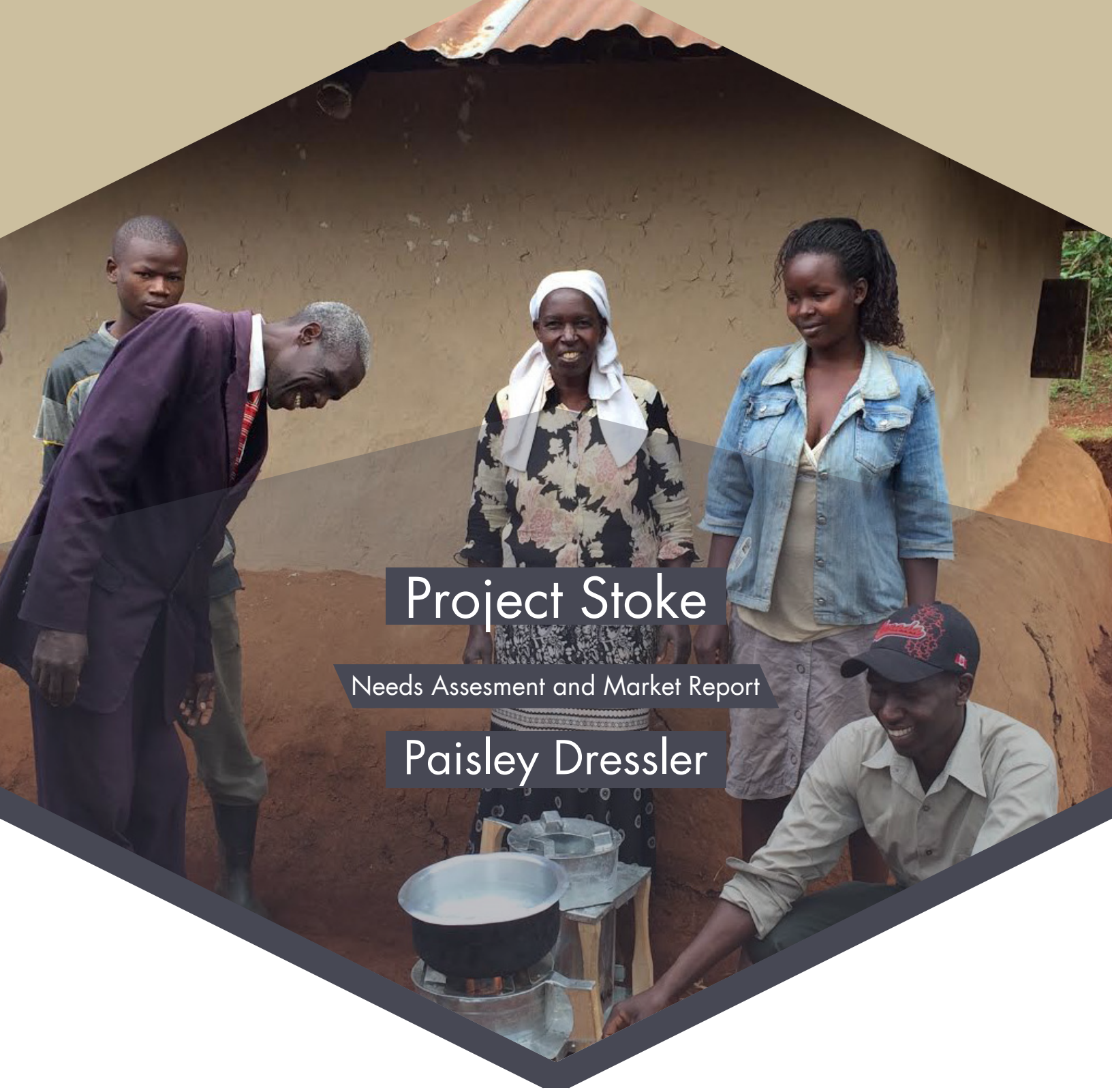

Project Stoke

Needs Assesment and Market Report

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Abstract

Every year millions of people die from smoke exposure from open fires used to cook food in developing countries. Research indicates that smoke is harmful because it contains carbon monoxide and particulate matter, which have both been proven to have adverse health effects in people. These effects are seen most commonly in women and children who spend a disproportionate amount of time in the home. There is a growing movement to find a solution to this global issue including introducing smoke reduced cooking technology. Project Stoke is an organization working in Kenya to create a social enterprise that is building and selling such stoves. Interviews conducted with customers indicate that the stove does significantly reduce cooking smoke and therefore is beneficial to the health of those using it. Although the product has been proven effective there are still a number of cultural barriers keeping the business from scaling and impacting more lives such as food preparation norms and the type of foods common in the region.

Introduction

Smoke from open fires is extremely harmful to the health of the women and children that traditionally cook with, and are surrounded by open fires. The effects are felt differently at each stage of human development, but are the most severe during pre-birth, infancy, and early childhood, as these are the most critical periods for neurological development.

There are however measures that can be taken to reduce the harmful effects of the smoke. There is a growing movement around the world to implement smoke reduced stoves to mitigate the harmful effects of CO and particle matter, the two harmful by-products of cooking with biomass in open systems. Project Stoke has been working in rural Kenya training local tins men to build stoves and training salesmen to sell them in the community. Interviews with 13 customers were overwhelmingly positive with 93% reporting reduced smoke, verifying Project Stoke's product as a solution to the indoor air pollution issue.

This paper explores the way that cooking smoke affects people through different phases of human development; this is important for Project Stoke because it provides evidence that there are better options than open flame cooking that are both culturally relevant and produce better health outcomes, contributing to the business case. Although interviews conducted with Stoke stove owners were positive, there are many challenges associated with introducing new technology into a market. Findings from the interviews show the barriers to stove adaptation and recommendations based on customer feedback and market observations are made that Stoke may be able to utilize in order to overcome these challenges.

Literature Review

According to the World Health Organization approximately three billion people in the world cook and heat their homes with fires and simple stoves.[1] One factor that forces people to continue with traditional and unsafe cooking practices is lack of sufficient access to electricity; there are still over 1.1 billion people in the world without access to electricity.[2] In sub-Saharan Africa the percentage of the population with access to electricity is far below the rest of the world, with 37 countries in the region demonstrating national electrification rates below 50%.[3] In Kenya, where the interviews were collected for this study, only 23% of people have access to electricity.[4] This number deteriorates significantly in rural areas where only 6.7% of people have access to electricity.[5] One of the main implications is the continued reliance on and use of biomass for fuel in open cook fires, or poorly designed cook stoves.

Cooking fires are generally referred to as three stone fires or open fires. In this method, three large rocks with flat tops are placed in a triangle and a fire is lit in the middle of the stones.[6] pot or pan can then be placed on top of the stones to heat the contents. The spaces between the stones allow for more wood to be fed in as needed but also allow smoke and ash to escape as well. Another method is clay or mud being formed into a 'U' shape so a fire can be lit in the center and a pot can be placed on

top.[7] The majority of this cooking is done without any sort of ventilation or chimney. Some foods are cooked on small metal or clay stoves that use charcoal or wood to cook, although they can be faster or use less wood they are not designed to be smoke free. Many people also use gasoline to cook, although the fuel and initial input for the stove can be very costly. This information comes from observations and interviews in rural Kenya.

The negative effects of indoor air pollution (IAP) on people's health caused by these cooking practices cannot be disputed. An ever-growing body of research continues to find links between IAP and many of the prevalent diseases most common in developing countries. Traditional ways of cooking including open fires and traditional stoves tend to be inefficient when combusting solid fuels, which leads to exposure to carbon monoxide (CO) and particle matter that can lead to many health complications.[8] The effects are felt differently at each stage of human development with particularly detrimental effects during more vulnerable stages such as pre-birth, infancy and childhood. The literature tends to contradict itself in the number of deaths that arise as a result of IAP but the range spans from 1.3[9] to 3.8[10] to 4 million[11] annually; the studies do however agree that women and children make up a disproportionately high number of these deaths due to the health vulnerability of children and cultural tendencies of women to do the cooking. The following is a compilation and review of studies showing the neurological and physical consequences of IAP from traditional cooking practices at different stages of human development: infancy, childhood and adulthood.

Even before birth the effects of traditional cooking methods can be detrimental to health. It is estimated that 95% of low birth weight (LBW) babies are born in low-income countries where virtually all of the people that still use traditional cooking practices live.[12] LBW is defined as infants weighing less than 2500 grams at birth and is linked to high mortality in infancy and childhood, as well as chronic diseases into adulthood.[13] One study compares cigarettes and cooking fires in terms of their effects on fetus development because of a common output, carbon monoxide (CO).[14] CO results from the incomplete combustion of biofuels such as tobacco, wood and other common cooking fuels.[15] When in haled CO combines with hemoglobin in the bloodstream creating carboxyhemogloin (COHb), a much more stable compound than hemoglobin on its own, which does not readily give up oxygen to tissues and organs, including the fetus.[16] Any interference with the delivery of nutrients to the placenta- including oxygen- can negatively affect fetal growth.[17]

Several studies have explored the link between maternal use of open fires and biofuels to cook food and low birth weight (LBW) of infants. One study measured the mean concentrations of CO in homes over a 24-hour period and found that it often significantly exceeded the World Health Organization (WHO) guidelines of 9 parts per million (ppm) in an 8-hour period. When researchers intervened with chimney stoves they saw a reduction of CO up to 39%.[18] Out of 534 pregnant women, half were randomly selected to receive a chimney stoves. At birth the infants born to mothers using the chimney stoves weighed an average of 89g more than their open fire counterparts.[19] Another much larger study had similar results. The study analyzed 1,717 women

in three groups: clean fuel users such as gas, stove with chimney users, and open fire users, and found that open fire led to the lowest birth weight of all three groups.[20] There were no links found between miscarriage and open fire groups,[21] however another study that analyzed data of over 19,000 women in India found that women using biofuels were twice as likely to have had two or more still births during their lifetime.[22] This statistic could also be in part due to lower income of families that use biofuels inferring less education and access to medical attention. Although the correlation is strong, the causation is still understudied and requires further research.

In addition to LBW there is a potential link suggesting that the CO and particulate matter (extremely small particles that when breathed in can have adverse health effects depending on their makeup)[23] found in cooking stove smoke can lead to pre-term birth. Pre-term births are a very serious issue in the developing world where 90% of premature infants die just days after birth due to a lack of access to inexpensive treatments and preventative measures available in more developed countries.[24] This is significant due to the fact that nine of the eleven countries with the highest preterm birth rates are in sub-Saharan Africa.[25] Although no studies have expressly looked at in-door air pollution from cooking stoves, the pollutants measured in the study were CO, sulphur dioxide, and nitrogen dioxide, two of which (CO and particulate matter) are also by-products of traditional cooking. Another study looked at 52,113 births in Korea and measured the pollution levels in each geographic area where the mothers lived. It found that relatively low rates of pollution compared to current air quality standards for pregnancy may lead to pre term birth, especially in the third trimester. The University of California found that high levels of carbon monoxide exposure increased the odds by up to 25%, they also found that exposure to particulate matter was also associated.[26] Another study showed that exposure to particulate matter in the first month or final two weeks of pregnancy was also linked to pre-term birth.[27]

In addition to the physical effects, researchers have found a definitive link between neurological development and pollution. Again, no studies have looked expressly at pollution from traditional cooking methods as a contributor to neurological impairment in infants, but the key agents measured in the studies and found in urban air pollution have commonalities with that of cooking fires. One team from the University of California has developed a methodology to test this link and have already completed a small scale pilot with women in rural Guatemala by measuring the pollution in homes using open fires or deteriorated chimney stoves and then measuring the infants, neurological development against the Rapid Neurodevelopmental Assessment cut off points.[28] Many of the infants in the pilot had moderate to severe impairments in 8 domains including motor, speech, behaviour, and vision.[29] Although the sample size was too small to solidify the link, it creates a framework for further testing and it is reasonable to assume the test was being carried out because of a hypothesized link between the cooking smoke and neurodevelopment.

Even into childhood exposure to air pollution can affect child neurodevelopment. Studies have shown a link between behavioral disorders and neurocognitive impairment, although the extent of this relationship is not yet fully understood. CO is one of the most common pollutants and a known neurotoxin, which is a substance

that negatively affects nervous system tissues including the brain. A study in Mexico measured two groups of middle income children aged 9 and10 in one city with low pollution and another with high air pollution levels. It found that the latter had decreased memory, reasoning, and problem solving abilities in addition to increased neuroinflammation and prefrontal vascular lesions.[30] The researchers suggested that this study implies that exposure to open fire cooking may have similar affects because of the toxin's interference in brain pathways that connect to areas regulating cognition, memory and executive functioning which are critical to learning and behavior regulation.[31]

The results of another study that reexamined data of cognitive ability in children in four communities and four age groups (3, 5, 7 and 9 years of age), was consistent with the idea that there are negative developmental consequences to exposure to open fire cooking.[32] These results were seen most strongly in the youngest age groups and decreased as the children got older, which may be because of the vulnerability of younger children due to rapid development phases and the increased time spent around the fires; the three year olds tended to be in the home 25% more than the other age groups tested.[33] Other studies showed the physical effects on children such as lung complications. A study done in rural Venezuela showed a significantly higher number of children with asthma lived in houses where they used firewood to cook rather than gas stoves.[34] Another study showed a reduction in clinic visits for respiratory illnesses by 26% after 90% of homes in a Guatemalan village were equipped with stoves designed to reduce carbon monoxide exposure and wood-fuel use.[35] Reductions for acute lower respiratory illnesses also fell by 45%.[36]

There are more studies on the effects of smoke exposure on women's health than any other demographic. This is likely due to women's primary role in most developing countries as homemakers leading to a higher exposure to cooking fire smoke while they carry out household tasks. Women use fires for household chores such as cooking, heating water, and heating the home. There were no studies found on the cognitive impact for this demographic, which may be because the brain is more or less done developing by the mid 20s and as such the neurological impact would be less pronounced.[37]

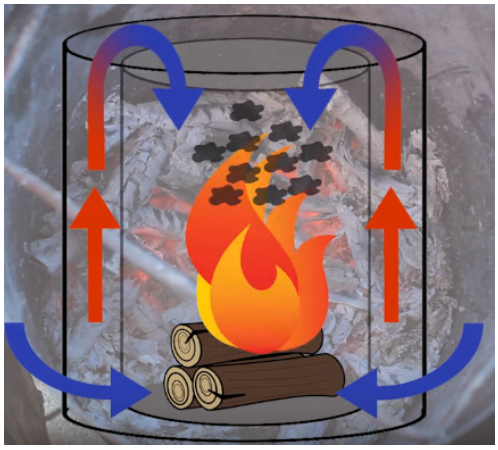
Also as seen in studies with children the neurological impacts of pollution evened out as children got older. There is however a large body of research on its contribution to lung function. The results for all were overwhelmingly negative. One looked at 2 groups of women, one cooking with biomass and the other with alternate fuels, found that the risk of developing bronchitis was 7.6% and .6% respectively.[38] Other lung related ailments positively associated with indoor air pollution were cough (22.6%), phlegm (15.1%), wheeze (25.1%) and, chest tightness (31.4%).[39] A separate study saw a significant reduction of all respiratory symptoms when an intervention trial was conducted that replaced the open fires with stoves that reduced CO emission by 61.6.[40]

At each stage of human development the effects of cooking smoke are felt in different ways. CO and particulate matter are the two outputs of traditional cooking practices that cause the most harm to people exposed to the practice. These effects are most commonly seen in women because of cultural tendencies to do the

cooking, and in young children. The latter group is most directly impacted because of their close proximity to their mothers in the first years of their lives, combined with the vulnerability of their developing brain and lungs. Cooking smoke can lead to life threatening complications like premature birth, low birth weight, and reduced cognitive ability in infants. The neurological impacts may be reduced with age but there are lasting and serious impacts on lung health. It is irrefutable that there are serious health effects to cooking smoke and there is a growing movement to introduce smoke reduced cooking alternatives for those in the developing world still using traditional cooking practices.

The Cookstove Solution

There is an abundance of evidence that smoke from open fire cooking is harmful. In addition to the adverse health effects these fires are often inefficient letting heat escape, therefore requiring a huge amount of wood to cook a single meal. The CO emitted from the stoves is not only harmful to people, but the environment as well. Studies have shown that 21% of black carbon emissions come from the burning of solid fuels from households in developing countries; further evidence shows that clean cook stoves can reduce these emissions by up to 90%.[41] Because of these reasons there is a growing movement towards clean cook stoves. One of the biggest movements is the Global Alliance for Clean Cook Stoves, which aims to bring clean cook stove technology to 100 million households by 2020 to save lives, protect the environment, and create a thriving global market for clean cook stoves.[42]



Project Stoke is another player in the fight against indoor air pollution. Founded in 2015 by a group of University students from Mount Royal University, Project Stoke is a social enterprise operating in rural Kenya that aims to equip households using open fire cooking systems with smoke reduced stoves to empower people to live healthier lives. Project Stoke trains tins men to make Top Lit Up Draft (TLUD) stoves that are then sold in the community by a local sales team.

In traditional stoves the burning of wood forms gases and by-products, but because of uncontrolled airflow they are not completely burned and rise into the air as smoke. A TLUD stove is a smokeless stove that works to control this process. It has 2 cylinders; the inner cylinder is filled with wood with air vents in the bottom. As the wood burns the oxygen comes in through the bottom of the inner cylinder. As it burns, the oxygen flows between the inner and outer cylinders and comes back in at the top, forcing the smoke back in to the flame.[43] This reduces the amount of pollutants given off by the stove allowing people to cook without negative health effects. The stove is used by completely packing the inner cylinder with wood or biomass and lighting it from the top before adding the lid. After lighting the stove it burns for 40 minutes to one hour until all the fuel is used.

In addition to smoke reduction, the technology of the stove allows it to create an output called biochar. As the fuel is being used, the closed oxygen system creates a charcoal-like product. The difference between biochar and charcoal is that biochar is more light and porous, making it a great addition to soil and fertilizer to increase crop yields. It can also be used in as a charcoal substitute in cooking, ironing and heating, although as it is lighter it tends to not burn as long. The TLUD technology used in the stove originated in 2001 when Dr. Thomas Reed created the first prototype, and with some adjustments Dr. Paul Anderson created his own "Champion" TLUD stove that was unveiled in 2005.[45] There has been several variations on this stove, each using the same technology but with minor adjustments on the handles, stands, or other non-essential pieces. The version that Project Stoke uses is called the Quad Stove. This model was chosen because of the built-in wooden stand with handles that make it difficult to knock over and easy to carry even when hot. The stove requires no welding, as such it can be made virtually anywhere that has the raw materials and basic tools.

In addition to the physical product, other considerations need to be made when implementing a successful stove business. As demonstrated by an Ethiopian stove company called Obama Stove, it is important that the community using the stoves feel ownership for the product and that it meet the unique needs of the people. The Obama Stove was created by a former resident of a village in Ethiopia to give back to the community after immigrating to the U.S.[45] It has been one of the most successful stove projects in the world selling over 200,000 units since 2007.[46]

Project Stoke has tried to mimic the practice of community ownership by partnering with local business people to create marketing and sales strategies and transfer the operating decisions to local entrepreneurs so they can respond to community needs more effectively. In January 2016 a member of the Canadian Project Stoke team travelled to Kenya to conduct market research and evaluate the project's success. The following is the results of the study including the most desirable traits of the product, the challenges in using or adopting the product, and recommendations on how to capitalize on the strengths and overcome the obstacles presented in the customer reviews. This will serve as a baseline for the future marketing and sales strategy for Project Stoke.

Methods

Interviews were conducted in person in both Kisumu and Kisii, counties in the western part of Kenya. The interview participants were asked a series of questions and invited to give comments based on their experience using the stove. All of the interviewees either purchased a stove, or

were given a stove from Project Stoke, or partner organizations. Individuals were asked which language they preferred to answer in to ensure the responses were not limited to language proficiency.[47]

There is a moderate to high likelihood of bias in the answers because of cultural tendencies to avoid conflict. Many of the interviewees did not purchase their stoves them selves, which could lead to more favourable responses in an effort to not offend the organization. One interview has been discarded because it was clear to at least one of the interviewers that the responses were scripted to what the interviewee thought would be the most favourable responses. Respondents may have given scripted or positive responses because they perceived such responses would increase their chance of receiving economic benefit from the interviewers. The presence of negative feedback demonstrates that at least some of the interviews were accurate. Measures were taken to verify responses that were unclear or did not translate directly.

Findings

The features of the stoves most attractive to the owners were the smoke reduction, efficiency, biochar production, and ability to move the stove as compared to a three stone fire. Overall the response to the product was positive with 12/13 participants reporting a reduction in smoke, the 13th participant did not mention it in her responses. This verified the effectiveness of the product in smoke reduction and therefore confirmed that the product can help to prevent the serious health effects mentioned in the literature review. Smoke reduction was the most common benefit expressed by the participants although very few specifically mentioned the effect of this on their lung health many did mention the difference it made on their eyes:

"Problems like for normal stoves that uses three stones is that it forces you to keep blowing in the fire to keep it lit. In that process the ashes jump and enter in your eyes irritating it also the increased smoke emitted is easily inhaled and can lead to respiratory problems."

The lack of comments specifically addressing lung function may be because users have not had the product long enough to notice a difference, whereas smoke in the eyes can cause more immediate irritating effects. Also in many cases the stoves are not being used as the sole means of cooking so there is a high likelihood of being exposed to smoke from other cooking methods. Efficiency related to fuel consumption was the second most attractive quality about the stove, the interviewees reported one third to half the amount of fuel used in the new stove compared to an open fire. Further cost savings were realized when the byproduct of biochar was utilized in charcoal stoves. As charcoal is wood that has undergone a process it is more expensive than wood, so reducing the need to purchase charcoal can have huge savings. Some customers reported completely stopping purchasing charcoal and others used the biochar to supplement their charcoal purchases. With these cost savings and a stove sale price of 1000 Ksh (12 CAD) the cost of the stove is recoverable in 5 – 10 weeks depending on the amount of use. It's important to note that the type of fuel used affects the biochar output. Thinner pieces of wood or small pellets may be reduced to ash. For best results thicker pieces of wood need to be used so they maintain their integrity during the cooking process. "It can make

charcoal if we use timber, sometimes I use lighter one that goes to ash." The biochar produced was also used in the owners' gardens:

> "I have tried it and I have noticed significant change. I have used it in growing Papayas and I have seen they are doing okay and they are also growing fast."

Users also reported a pest control element to the biochar:

> "I have used the bio char that emanates from the stove in my farm while growing tomatoes and it has reduced my cost of procuring pest control medicine."

Efficiency in terms of cooking speed was also highly desired, it was even compared to cooking with electricity in one interview, "what I can say, when you are cooking with it, it goes very fast like a gas cooker or with electricity, it is good." Another notable positive comment on the stove was the portability. In times of heavy rain the kitchens can often flood making it impossible to cook on the ground with a three stone fire. The wooden handles allow the stove to be moved even after lighting because they remain cool even when the stove is on. "Sometimes there is small water in the house so you have to carry it out of the house, as compared to the fire, which you cannot move." This is particularly useful during the rainy season, when it can also be hard to find firewood that is dry enough to be used for cooking. The Stoke stove allows people to use small amounts of dry firewood and turn it into charcoal to be used in other stoves.

Even with the positive feedback on the stove, most reported using the stove only one or two times per day with two people using it three times a day and one using it only once per week. Even those using the stove three times a day often used other methods of cooking to supplement their stove use. This is comparable to buying a microwave but still using your stove and oven. It is important to understand the factors that lead users to continue to use other forms of cooking even after purchasing the stove. These include lack of fuel, the quantity and type of food being prepared, and length of cooking that needs to be done.

Lack of fuel as discussed earlier can be a significant challenge, especially during periods of rain. Stove owners are sometimes forced to use charcoal stoves when dry wood cannot be found. The quantity of wood needed to fill the barrel can also be an obstacle, if not enough dry wood can be cut or purchased users may need to buy charcoal which is easier to carry from a market than wood.

During lunch where it is more common to cook for less people while children are at school and have lighter foods like potatoes, vegetables, and plantains, the open fire may be used because it is easier to extinguish. "Lunch needs small quantity of food so we don't need to use it, if we used it at lunch we would remain with firewood." Another interviewee said, "the other challenge as to why I do not use it during day I that when I cook light meals like breakfast, it forces me to put it out which at most times is challenging for me because I use water to put it out. I then take the bio char and dry it to use it later." The opposite challenge can also present itself; when a larger quantity of food needs to be prepared than can be cooked on the stove they may need to use an open fire because it can accommodate any size pot. Some foods also require longer cooking times than the

stove can handle, which was noted by some users. "The biggest challenge is that you have to remove the lid and put more in, I wish it was made in a way that you put the wood in, so you don't have to remove the lid and put it back. You see when you are still cooking and the fire has gone down you have to remove it and refill."

Recommendations

In order to overcome the challenges mentioned and to take advantage of the users' favourite features, four recommendations are suggested.

1. Education and awareness around the benefits, and solutions for the perceived issues with the product

Education is necessary for Stoke ambassadors and sales people so there is an understanding in the market of the negative effects of cooking smoke and the role stoke stoves can play in mitigating health, deforestation and fuel issues. Equipping sales people with statistics such as stove can pay for itself in 5 – 10 weeks and testimonies from other happy stove users is crucial for future sales. It is also important to educate buyers on the technology of the stoves. Some users wanted a stove that could be refilled more easily, but education on the stove's technology to tell them that the biochar is only made because of the closed system, would help them to understand the value better. Creating a training manual would ensure proper and consistent training for all sales people and ambassadors so they are empowered to spread knowledge about Stoke's product.

2. Different sized stoves

It is clear there is a need for different sized stoves in the market to cater to different sized families and foods. Selling larger stoves would also open up the commercial market and allow Stoke to sell to restaurants and vendors.

3. Market penetration will allow for a large enough market to allow for businesses to emerge that cater to the stove's fuel

Once there is sufficient market penetration there will be the opportunity to open up a separate business selling fuel of either compressed biomas briquettes or pieces of wood pre cut to fit the barrel of the stove. Rather than waste energy on the conversion to charcoal people can purchase fuel designed for the stove then use the biochar they produce in cooking.

4. More emphasis on cost savings during sales pitches

The interviews with customers showed that although most people were happy with the smoke reducing benefit, cost savings was their favourite thing about the stove. In places that are consistently becoming more crowded with more strain on the environment, the cost of wood and charcoal will only continue to rise. With average savings of 30ksh/day in wood use and an additional creation of 30ksh in biochar creation that can be used rather than purchasing charcoal provides users with a reduction of 60Ksh/day if they use it at least twice a day in place of the open fire. Marketing pitches should document how quickly individuals can save enough to pay for their stoves in one month on wood savings alone and in half that time if they substitute the biochar for charcoal.

Conclusion

The purpose of this paper was to verify that there are substitutes for open flame cooking. Through the interviews conducted with customers it has been verified that the Stoke Stove not only decreases smoke, but is valued by the customer for its efficiency, biochar creation, and portability. The thorough understanding of the negative effects on open fire user's health, combined with the positive response has verified both the need, and a solution that has the potential for market acceptance in Kenya. Stoke has the opportunity to create a strategy to scale the project in these communities and around Kenya which can be done through education, expanding the product line, a more convenient fuel source, and an emphasis on the cost saving benefits during sales pitches. Through scaling Project Stoke, more people can be reached with smoke reducing technologies to help them live healthier lives.

Endnotes

[1] W.H.O., 2016

[2] World Bank 2016

[3] ONE, n.d.

[4] The World Bank, n.d

[5] The World Bank, n.d

[6] Image 1 Old and Interesting, 2009

[7] Image 2 Old and Interesting, 2009

[8] Thompson et al.., 2011

[9] OECD, 2011

[10] W.H.O., 2016

[11] ONE, n.d.

[12] Thompson et al.., 2011

[13] Ibid

[14] Boy, Bruce & Deldago, 2002

[15] Ibid

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[17] Ibid

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[20] Ibid

[21] Ibid

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[23] EPA, 2016

[24] W.H.O., 2012

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[26] Ritz, Wilhelm, Hoggatt & Ghosh, 2007

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[28] Thompson et al, 2006

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[33] Ibid

[34] Kraai et al, 2013

[35] Ibid

[36] Harris, Weeks, Chen & Layde, 2011

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[40] Smith-Silvertsen, 2009

[41] Global Alliance for Clean Cookstoves, n.d.

[42] Global Alliance for Clean Cookstoves, n.d.

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