Feasibility and acceptability of a midwife-led health education strategy to reduce exposure to biomass smoke among pregnant women in Uganda, A FRESH AIR project.

*Rebecca Nantanda[1,2], Shamim Buteme[1], Sanne van Kampen[4], Lucy Cartwright[4], Jill Pooler[4], Andy Barton[4], Lynne Callaghan[4], Jean Mirembe[5], Grace Ndeezi[2], James K Tumwine[2], Bruce Kirenga[1,3], Rupert Jones[4]

Affiliation:

1. Makerere University Lung Institute, Makerere University College of Health Sciences
2. Department of Paediatrics and Child Health, Makerere University College of Health Sciences
3. Department of Internal Medicine, Makerere University College of Health Sciences
4. Clinical Trials and Population Studies Department, University of Plymouth
5. Directorate of Health Services, Jinja district, Uganda

*Corresponding author

Abstract

Background

Biomass smoke exposure is a threat to child and maternal health in many resource-limited countries, as it is associated with respiratory infections, chronic lung diseases and poor pregnancy outcomes. We aimed to assess the feasibility, acceptability and impact of a midwife-led education programme on biomass risks and prevention measures for women attending antenatal / postnatal clinics in Uganda.

Methods

Education materials were developed through an iterative process that involved all levels of stakeholders from the Ministry of Health to villagers. The materials were serially tested and improved and finally approved by the Ministry of Health and used with midwives to the women attending clinics and village health teams (VHTs). Feasibility, acceptability and impact were assessed through qualitative interviews with women three months after the sessions.

Results

The district health team, 12 midwives and 40 VHTs were sensitized on biomass smoke. 244 women were educated about biomass smoke by midwives; pre- and post-session questionnaires showed major improvements in knowledge of biomass smoke risks by as high as 47.8% in some aspects. The qualitative data showed that participants had made behavioural changes such as staying away from the kitchen while cooking, using dry wood, using solar power for lighting and improved ventilation in their kitchens. Plans for future changes such as saving money to buy clean cookstoves and solar batteries was reported. The major barrier to behavioural changes was poverty. The major facilitators were the 'discovery' of the range and duration of harms from biomass smoke, and that some improvements cost no money.

Conclusions
This project highlights that a programme delivered by midwives is a feasible and acceptable approach to educating mothers and VHTs about the dangers of biomass smoke. Implementing this programme has the potential to reduce exposure to smoke with benefits to mother, foetus, and young children throughout their lives.

Keywords: biomass smoke exposure; respiratory health; antenatal education programme

Introduction

Nearly half the world's population uses solid biomass fuel for heating and cooking.[1, 2] Exposure to air pollution from biomass smoke is associated with a range of long-term health problems, including increased incidence of respiratory infections, asthma, chronic obstructive pulmonary disease (COPD) and lung cancer.[3-8] Globally in 2015, 2.8 million people died from the effects of household air pollution and 4.2 million people from ambient air pollution.[9] COPD is now the third leading cause of death with 3.2 million deaths worldwide and the same number dying from lower respiratory tract infections.[10]

Biomass smoke exposure in children is associated with an increased incidence of acute respiratory tract infections, pneumonia, asthma exacerbations, and impaired lung function.[11] Epidemiological studies have shown a link between indoor air pollution and a range of pregnancy-related complications and poor outcomes such as pre-eclampsia, premature labour, low birth weight, and neonatal deaths.[12] Thus, there is evidence that people of all ages are at risk from biomass smoke exposure. The time when most damage to the lungs occurs is not entirely clear, but from studies on outdoor air pollution, children's lung function impairment occurs in utero and early infancy.[13, 14] To limit the lifelong risk of respiratory diseases, interventions to reduce exposure to biomass smoke during pregnancy are needed.[15] Furthermore, reduction of exposure to biomass smoke among pregnant mothers may also reduce exposure in children who are in close contact with their mothers as they do the cooking.

A number of studies have addressed the impact of reduction of exposure to biomass smoke, many of them focusing on clean cookstoves.[16-18] Few studies have focused on pregnant women.[19, 20] In a large randomised controlled trial in Guatemala, the introduction of cooking stoves with chimneys reduced particulate exposures and was associated with a trend to increased birth weight and a reduction in the incidence of acute respiratory tract infections and pneumonia.[20] Another study in Nigeria noted a reduction in the number of pregnant women with high blood pressure and higher birth weights among women with clean cookstoves.[19] A systematic review of clean cookstoves concluded that there was little consistent evidence of benefits in birthweight and respiratory infections in children.[21] However, the reduction of biomass exposure was not always delivered by the cookstoves and a broader cultural approach is needed for a complex problem rather than a single intervention such as clean cookstoves.[22] None of the studies used a health education intervention to stimulate behavioural change towards reducing exposure to biomass smoke. In a previous study

in Uganda, we have shown that the population is widely exposed to biomass smoke from conception to adulthood, with consequent respiratory symptoms and impaired lung function even in younger non-smoking women.[17, 23]

To our knowledge, this study is the first to focus on a health education intervention delivered by midwives. The aims of this implementation study were to: 1) develop an education programme aiming to teach midwives and other community healthcare workers about the dangers of biomass smoke and how to reduce exposure to mother, foetus and young children; 2) evaluate the benefits of the midwives providing education to pregnant women and postnatal mothers during the routine clinic visits and; 3) assess the feasibility and acceptability of a midwife-led health education programme on biomass smoke and whether implementation was associated with change in knowledge, attitudes and behaviours. The study was part of the FRESH AIR research programme.[24]

Methods

Design and setting

In line with Standards for Reporting Implementation Studies (StaRI),[25] this study had an implementation research design containing both qualitative and quantitative elements which addressed feasibility and acceptability of a midwife-led education programme. The Plan-Do-Study-Act (PDSA) cycle was used in several cycles to test changes in real clinical settings.

The health education programme was implemented in four Health Centre IIIs in Jinja district in South Eastern Uganda. Health Centre IIIs are primary care facilities which act as the first point of care for maternity services (antenatal, intra-partum and post-natal care). They are manned by clinical officers, nurses and midwives. Daily group health education sessions are provided on varied topics including immunization, nutrition, and prevention of mother-to-child transmission of HIV, among others, but none on air pollution/biomass smoke. The health facility team is linked to the communities through unpaid Community Health Workers, known as Village Health Teams (VHTs). The VHTs are members of the communities and trained to provide basic health care and education.

We randomly selected four Health Centre IIIs in the district: Busede, Mpambwa, Lukolo and Wakitaka. The study population consisted of midwives, antenatal and postnatal women, and VHTs in these four sites. All women attending the four maternity clinics during the intervention period were free to participate in the study.

Implementation strategy

An implementation strategy was developed, which led to the design of an appropriate intervention. The implementation strategy involved facilitating, co-developing, and delivery of a midwife-led education programme for pregnant women, postnatal mothers and VHTs about the dangers of biomass smoke and ways of reducing the risks to mother, foetus, and young children. The co-development of the programme involved various stakeholders including midwives, VHTs, pregnant women, the general community and the members of the directorate

of district health services, facilitated by the research team from Makerere University Lung Institute Uganda, and Plymouth University, United Kingdom. The process of co-development built upon previous successful experience of developing education material on lung health for the general population in Masindi district, Uganda during a project funded by Global Bridges.[26] In the Masindi project, the education materials and the education programme were for a general adult audience, and so the materials here were adapted to target messages on reducing exposure to biomass smoke among mothers and children.

Programmatic implementation of the intervention started with collaborative discussion and planning with a core group of midwives to understand their knowledge base regarding biomass smoke and its impact on the health of the mother, the foetus and young children, and seek their input on: (i) the education materials, (ii) the training programme, (iii) the way the programme would be integrated into the routine health education activities at the health facilities.

Development of the educational materials

The process of co-developing the educational materials started with groundwork including stakeholder engagement and visits to facilities and villages. In a series of steps, the education materials were co-developed involving developing key messages, developing a programme and developing supportive materials.

The Intervention

The intervention was delivery of health education messages on the dangers of biomass smoke to pregnant women and postnatal mothers through the regular ante- and post-natal clinics. Women arriving at the study sites were told about the topic for the day. A knowledge questionnaire on biomass smoke was administered before and after the health education sessions. Women who were unable to read and write were assisted by the midwives, who read the questions and choice of answers to them. The midwives then recorded the answers.

The midwives conducted a health education session on biomass smoke using the health education materials in form of flip charts, posters and small leaflets (additional file 1). At the end of the session, the participants were encouraged to ask questions and make comments and these were recorded.

Three months after participating in the health education sessions, a purposive sample of women were invited to participate in qualitative interviews. The aim of the qualitative interviews was to assess for sustained understanding of the messages previously received through the health education sessions at the health facilities, and also explore their intent to effect changes that would reduce their exposure to biomass smoke.

Outcomes

Implementation outcomes

The main outcome of the implementation strategy was health education materials on biomass smoke and its impact on the health of the mothers, unborn babies and young children, approved by the Ministry of Health. The key outcomes included: 1) adoption and reach of the

intervention, i.e. number of sites, midwives trained, education sessions delivered, and women and VHTs being educated; 2) feasibility and acceptability of the intervention through qualitative interviews and stakeholder consultations to capture their experiences with the implementation process and the intervention and; 3) sustainability of the intervention through consultations with stakeholders about wider implementation of the programme.

Intervention outcomes

The major outcomes of the intervention were; 1) changes in the knowledge about biomass smoke and its health impact on mothers, unborn babies and young children among VHTs and mothers, following the training and health education sessions respectively. Questionnaires were developed for this project in parallel with the education materials by the project team and testing the and revising according to feedback and 2) behavioural change intentions to reduce biomass smoke exposures, such as using clean cookstoves and improved ventilation of their kitchens among the women who participated in the health education sessions.

Process outcomes

Process outcomes included the number of midwives trained to deliver the education, the number of women receiving the training during the intervention period April-June 2018, the number of VHTs trained, and the number of VHTs and women attending clinics to complete the pre- and post-test knowledge questionnaires.

Data analysis

Analysis of the implementation strategy was done descriptively, including a summary of the adaptation of education resources, barriers and facilitators of implementation, and context using stakeholder meeting reports, field notes and workshop reports.

Knowledge gained by the women and VHTs was assessed by comparing the scores from the pre- and post-session questionnaires.

Feasibility and acceptability of the intervention was assessed through qualitative interviews with women who attended the health education sessions. The interviews were audio-recorded and transcribed verbatim. A thematic analysis was conducted where all data were coded and themes generated around women's experiences with the implementation process and intervention.

Analysis of data was conducted using NVivo 12.1.1 (QSR International).

Ethics approval and consent to participate

Primary ethical approval was obtained from the Mulago Hospital Research and Ethics Committee, Kampala as part of the FRESH AIR giant protocol (MREC 971). Trial ID: NTR5759. http://www.trialregister.nl/trialreg/admin/rctsearch.asp?Term=23332

Results

Development of implementation plans and intervention

The development of the implementation strategy and intervention started with ground work that involved meetings between the research team and Jinja district health service leaders that included the District Health Officer, Head of Maternity and Child Health Services, Health Education Officer, and Environmental Health Officer. Visits to two Health Centre IIIs and one Health Centre IV were conducted, aimed at discussing the project with midwives and other healthcare workers including clinic officers, nurses, pharmacists, and healthcare assistants.

Specifically, we discussed the range of health education topics conducted in the facilities, the scope of the attendees, frequency of the sessions and whether the healthcare workers thought that health education sessions on biomass and its impact to the health of mothers and children would be important to the health of their community, and if they were willing to participate in such a programme. We also briefly discussed what the healthcare workers knew about biomass smoke.

The healthcare workers also indicated that it was both feasible and acceptable for the midwives to develop education materials for use in education sessions on biomass smoke to antenatal and postnatal women attending clinics. Furthermore, the healthcare workers were unaware about the impact of exposure to biomass smoke to the health of unborn babies, and mainly highlighted the commonly known effects such as lung cancer, asthma, cough and itching of the eyes. However, there was considerable interest and enthusiasm to work on the project in Jinja district.

Developing education materials

Following the groundwork, PowerPoint slides were developed by the research team and experts from paediatrics and obstetrics. The steps in the process are outlined in Table 1. The slide set was evaluated at a workshop (workshop 1 in January 2017) which involved the 11 midwives from the study sites, experts from the District Health Office, Makerere University and the University of Plymouth. The format, contents and methods of education materials were determined by incorporating participants' views. In addition, the main themes of the education materials were agreed upon by the team and these were: 1) definition of biomass smoke, 2) sources of biomass smoke, 3) health effects of biomass smoke exposure to foetus, children and adults, 4) how to reduce exposure to biomass smoke including behavioural change and 5) benefits of avoiding biomass smoke during pregnancy and early life. This led to adaptations in the educational materials as shown in table 1 below.

Table 1: The process of developing educational materials

Steps	**Facilitators (number of participants in brackets)**	**Participants**	**Outcomes**

Workshop 1	Makerere University (2) and Plymouth University (3) District Health team (4)	Midwives	Midwives trained on biomass smoke Draft materials developed in power-point slides
Review	Health education (1) and communication specialist (1)		Messages clarified, materials revised
Review	Ministry of Health (Health Promotion and Education)		Messages clarified, materials revised-flipchart produced
Workshop 2 Testing of revised materials	Makerere University (2) and District health team (4)	All midwives in four Level 3 Health Centres	Trained in use of revised materials and tested them in the field
Site visits	Makerere University (2) and Plymouth University (3) District Health team (3)	Midwives in four Health Centre IIIs	Observation of the midwives delivering the education sessions Group feedback by midwives in all 4 clinics Revisions made messages and content
Review		VHTs and community members including women attending the HCIIIs	Revisions made to messages, images and text
Review	Final review by UK and Makerere University		Minor revisions made
Review and sign off	Ministry of Health		Final documents produced with Uganda Government logo: Booklet, Poster and flipchart

Handwritten notes from the development workshop were collated and used to produce draft education messages. These were then circulated by email to the research team and FRESH AIR experts for comments. Once agreed upon, the messages were converted into draft education materials (Figure 1) by a health education and communication expert. The draft materials were

then reviewed by a team of health education and communication experts at the Ministry of Health who provided further guidance on the content, language and illustrations. More changes were made leading to another draft of materials which were then pilot-tested by the midwives to check understanding of the messages and illustrations, and cultural relevance. Table 2 summarises the main changes that were made.

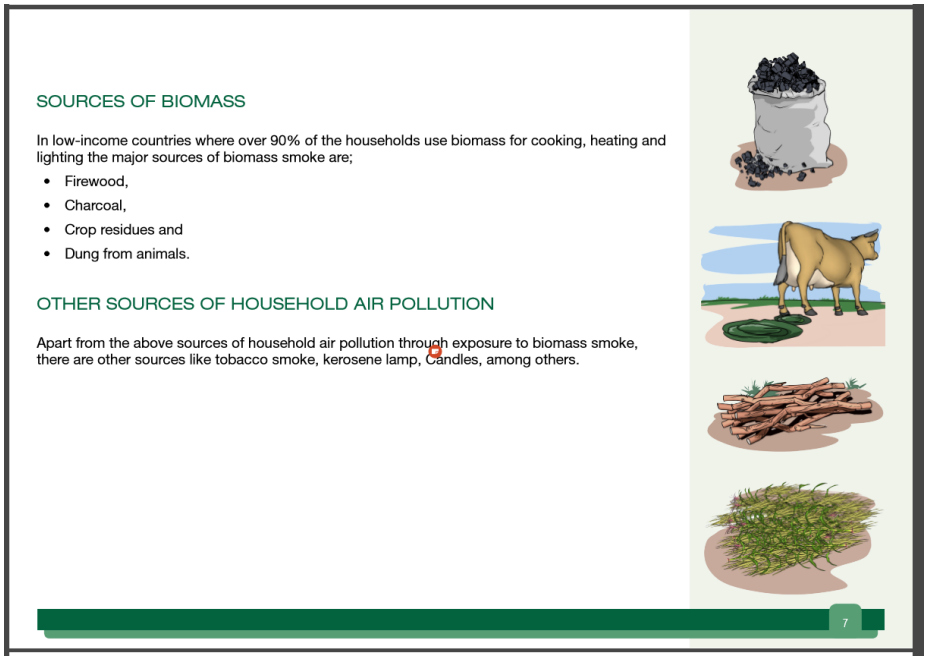

Figure 1. Draft flipchart page showing the educator's view of the image and text

Table 2. Main adaptations of content and delivery of midwife-led education material informed by local stakeholders in Jinja district

Materials should include posters, leaflets and flipcharts
There was a need for two sets of materials, one for educating pregnant or postnatal women and another for training other midwives
The materials for pregnant or postnatal mothers: • should have more pictures than words • be in layman's terms with advice on simple dos and don'ts • should be translated into Lusoga, the local language in Jinja district
The materials for healthcare workers should be more detailed, emphasize key messages and designed as PowerPoint slide sets.
Posters should be kept simple, focusing on effects of biomass smoke (including on unborn babies) and symptoms in children and adults
It was agreed to involve VHTs in the education
The terminology was discussed: to focus on the biomass smoke rather than household air pollution as this was thought to have most relevance to the people to be educated.

The depiction of male and female roles; for example, there was laughter at the picture of a man helping with rubbish as it was felt that this was not culturally appropriate and would not happen
The children's clothes were felt to be too clean in the pictures as most children in the rural villages either wore dirty tattered clothes or none
There was laughter when it was suggested by the midwives that they ask their husbands not to smoke around them
Generally, some pictures were too distressing, misunderstood, or not accurately reflective of real life

Pilot testing of the education material

Pilot testing of the education material was conducted following pre-test guidelines provided by the Health Promotion and Education division of the Ministry of Health. This exercise followed a qualitative approach, informed by focus group discussions with pregnant women, VHTs and general community members (including men) in the target areas of Jinja district. Midwives at all the four selected study sites also tested the materials in their respective routine antenatal/ postnatal education sessions. Feedback from all focus groups and session observations were compiled by experts from Makerere University Lung Institute and shared with the Health Education specialist at the Ministry of Health, who revised the materials to incorporate the proposed changes in line with health policies.

The educational materials were then used opportunistically by the project midwives to teach groups of women in clinics, as often as the midwives could provide it. The women attending these groups were either pregnant or recently postnatal and were attending the health centre for other clinics, for example, children's immunisations.

During stakeholder meetings at health facilities, midwives were observed delivering the education and feedback was obtained from midwives, VHTs, and the local community. Amendments were made to the education materials again to reflect the feedback given, so that the materials were more culturally appropriate. After final changes were made, Ministry of Health approval was obtained for use in the intervention and for national use.

Barriers and facilitators of the implementation strategy

The District Health team and health care workers from the study sites welcomed the collaboration, especially because non-communicable lung diseases were not receiving the deserved attention within the health system. Healthcare workers were not aware of the dangers of biomass smoke on health, but were extremely willing to learn and educate. The positive attitude of health care workers was enhanced by the support from the District Health Officer and his deputy in charge of Child and Maternal Health services. They participated in the visits to the study sites and worked closely with the research team.

The midwives were pivotal in designing and implementing the programme. They were enthusiastic and very involved throughout the project. They collaborated well with other staff within the health facilities in delivering the education sessions.

During the process of co-developing the education materials, discussions explored the possibility of using technology such as iPads or television screens to deliver the sessions but this was thought not to be feasible due to resource constraints. Hard copies of materials were felt to be the most appropriate option, because this is the way in which most public health education is conducted and the midwives felt that there were no barriers to adopting the education materials into their normal antenatal clinic education sessions.

The workshops confirmed our prior experience that educational initiative had to be owned by the midwives and relevant to the community. The community needed to be involved so the mothers receiving the education would be supported by their families, village elders and the VHTs. For example, in one meeting, the male elders and political leaders indicated their willingness and openness to support the changes being promoted by the midwife led education programme, provided they were also informed about it. One commented that keeping children away from the kitchen was not culturally appropriate because they (children) need to learn how to cook. The use of alternative fuel such as charcoal was thought not to be feasible because of expense, but improved ventilation and clean cookstoves were feasible. These views were also confirmed by the midwives using feedback from the women during the health education sessions.

The midwives indicated that the education topics had been understood, appreciated, and recognised by the patients and the community. They were optimistic that the mothers would implement what they had learned provided this was part of a long term initiative, for example for women to acquire better cook stoves with support from the District Health Officer and local organisations such as those providing such cook stoves at subsidised prices.

The Ministry of Health was pivotal in the development of the materials. Through interactions with the project team, the communication and health education experts were made aware of the key messages, the evidence underpinning them, the public health importance, and the way in which they would be delivered. The aims and ambitions of the project were discussed with reference to the protocol. The Ministry expert confirmed that the project materials did not clash with other health education initiatives, and also provided guidance on development and piloting of materials in line with the Ministry of Health guidelines.

The visits to the Health Centres revealed that the education sessions were being integrated well into routine clinic activities. The midwives were experts in teaching the patients and communities, they had very good rapport with the mothers, and the groups were relaxed. The presence of children in the clinics was sometimes a distraction to their mothers, although the midwives were not distracted at all, and engagement and concentration was generally very

high. Some of the women who attended the sessions were visiting the health facilities for other reasons such as child immunisations and general medical care.

Delivering the intervention

The education programme was delivered by midwives to 244 women attending clinics in Jinja district between April-June 2018. Of these, 92 participated in the pre-test while 88 participated in the post-test knowledge questionnaires. In addition, 12 midwives and 42 VHTs were trained on biomass smoke and its health impacts to women, unborn babies and young children.

The midwives were assessed regarding their knowledge about biomass smoke and its health impact through a pre-and post-test knowledge questionnaire. The results showed an increase of the knowledge gained from an average score of 65.5% to 85.5%.

The quantitative assessment showed significant knowledge gaps among mothers regarding biomass smoke and the health of the pregnant woman, foetus and young children. Table 3 below outlines the different knowledge areas assessed to which the participants were asked to indicate 'Yes' if they knew and 'No' if they did not know about it.

Table 3: Proportion of women assessed who selected the option before and after the health education session

Item	**Pre-test N=92 Number (%)**	**Post-test N=88 Number (%)**	**Percentage difference (%)**
Wood as a source of biomass smoke	79 (85.9)	84 (95.5)	9.6
Charcoal as a source of biomass smoke	52 (56.5)	78 (88.6)	32.1
Pregnant women as group most affected by biomass smoke	54 (58.7)	81 (92.1)	33.4
Young children as a group most affected by biomass smoke	57 (62.0)	80 (90.9)	28.9
Pneumonia as a major health problem associated with biomass smoke	41 (44.6)	74 (84.1)	39.5
Premature births as a major problem associated with biomass smoke	24 (26.1)	65 (73.9)	47.8
Reducing time spent near the fire as a way of reducing biomass smoke exposure	60 (65.2)	87 (98.9)	33.7
Avoiding use of wet wood as a way of reducing biomass smoke	57 (62.0)	83 (94.3)	32.3
Improving kitchen ventilation as a means of reducing biomass smoke exposure	34 (35.0)	68 (77.3)	42.3
Using improved cookstoves	35 (38.0)	63 (71.6)	33.6

Using a stove/cooking area with a chimney	29 (31.5)	70 (79.6)	48.1
Add a second adjacent window	27 (29.4)	65 (73.9)	44.5
Keep children out of the kitchen	48 (52.2)	79 (89.8)	37.6
Healthy pregnancy as a benefit of reducing exposure to biomass smoke	56 (60.9)	86 (97.7)	36.8
Healthy baby as a benefit of reducing exposure to biomass smoke	58 (63.0)	84 (95.5)	32.5
Decreased risk of pneumonia as a benefit of reducing exposure to biomass smoke	30 (25.0)	69 (72.7)	47.7
Decreased risk of asthma as a benefit of reducing exposure to biomass smoke	30 (32.8)	69 (78.4)	45.6

In addition, the feedback from the mothers during the sessions indicated specific areas where they needed clarification, such as how biomass smoke causes pre-eclampsia, and how it affects a baby inside the womb. They also indicated changes they wanted to make; the most highly ranked change was improving the cooking area (either by getting improved cookstoves or improved ventilation) followed by reducing time spent in the kitchen. To this effect, they requested lessons/skills on how they could build cleaner cook stoves in their homes.

A total of 42 VHTs were trained about biomass smoke and its impact on the health of pregnant women, unborn babies and young children. All of them filled in the pre-test knowledge questionnaire, and 41 participated in the post-test. Table 4 below outlines the different knowledge areas assessed to which the participants were asked to indicate 'Yes' if they knew and 'No' if they did not know about it.

Table 4: Proportion of VHTs assessed who selected the option before and after the health education session

Item	**Pre-test (N=42) Number n (%)**	**Post-test (N=41) Number n (%)**	**Percentage difference (%)**
Wood as a source of biomass smoke	29 (69.1)	41 (100.0)	30.9
Charcoal as a source of biomass smoke	27 (64.3)	35 (85.4)	21.1
Pregnant women as group most affected by biomass smoke	37 (88.1)	38 (92.7)	4.6
Young children as a group most affected by biomass smoke	29 (69.1)	40 (97.6)	28.5
Pneumonia as a major health problem associated with biomass smoke	22 (52.4)	37 (90.2)	37.8

Premature births as a major problem associated with biomass smoke	13 (30.9)	35 (85.4)	54.5
Reducing time spent near the fire as a way of reducing biomass smoke exposure	27 (64.3)	38 (92.7)	28.4
Avoiding use of wet wood as a way of reducing biomass smoke	25 (59.5)	38 (92.7)	33.2
Improving kitchen ventilation as a means of reducing biomass smoke exposure	25 (59.5)	36 (87.8)	28.3
Using improved cookstoves	24 (57.1)	34 (82.9)	25.8
Using a stove/cooking area with a chimney	26 (61.9)	36 (87.8)	25.9
Add a second adjacent window	18 (42.9)	39 (95.1)	52.2
Keep children out of the kitchen	24 (57.1)	38 (92.7)	35.6
Healthy pregnancy as a benefit of reducing exposure to biomass smoke	30 (71.4)	40 (97.6)	26.2
Healthy baby as a benefit of reducing exposure to biomass smoke	31 (73.8)	41 (100.0)	26.2
Decreased risk of pneumonia as a benefit of reducing exposure to biomass smoke	21 (50.0)	35 (85.4)	35.4
Decreased risk of asthma as a benefit of reducing exposure to biomass smoke	26 (61.9)	37 (90.2)	28.3

21 qualitative interviews were undertaken. Through the qualitative interviews, we assessed the retention of key messages delivered during the health education sessions, and the feasibility and acceptability of the intervention by exploring the perspectives of the mothers.

The interviews indicated that knowledge was gained with regard to the health risks of exposure to biomass smoke for pregnancy, children and adults. Women reported knowledge gained for fuel use, cooking and the kitchen, modifications that could be made to their houses, and the burning of rubbish:

'We learnt that smoke is very harmful to our health and that we should avoid it by using dry firewood which doesn't produce a lot of smoke.' [Mpambwa mother I]

As also mentioned as motivators for attendance, women were motivated to make changes due to the knowledge they had gained and a desire to be healthy. Many women reported changes made to their fuel use, rubbish handling, kitchens, and keeping both themselves and their children away from smoke:

'When the children follow me when am cooking in the kitchen, I get out of the kitchen and they follow me or I stoke the fire and check on the food then stay outside the kitchen while the children go and play. By the time they come back, food is ready.' [Lukolo mother IV]

Women also reported sharing what they had learned with others in the community, and that this knowledge had been implemented by others, although some still stated that it was not taken seriously.

Follow-up interviews are being conducted to assess the longer-term impact of the intervention and a separate paper will detail the combined results.

Barriers and Facilitators and barriers of the intervention

Facilitators

The education sessions themselves were largely well-received, with positive comments made about the education materials, venue, delivery and session length. Some women commented that their motivation was wanting to learn and wanting to be healthy. They were facilitated by having money, having access to transport and having supportive husbands, as reflected in the barriers above.

Barriers

The participants reported some barriers to recruitment and engagement including; being unable to attend due to work responsibilities and having no money to get transport to the clinic. Some women felt that recruitment could be improved if there had been better communication beforehand that the education sessions were taking place. A common theme throughout was the relationship the women had with their husbands; permission had to be obtained before attending the education sessions, or before making changes, with some husbands being supportive and others not.

With regard to the sessions themselves, some women commented that they felt the venue was too small, the sessions too long, and also suggested improvements for the education materials. Suggested adaptations for the programme included making more of the education materials so that more women could benefit during the sessions, and making the venue larger and dedicated to the education. There were also barriers to making changes to reduce biomass smoke exposure following education, the most common being lack of money to modify their kitchen or obtain alternative fuels.

Sustainability of the intervention

The qualitative interviews with the women and stakeholders who gave feedback on the project showed the importance they attach to growing the programme in to a national programme. Critically, throughout the project, there was engagement of stakeholders at the district, health facilities and communities. The Ministry of Health was also heavily engaged in the development of the materials and approved them for use in health facilities beyond the study sites.

Discussion

We demonstrated that it was both feasible and acceptable to implement a midwife-led education programme about biomass smoke exposure rural Uganda. There are plans to roll out the programme to other Health Centres of Jinja district and other districts of the country.

The implementation strategy showed that it was possible to co-develop education material together with local stakeholders that were culturally appropriate and approved by the Ministry of Health of Uganda. Sharing ideas with the District Health Office was a key element in allowing adoption by the local health services. Further, the education programme could be integrated into the routine practice of midwives at four rural Health Centre IIIs in Jinja district. The intervention was successful in terms of outcomes, and stakeholder and patient perspectives. The successes may be related to the involvement and continued interactions of all key stakeholders in the development of the materials and implementation of the intervention. The approach of active engagement with participants has been used in other behavioural-related health programmes such as nutrition, and found to be feasible and acceptable.[27] Quantitative data indicated the programme was successful in changing knowledge of mothers and VHTs about the dangers of biomass smoke exposure to their own lung health and that of their children. The qualitative data indicated this programme was received well by the mothers and VHTs, and that it had the potential to stimulate behavioural changes towards reduction of exposure to biomass smoke.

The importance of the study is that it provides a practical and locally acceptable approach to co-developing a solution as opposed to research that identifies problems. Africa has enough problems. We followed a behaviour change agenda based around work by Michie et al[28] that emphasises identifying both the problem and potential ways to change behaviour at an individual and societal level. Existing research makes it clear that biomass smoke is harmful and the focus of our research was collaborating to find ways to reduce the harm. Controlled trials of interventions aiming to reduce biomass exposure to at risk populations have shown limited success.[17, 29, 30] These studies imposed a single intervention such as improved cookstoves, but in our research the community owned the problem and found a solution from a menu of different approaches. To understand the barriers to making changes to reduce biomass smoke exposure, a comprehensive framework of barriers at different levels may be helpful.[31] Some barriers are difficult to overcome such as poverty, gender inequality, lack of infrastructure, and transport, but many solutions are implementable swiftly and at very low cost.

More work is ongoing to assess the longer-term impacts of the educational programme on reducing exposure to biomass smoke. New ways of sustaining the message are being developed including a childrens' book and an animated cartoon of the 'Smoke Monster' for children and schools with the aim that the messages will come from children to their families to encourage behaviour change.

Finally, a film of the midwife-led education programme was recently completed and has been presented at large conferences and on the Universities' and project websites.[32] This film will be instrumental in informing the development and implementation of other health behaviour-related programmes.

Strengths and limitations of the study

Strengths

The development of the materials and implementation involved a wide scope of experts and stakeholders from policy-makers (Ministry of Health), implementers (District and health facility staff and VHTs) and target population (pregnant women, community members). This approach ensured that the views and perspectives of the different stakeholders were represented in the project, and this lays a good platform for sustainability and scale-up.

Limitations

We were unable to measure knowledge/skills/intentions in the community with a mini-survey due to time and resource constraints of researchers and need for ethics approval.

Conclusions and Recommendations

The results of this project highlight that an educational programme delivered by midwives may constitute a feasible, acceptable, and effective approach to educate mothers and VHTs about the dangers of biomass smoke exposure in rural settings of Uganda. We recommend a community trial to document the health-related outcomes of reducing exposure to biomass smoke.

List of abbreviations

ANC	antenatal clinic
COPD	chronic obstructive pulmonary disease
DHO	district health office
LMICs	low and middle-income countries
PNC	postnatal clinic
VHT	village health team
WHO	World Health Organization

Declarations

Availability of data and material

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

RJ, BK, GN, AB. JKT and RN participated in the conception of the idea and writing the proposal. RJ, BK, RN, SB, LC participated in stakeholder engagement. RJ, RN, SB, JM, SK, LC, collected and analysed the data. SK drafted the manuscript and RN extensively reviewed the first draft. RJ, BK, SB, JM, AB, LC, JP, GN, JKT, SK and LC read and approved the final manuscript.

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