 2= Kartik 3=Agrahayan 4=Poush 5=Magh 6=Falgun 7=Choitro
1.24. Were skirts used on raw sap consumption trees until the household members stopped collecting sap for raw consumption?	1=Yes → ***Skip to 1.28*** 0=No
1.25. In what month did household members collecting sap for raw consumption stop using skirts?	1= Arshin 2= Kartik 3=Agrahayan 4=Poush 5=Magh 6=Falgun 7=Choitro
1.26. Why did [you/he/ they] stop using skirts?	1=Stop drinking raw sap 2=Difficult to use skirts 3= Due to time constraints 4=The skirt was broken 5=The skirt was stolen 6=Do not see any more bats 7=Sap is not sweet enough for raw consumption 8=Season is over 88=Other _____ ***Skip to 1.28***
1.27. In which month did household members stop collecting sap for raw consumption?	1= Arshin 2= Kartik 3=Agrahayan 4=Poush 5=Magh 6=Falgun 7=Choitro
1.28. Did you have any *gachhis* to collect sap from trees belonging to this household during last season?	1= Yes 0=No → ***Skip to 1.57***
1.29. How many *gachhis* collected sap from your trees during last season? *(Integer Response)*	☐☐
1.30. Under which type of agreement did *gachhi(s)* collect sap during last season from the date palm trees that you and your household own? *[Multiple response acceptable]*	1=Sap agreement 2=Molasses agreement 3=Money agreement 8=Other _____ ***Skip to 1.57***
1.31. Who was it from this household who made the agreement(s) with the *gachhi(s)* last season? Was it you alone, you and others in the household or others from this household but not yourself?	1= Respondent only (you alone) 2= Respondent and others 3= Others from household, not respondent
1.32. In which month did the *gachhi(s)* start collecting sap for raw consumption? *[Probe once]*	1= Arshin 2= Kartik 3=Agrahayan 4=Poush 5=Magh 6=Falgun 7=Choitro

1.33. During last season how often did the household get sap for raw consumption from these *gachhi(s)*?	1= Very frequently (daily or several times a week) 2= About once a week 3= Every few weeks 4= A few times 5= Not at all
1.34. In the last season did your *gachhi(s)* who collected sap for raw consumption use skirts to cover the shaved part of the tree and the sap collection pots?	1=Yes 0=No 7= Don't know } ***Skip to 1.36***
1.35. Did your *gachhi(s)* cover only shaved part of the tree or only sap collection pot or both shaved part of the tee and pot?	1=Only shaved part of tree 2=Only sap collection pot 3=Covered both } ***Skip to 1.39***
1.36. Have any of your contracted *gachhi* ever used any skirt to the raw sap collection trees belonging to your household?	1=Yes 0=No 7= Don't know } ***Skip to 1.56***
1.37. Did your *gachhi(s)* cover only shaved part of the tree or only sap collection pot or both shaved part of the tee and pot? A	1=Only shaved part of tree 2=Only sap collection pot 3=Covered both
1.38. What were the reasons your *gachhi* did not use skirts this past season? (Multiple answers)	1=Not drinking raw sap 2=Difficult to use skirts (3= Due to time constraints 4=The skirt was broken 5=The skirt was stolen 6=Do not see any more bats 7=Sap is not sweet enough for raw consumption 8= *Gachhi* is reluctant to use 9= Did not know how to use 88=Other _____ } ***Skip to 1.56***
1.39. Was this last season the first time that the *gachhi* to use skirts on your household's trees for raw sap consumption?	1=Yes → ***Skip to 1.41*** 0=No
1.40. For how many years has the *gachhis* been using skirt on your household's trees for raw sap consumption? *(Integer Response)*	☐☐
1.41. Did you or someone else from the household tell the *gachhi(s)* to use skirts?	1= Yes 0=No → ***Skip to 1.43***
1.42. What was the reason that this household told the *gachhis* to use skirts this past season? (Multiple answers)	1=To get more sap 2=To get good quality sap (3=To get clean sap free from dirt 4=Can prevent disease 5= Told by authority (community leader) 6= Told by NGO 8=Others _____
e	1=Tree owner 2=*Gachhi* 3=Both tree owner and *gachhi*

1.44. From where/whom did people in this household learn about using skirt?	1= Family members 2= Other *gachhis* 3= NGO worker 4= Community meeting 5=Poster 6=Television in tea stall 7=Television at home 8=Tree owner 88= Other _____
1.45. From where did your gachhi(s) obtain skirt for your sap collection trees during last season? *[Multiple response acceptable]*	1=Supplied by tree owner 2=Made/collected by *gachhi* but we provided the cost 3=Made/collected by gachhi at his own cost → ***Skip to 1.47*** 7=Don't know → ***Skip to 1.47***
1.46. How many skirts did you supply or bear the cost of making skirts during last season?	☐☐ *(Write 77 in case of don't know)* *(Write 00 in case of none)*
1.47. How many total skirts did your gachhi(s) use in your sap collection trees during last season?	☐☐ *(Write 77 in case of don't know)* *(Write 00 in case of none)*
1.48. What material was used to make skirts during last season? *[Probe once] Multiple response acceptable*	1=Bamboo 2=Dhoincha 3=Jute stalk 4=Polythene 7=Don't know 8= Others _____
1.49. You said that *gachhis* harvested sap for raw consumption from xx trees this past season. Now I am going to ask you how often the *gachhis* used skirts on those trees during the time that sap was being collected for raw consumption – never, sometimes, most of the time, or always. How many of your sap collection trees that your *gachhi(s)* used for raw sap consumption were covered with skirts in last season? (consider only during raw sap consumption)	
1.49.1. Never *(Integer Response)*	☐☐ *(Write 77 in case of don't know)*
e	☐☐ *(Write 77 in case of don't know)*
1.49.3. Most of the time *(Integer Response)*	☐☐ *(Write 77 in case of don't know)*
1.49.4. Always *(Integer Response)*	☐☐ *(Write 77 in case of don't know)*
1.50. What benefit did the household get from the *gachhis* using skirts on the household trees for raw sap consumption? *[Probe once] (Multiple response acceptable)*	1=Got more sap 2=Got good quality sap 3=Got clean sap free from dirt 4=Could prevent disease 5=No benefits 8=Other _____

1.51. In which month did the *gachhis* stop collecting sap for raw consumption?	1= Arshin 2= Kartik 3=Agrahayan 4=Poush 5=Magh 6=Falgun 7=Choitro
1.52. Did the *gachhis* use *bana*/skirts on the household's raw sap consumption trees until they stopped collecting sap for raw consumption?	1=Yes → ***Skip to 1.57*** 0=No
1.53. In what month did the *gachhis* stop using skirts?	1= Arshin 2= Kartik 3=Agrahayan 4=Poush 5=Magh 6=Falgun 7=Choitro
1.54. Did someone from the household tell the *gachhis* to stop using skirts?	1=Yes 0=No
1.55. Why did the *gachhi(s)* stop using skirts? *(Multiple response acceptable)*	1=Stop drinking raw sap 2=Difficult to use skirts 3= Due to time constraints 4=The skirt was broken 5=The skirt was stolen 6=Do not see any more bats 7=Sap is not sweet enough for raw consumption 8=Season is over 88=Other _____ ***Skip to 1.57***
1.56. In which month did the *gachhis* stop collecting sap for raw consumption?	1= Arshin 2= Kartik 3=Agrahayan 4=Poush 5=Magh 6=Falgun 7=Choitro
1.57. Did anyone from this household work as a *gachhi* for other households during last season?	1= Yes 0=No → ***Skip to section 2***
1.58. Who was it from this household who [collected sap for from trees owned by others /worked as a *gachhi* for other households] during last season? Was it you alone, you and others from the household, or others from this household but not yourself?	1= Respondent only (you alone) 2= Respondent and others 3= Others from household, not respondent → ***Skip to section 2***
1.59. During last season about how often did the household get sap for raw consumption from these household members (*gachhis*)?	1= Very frequently (daily or several times a week) 2= About once a week 3= Every few weeks 4= A few times 5= Not at all

2.1. Thinking about all the raw sap members of this household used during last season I'd like to ask how frequently members of your household used raw sap for other things. Did residents of this household use raw date palm sap never, sometimes or frequently to (*read each category*)	
2.1.1. Make molasses	0=No, 1=Sometimes, 2=Frequently ☐
2.1.2. Make *Tari*	0=No, 1=Sometimes, 2=Frequently ☐
2.1.3. Sold raw for human consumption	0=No, 1=Sometimes, 2=Frequently ☐
2.1.4. Drunk raw by household members	0=No, 1=Sometimes, 2=Frequently ☐
2.1.5. Shared with neighbours and relatives	0=No, 1=Sometimes, 2=Frequently ☐
2.1.6. Used to feed animals	0=No, 1=Sometimes, 2=Frequently ☐
2.1.7. Use *jhora* medication to drink	0=No, 1=Sometimes, 2=Frequently ☐
2.1.8. Use *jhora* medication to massage on the body	0=No, 1=Sometimes, 2=Frequently ☐
2.1.9. Others _____	0=No, 1=Sometimes, 2=Frequently ☐
2.2. Have you ever drunk raw data palm sap?	1=Yes 0=No → ***Skip to 2.19***
2.3. When was the last time you drank raw date palm sap?	1=Last season → ***Skip to 2.5*** 2=2 years back 3=3-5 years back 4= More than 5 years back 7= Don't know
2.4. Why didn't you drink raw date palm sap during last sap season? *[Multiple answers acceptable]*	1=Did not like to drink 2=Heard about disease (Nipah) 3=Sap was not available 88=Other _____ } ***Skip to 2.19***
2.5. In which month did you drink raw date palm sap most?	1= Arshin 2= Kartik 3=Agrahayan 4=Poush 5=Magh 6=Falgun 7=Choitro
2.6. How often do you drink raw date palm sap during the peak of last sap season?	1=Multiple times a day 2=Usually once a day 3=2-3 times per week 4=About once per week 5=Once or twice a month 6=Once or twice a season 77=Don't Know

2.7. Where did this raw date palm sap come from? (*multiple answers acceptable*)	1=Own household trees harvested by household members 2= Own household trees harvested by *gachhi* 3= Gift 4=Purchased from neighbouring *gachhi*/tree owner 5= Purchased from market/mobile vendor
2.8. (if consumed sap from household trees) Did the raw date palm sap you consumed that came from household trees came from trees with skirts/*bana?*	1=Yes 0=No → ***Skip to 2.10*** 7=Do not know → ***Skip to 2.10*** 9=Not applicable → ***Skip to 2.10***
2.9. How do you know? (*multiple answers acceptable*)	1=Saw/know the tree 2= Told 3= Asked 4= Trust the *gachhi* 5=*Gachhi* wore sweatshirt 6= Pot marked 8= Other_____
2.10. (if consumed sap obtained as a gift) Did the raw date palm sap you consumed that was a gift come from trees with skirts/*bana?*	1=Yes 0=No → ***Skip to 2.12*** 7=Do not know→ ***Skip to2.12*** 9=Not applicable → ***Skip to2.12***
2.11. How do you know? (*multiple answers acceptable*)	1=Saw/know the tree 2= Told 3= Asked 4= Trust the *gachhi* 5=*Gachhi* wore sweatshirt 6= Pot marked 8= Other _____
2.12. (if consumed sap purchased from *gachhi*) Did the raw date palm sap you consumed that was purchased from a *gachhi* come from trees with skirts/*bana?*	1=Yes 0=No → ***Skip to 2.14*** 7=Do not know → ***Skip to2.14*** 9=Not applicable → ***Skip to2.14***
2.13. How do you know? (*multiple answers acceptable*)	1=Saw/know the tree 2= Told 3= Asked 4= Trust the *gachhi* 5=*Gachhi* wore sweatshirt 6= Pot marked 8= Other _____
2.14. (if consumed sap purchased from market/mobile vendor) Did the raw date palm sap you consumed that was purchased in the market come from trees with skirts/*bana?*	1=Yes 0=No 7=Do not know 9=Not applicable

2.15. How do you know? (*multiple answers acceptable*)	1=Saw/know the tree 2= Told 3= Asked 4= Trust the *gachhi* 5=*Gachhi* wore sweatshirt 6= Pot marked 8= Other _____

Survey questionnaire for *gachhis* on date palm trees and sap collection and use of *bana*

1.1. How old are you?	☐☐
1.2. If you have any formal education, what class have you passed?	1=No schooling 2=Some primary 3=Finished primary 4=Some secondary 5=Finished secondary 6= Finished higher secondary
1.3. Did anyone in this household collect date palm sap during last season?	1= Yes 0=No → ***Stop interview***
1.4. How many people in this household, including yourself, collected date palm sap during last season? *(Integer Response)*	☐☐☐
1.5. How many total date palm trees did you yourself collect date palm sap from during last season? (Integer Response)	☐☐☐☐
1.6. How many of these trees that you yourself collected date palm sap from during last season were used for raw sap consumption (including selling raw sap)? *(Integer Response)*	☐☐☐☐
1.7. Does this household own all, some or none of the trees that you harvested last season for raw consumption?	1= All → ***Skip to 1.10*** 2= Some 3= None → ***Skip to 1.9***
1.8. How many of the trees belong to this household? (integer response)	☐☐☐☐
1.9. How many other different tree owners did these trees belong to? (integer response)	☐☐☐☐
1..10. In which month did you start collecting sap for raw consumption? *[Probe once]*	1= Arshin 2= Kartik 3=Agrahayan 4=Poush 5=Magh 6=Falgun 7=Choitro
1.11. During last season how often did you bring sap for raw consumption from these trees to your own household?	1= Very frequently (daily or several times a week) 2= About once a week 3= Every few weeks 4= A few times 5= Not at all

1.12. During last season how often did you sell raw sap from these trees?	1= Very frequently (daily or several times a week) 2= About once a week 3= Every few weeks 4= A few times 5= Not at all
1.13. This last season, when harvesting sap for raw consumption from these trees did you use any skirt/*bana* to cover the shaved part of the tree and the sap collection pots?	1=Yes 0=No → ***Skip to 1.15***
1.14. Did you cover only shaved part of the tree or only sap collection pot or both shaved part of the tree and pot?	1=Only shaved part of tree 2=Only sap collection pot 3=Covered both → ***Skip to 1.18***
1.15. Have you or anyone of this household ever used any *bana*/skirt to cover the shaved part of the tree and the sap collection pots?	1=Yes 0=No → ***Skip to 1.36***
1.16. Did you cover only shaved part of the tree or only sap collection pot or both shaved part of the tree and pot?	1=Only shaved part of tree 2=Only sap collection pot 3=Covered both
1.17. What were the reasons this household did not use skirts this past season? (multiple answers)	1=Not drinking raw sap 2=Difficult to use skirts 3= Due to time constraints 4=The skirt was broken 5=The skirt was stolen 6=Do not see any more bats 7=Sap is not sweet enough for raw consumption 9= Did not know how to use 88=Other _____ → ***Skip to 1.36***
1.18. Was last season the first time that you used skirts when harvesting sap for raw consumption?	1=Yes → ***Skip to 1.20*** 0=No
1.19. For how many years have you used skirts/*banas* on trees for raw sap consumption? (integer response)	☐☐
1.20. From where/whom did you learn about using skirts/*banas*? *[Multiple response acceptable]*	1= Family members 2= Other *gachhis* 3= NGO worker 4= Community meeting 5=Poster 6=Television in tea stall 7= Television at home 8= Tree owner 88= Other _____
1.21. How many total skirts/*banas* did you use in sap collection trees during last season? *(Integer Response)*	☐☐☐
1.22. From where or whom did you obtain skirts/*banas* for your sap collection trees during last season? *[Multiple responses acceptable]*	1=Supplied by tree owner(s) → ***Skip to 1.25*** 2=Made/collected by me but tree owner provided the cost → ***Skip to 1.24*** 3=Made/collected by me with my own cost 8=Other _____→ ***Skip to 1.25***

1.23. How many skirts/*banas* did you make/collect with your own cost? *(Integer Response)*	☐☐☐ *(Write 000 in case of none)*
1.24. From where/from whom did you learn to make skirt/*bana*? *Multiple responses acceptable*	1= Family members 2= Other *gachhis* 3= NGO worker 4= Community meeting 5=Poster 6=Television in tea stall 7= Television at home 8= Other _____
1.25. What material was used to make skirts during last season? *[Probe once] Multiple responses acceptable*	1=Bamboo 2=Dhoincha 3=Jute stalk 4=Polythene 8= Other _____
1.26. Did you use special pots/marking for sap that you harvested from *bana*-protected trees?	1= Yes 0= No → ***Skip to 1.28***
1.27. What special pots/marking did you use?	_____
1.28. Do you wear any kind of special clothing to show people that you use *banas*?	1= Yes 0= No → ***Skip to 1.30***
1.29. What kind of special clothing do you wear?	_____
1.30. Now I am going to ask you how often the household used skirts on those trees during the time that sap was being collected for raw consumption – never, sometimes, most of the time, or always. How many of your sap collection trees that you yourself harvested for raw sap consumption were covered with skirts in last season? (consider only during raw sap consumption)	
1.30.1. Never *(Integer Response)*	☐☐☐ *(Write 77 in case of don't know)*
1.30.2. Sometimes *(Integer Response)*	☐☐☐ *(Write 77 in case of don't know)*
1.30.3. Most of the time *(Integer Response)*	☐☐☐ *(Write 77 in case of don't know)*
1.30.4. Always *(Integer Response)*	☐☐☐ *(Write 77 in case of don't know)*
1.31. What benefit did you get from using skirts? *[Probe once] Multiple responses acceptable*	1=Got more sap 2=Got good quality sap 3=Got clean sap free from dirt 4=Could prevent disease 5=No benefits 8=Others_____

1.32. In what month did you stop collecting sap for raw sap consumption? (Bangla months)	1= Arshin 2= Kartik 3=Agrahayan 4=Poush 5=Magh 6=Falgun 7=Choitro
1.33. Did you use skirts on the raw sap consumption trees until you stopped collecting sap for raw consumption?	1=Yes 0=No
1.34. In what month did you stop using skirts?	1= Arshin 2= Kartik 3=Agrahayan 4=Poush 5=Magh 6=Falgun 7=Choitro
1.35. Why did you stop using skirts? *[Multiple responses acceptable]*	1=Stop drinking raw sap 2=Difficult to use skirts 3= Due to time constraints 4=The skirt was broken 5=The skirt was stolen 6=Do not see any more bats 7=Sap is not sweet enough for raw consumption 8= tree owner said to stop 88=Other _____

Survey questionnaire on information about intervention

Now I would like to talk with you about some things that may have happened during last *hemonto* and *sit (cold months referring sap harvesting season)*.	
1.1. During last hemonto and sit did anybody arrange any community meeting where people talked about harvesting and consuming date palm sap?	1= Yes 0= No → ***Skip to 1.7*** 77= Do not know → ***Skip to 1.7***
1.2. Did you attend any of these community meetings during the last hemonto and sit?	1= Yes 0= No → ***Skip to 1.5***
1.3. How many times did you attend these community meetings during the last hemonto and sit? *(Integer question*	☐☐
1.4. What was discussed in community meetings? (multiple answers acceptable)	1= Disease caused through date palm sap 2= Disease from bats 3=About Nipah virus 4=Stop consuming raw sap 7=Bats are bad 8=Bats are useful 9=Use of skirts 10=Drink sap from skirt protected trees 88=Other _____

1.5. Did any other members of your household attend any of these community meetings during hemonto and sit?	1= Yes 0= No 77= Don't know } ***Skip to1.7***
1.6. How many members of your household attended any of these community meetings during hemonto and sit? *(Integer question)*	☐☐
1.7. Have you seen a poster about harvesting and consuming date palm sap during hemonto and sit?	1=Yes 0=No → ***Skip to 1.12***
1.8. Where did you see the poster during hemonto and sit? (multiple answers possible)	1=Bazar/ Market 2=Tea stall 3=Community clinic 4=Mosque 5=On a road side tree 6=On a road side house 88=Other _____
1.9. What was the picture on the poster? DO NOT READ RESPONSES [Multiple answers acceptable]	1= Bat 2= Date palm tree 3= Sap collection 4 = Bat near tree 5= Man refusing sap 6= *Gachhi/ gachhi* selling sap 7= Skirts/use of skirts/*banas* 8=Drink sap from skirt protected trees 9= *Bana* protected sap sticker 10=Tree with *banas* 88=Others_____
1.10. What did on the words on the poster say? DO NOT READ RESPONSES [Multiple answers acceptable]	1= Disease caused through date palm sap 2= Disease from bats 3=About Nipah virus 4=Stop consuming raw sap 5=Bats are bad 6= Can't read 7=Government says avoid drinking sap 8=Deadly Nipah virus 9=Use of skirts 10=Drink sap from skirt protected trees 88=Other _____
1.11. What did you learn from the poster?	1=Nothing 2=Did not understand 8=Others _____ *(write the responses clearly)*
1.12. Have you seen any TV movie or announcement about harvesting and consuming date palm sap during last hemonto and sit?	1=Yes 0=No → ***Skip to 1.22***
1.13. Where did you see the TV movie or announcement? (multiple answers possible)	1=Tea stall 2=At home 3=At community meeting 4= At someone else's home 88=Other _____
1.14. How many times did you see a TV movie or announcement about harvesting and consuming date palm sap during last hemonto and sit? *(Integer Response)*	☐☐☐

1.15. What people did the TV movie show? Anyone else? (multiple responses acceptable) DO NOT READ RESPONSES	1=Girl 2= *Gachhi* 3= Mother 4= Father 5=Grandmother 6= Grandfather 77= Don't know/ remember 88= Other _____ ***Skip to 1.20***
1.16. What did the little girl want? DO NOT READ RESPONSES	1=A doll 2=Drink of raw sap 77=Don't know 88=Other _____
1.17. Did she get what she wanted immediately?	1=Yes → ***Skip to 1.19*** 2=No 77=Don't know 99=Do not remember
1.18. Why she didn't get what she wanted immediately?	1= Tree was not *bana* protected 8=Others_____
1.19. What else did TV movie show? [Multiple answers acceptable]	1= Bat 2= Date palm tree 3= Sap collection 4 = Bat near tree 5= *Gachhi* climbing tree 6= skirts/use of skirts/*banas* 7=Drink sap from skirt protected trees 8= *Bana* protected sap sticker 88=Others_____
1.20. What did the TV movie or announcement say? DO NOT READ RESPONSES [Multiple answers acceptable]	1= Disease caused through date palm sap 2= Disease from bats 3=About Nipah virus 4=Stop consuming raw sap 7=Bats are bad 8=Use of skirts 9=Drink sap from skirt protected trees 88=Other _____
1.21. What did you learn from the TV movie or announcement?	1=Nothing 2=Did not understand 8=Others _____ *(write the responses clearly)*
1.22. From where or whom else did you hear or see information about harvesting or consuming date palm sap during last hemonto and sit? [Multiple answers acceptable]	1=Radio 2=Village head 3=Religious head 4=Teacher 5= Neighbours 8=Others_____
1.23. Have you discussed with anyone in your household about any (new) information about harvesting and consuming date palm sap that you heard or saw during last hemonto and sit?	0=No 1=Yes 2= Not heard any new information

1.24. What did you discuss? [Multiple answers acceptable]	1= Disease caused through date palm sap 2= Disease from bats 3=About Nipah virus 4=Stop consuming raw sap 7=Bats are bad 8=Use of skirts 9=Drink sap from skirt protected trees 88=Other _____

Knowledge about Nipah

Knowledge and attitude about bat and raw date palm sap consumption

Now we would like to know your opinion about drinking raw date palm sap and bats.	
1.1. Have you ever heard about a disease that comes from bats that people can get?	1= Yes 0=No → ***Skip to 6.3***
1.2. What is the name of that disease?	1=Nipah 2=Cannot recall 88=Other _____
1.3. Have you ever heard about a disease that people can get from drinking raw date palm sap?	1= Yes 0=No → ***Skip to 6.5***
1.4. What is the name of that disease?	1=Nipah 2=Cannot recall 88=Other _____
1.5. Have you heard of Nipah disease?	1= Yes 0=No
Skip note: If answer of all 6.1 and 6.3 and 6.5 is "No", skip to Q 6.12 Note: If the respondents fail to recall the name of "Nipah", don't mention the name of the disease (Nipah) in the following questions.	
1.6. What have you heard about that disease (Nipah)? *[Multiple answers acceptable]* *Probe twice: "Anything else?"*	1=Deadly disease 2=Disease caused through date palm sap 3=Disease from bats 4=Disease caused through eating dropped fruits 5=Disease from birds 88=Other _____
1.7. What can people do, if anything, to avoid getting the disease? Probe once: Anything else?	1=Nothing 2 =_____ *(write the response clearly)*
e	1=Nothing 2 =_____ *(write the response clearly*
1.9. How long ago did you first hear about that disease (Nipah) disease?	1=This year 2=One year back 3=Two years back 4= Three years back 5= Four or more years back

1.10. Did you hear about that disease (Nipah) during last hemonto and sit? *[Probe once]*	1=Yes 0=No → ***Skip to 6.2***
1.11. From where or from whom have you heard about that disease (Nipah) at that time? *[Multiple answers acceptable]*	1=Community meeting 2=Community clinic 3=Poster 4=Calendar 5=Television (at tea stall) 6= Television (at home) 7=News paper 8=Radio 9=Hospital 11=NGO workers 12=Community health worker 13=Local doctor 14=Imam 15=Neighbours 16=Local leaders 17=Family members 18=Doctors from Dhaka 88=Other _____ 99= Not applicable

Curriculum vitae

[Omitted for data protection purposes.]