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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.

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

4
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16
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19

20 **Abstract**

21
22 **Background**

23 Biomass smoke exposure is a threat to child and maternal health in many resource-limited countries, as
24 it is associated with respiratory infections, chronic lung diseases and poor pregnancy outcomes. We
25 aimed to assess the feasibility, acceptability and impact of a midwife-led education programme on
26 biomass risks and prevention measures for women attending antenatal / postnatal clinics in Uganda.
27

28 **Methods**

29 Education materials were developed through an iterative process that involved all levels of stakeholders
30 from the Ministry of Health to villagers. The materials were serially tested and improved and finally
31 approved by the Ministry of Health and used with midwives to the women attending clinics and village
32 health teams (VHTs). Feasibility, acceptability and impact were assessed through qualitative interviews
33 with women three months after the sessions.
34

35 **Results**

36 The district health team, 12 midwives and 40 VHTs were sensitized on biomass smoke. 244 women
37 were educated about biomass smoke by midwives; pre- and post-session questionnaires showed major
38 improvements in knowledge of biomass smoke risks by as high as 47.8% in some aspects. The
39 qualitative data showed that participants had made behavioural changes such as staying away from the
40 kitchen while cooking, using dry wood, using solar power for lighting and improved ventilation in their
41 kitchens. Plans for future changes such as saving money to buy clean cookstoves and solar batteries
42 was reported. The major barrier to behavioural changes was poverty. The major facilitators were the
43 ‘discovery’ of the range and duration of harms from biomass smoke, and that some improvements cost
44 no money.
45

46 **Conclusions**

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

51

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

53

54

55

56 **Introduction**

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

64

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

76

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

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

93
94 To our knowledge, this study is the first to focus on a health education intervention delivered
95 by midwives. The aims of this implementation study were to: 1) develop an education
96 programme aiming to teach midwives and other community healthcare workers about the
97 dangers of biomass smoke and how to reduce exposure to mother, foetus and young children;
98 2) evaluate the benefits of the midwives providing education to pregnant women and postnatal
99 mothers during the routine clinic visits and; 3) assess the feasibility and acceptability of a
100 midwife-led health education programme on biomass smoke and whether implementation was
101 associated with change in knowledge, attitudes and behaviours. The study was part of the
102 FRESH AIR research programme.[24]

105 **Methods**

106 *Design and setting*

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

111
112 The health education programme was implemented in four Health Centre IIIs in Jinja district
113 in South Eastern Uganda. Health Centre IIIs are primary care facilities which act as the first
114 point of care for maternity services (antenatal, intra-partum and post-natal care). They are
115 manned by clinical officers, nurses and midwives. Daily group health education sessions are
116 provided on varied topics including immunization, nutrition, and prevention of mother-to-child
117 transmission of HIV, among others, but none on air pollution/biomass smoke. The health
118 facility team is linked to the communities through unpaid Community Health Workers, known
119 as Village Health Teams (VHTs). The VHTs are members of the communities and trained to
120 provide basic health care and education.

121
122 We randomly selected four Health Centre IIIs in the district: Busede, Mpambwa, Lukolo and
123 Wakitaka. The study population consisted of midwives, antenatal and postnatal women, and
124 VHTs in these four sites. All women attending the four maternity clinics during the intervention
125 period were free to participate in the study.

127 *Implementation strategy*

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

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

141
142 Programmatic implementation of the intervention started with collaborative discussion and
143 planning with a core group of midwives to understand their knowledge base regarding biomass
144 smoke and its impact on the health of the mother, the foetus and young children, and seek their
145 input on: (i) the education materials, (ii) the training programme, (iii) the way the programme
146 would be integrated into the routine health education activities at the health facilities.

147
148 *Development of the educational materials*

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

153
154 *The Intervention*

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

161
162 The midwives conducted a health education session on biomass smoke using the health
163 education materials in form of flip charts, posters and small leaflets (additional file 1). At the
164 end of the session, the participants were encouraged to ask questions and make comments and
165 these were recorded.

166
167 Three months after participating in the health education sessions, a purposive sample of women
168 were invited to participate in qualitative interviews. The aim of the qualitative interviews was
169 to assess for sustained understanding of the messages previously received through the health
170 education sessions at the health facilities, and also explore their intent to effect changes that
171 would reduce their exposure to biomass smoke.

172
173 *Outcomes*

174 *Implementation outcomes*

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

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

183

184 Intervention outcomes

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

192

193 Process outcomes

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

198

199

200 **Data analysis**

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

204

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

207

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

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

214

215

216 **Ethics approval and consent to participate**

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

220

221 **Results**

222 *Development of implementation plans and intervention*

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

229
230 Specifically, we discussed the range of health education topics conducted in the facilities, the
231 scope of the attendees, frequency of the sessions and whether the healthcare workers thought
232 that health education sessions on biomass and its impact to the health of mothers and children
233 would be important to the health of their community, and if they were willing to participate in
234 such a programme. We also briefly discussed what the healthcare workers knew about biomass
235 smoke.

236
237 The healthcare workers also indicated that it was both feasible and acceptable for the midwives
238 to develop education materials for use in education sessions on biomass smoke to antenatal and
239 postnatal women attending clinics. Furthermore, the healthcare workers were unaware about
240 the impact of exposure to biomass smoke to the health of unborn babies, and mainly highlighted
241 the commonly known effects such as lung cancer, asthma, cough and itching of the eyes.
242 However, there was considerable interest and enthusiasm to work on the project in Jinja district.

243

244 *Developing education materials*

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

256

257 **Table 1: The process of developing educational materials**

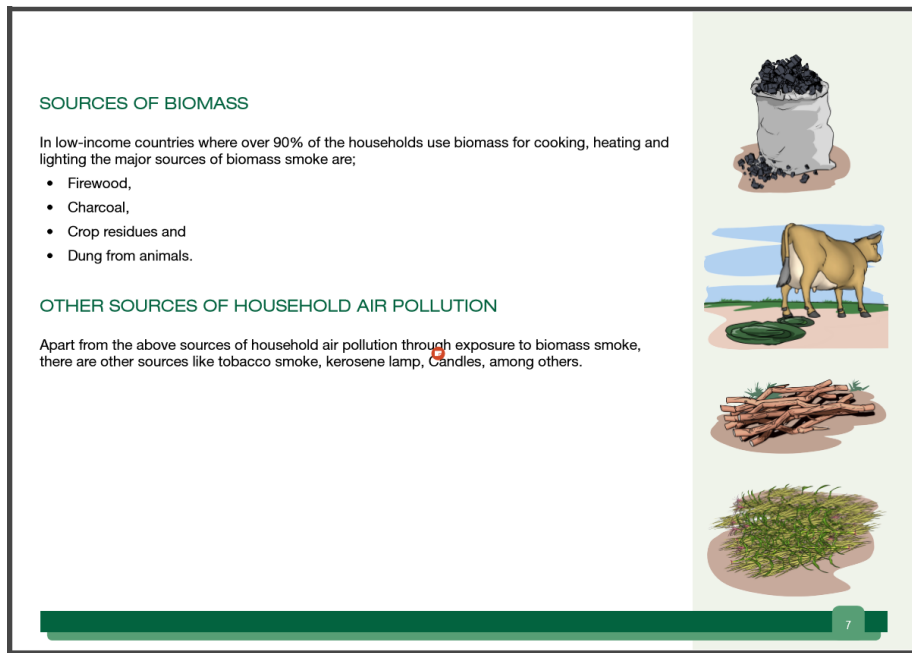
Steps	Facilitators (number of participants in brackets)	Participants	Outcomes
--------------	--	---------------------	-----------------

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

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263

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

264 then reviewed by a team of health education and communication experts at the Ministry of
 265 Health who provided further guidance on the content, language and illustrations. More changes
 266 were made leading to another draft of materials which were then pilot-tested by the midwives
 267 to check understanding of the messages and illustrations, and cultural relevance. Table 2
 268 summarises the main changes that were made.
 269
 270



271
 272 **Figure 1. Draft flipchart page showing the educator's view of the image and text**

273
 274
 275 **Table 2. Main adaptations of content and delivery of midwife-led education material**
 276 **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: <ul style="list-style-type: none"> • 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

277

278

279 *Pilot testing of the education material*

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

289

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

294

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

300

301 *Barriers and facilitators of the implementation strategy*

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

309

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

313

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

320

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

332

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

338

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

346

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

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

354

355 *Delivering the intervention*

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

360

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

364

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

369

370 **Table 3: Proportion of women assessed who selected the option before and after the health**
 371 **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

372

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

379

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

385

386 *Table 4: Proportion of VHTs assessed who selected the option before and after the health*
387 *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

388

389 21 qualitative interviews were undertaken. Through the qualitative interviews, we assessed the
390 retention of key messages delivered during the health education sessions, and the feasibility
391 and acceptability of the intervention by exploring the perspectives of the mothers.

392

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

397

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

400

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

405

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

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

413

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

416

417 **Barriers and Facilitators and barriers of the intervention**

418 *Facilitators*

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

424

425 *Barriers*

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

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

440

441 *Sustainability of the intervention*

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

448

449 **Discussion**

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

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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.

496

497 **Strengths and limitations of the study**

498 *Strengths*

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

504

505 *Limitations*

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

508

509

510 **Conclusions and Recommendations**

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

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517

518 **List of abbreviations**

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

527 **Declarations**

528 **Availability of data and material**

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

531

532 **Competing interests**

533 The authors declare that they have no competing interests.

534

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539

540 **Authors' contributions**

541 RJ, BK, GN, AB, JKT and RN participated in the conception of the idea and writing the
542 proposal. RJ, BK, RN, SB, LC participated in stakeholder engagement. RJ, RN, SB, JM, SK,
543 LC, collected and analysed the data. SK drafted the manuscript and RN extensively reviewed
544 the first draft. RJ, BK, SB, JM, AB, LC, JP, GN, JKT, SK and LC read and approved the final
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546

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551

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556

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