Cooking that Kills

The hot equatorial sun is just rising at 5 AM and so is Gloria Elena who is beginning her day in the community of El Fortín, Nicaragua. She wakes to the scene of her home made of sheet metal, wood, and dirt. Her chickens are scattered throughout the home in their hiding places elevated off the ground to keep away from the rampant stray dogs. Busy sounds fill the air as many of the other residents of El Fortín begin their daily routines. It is a normal day in the small rural community and the first act of the day for Gloria is igniting a fire used for cooking her family’s meals for the day.

The fire is started with a piece of throwaway plastic, matches, and wood purchased from a neighbor. Her pots and pans, engineered with hammered-out sheet metal, will be placed directly over the flames. Constant maintenance of the heating source is required from Gloria to keep the blaze fit for cooking. Gloria will repeat this process 3 times each day in order to provide enough beans and rice for living. With every fire constructed and meal produced, she is forced to remain in close quarters to a cooking source filling her lungs and house with deadly smoke.
This is not the story of one woman in Nicaragua, but rather the story of millions of women across the globe forced to use open fires as their sole source for heating and cooking. The World Health Organization estimates 1.5 million people die annually from the silent killer of indoor air pollution. The majority of these women reside in the underdeveloped and developing nations of the world. For them, cooking is not a simple matter of opening the fridge, walking to the microwave, pushing a few buttons, and waiting a minute and thirty seconds. Instead, cooking is a daily process consuming three to four hours of their days and cooking never takes a day off. Groups and nations around the world are combating the global health issue of indoor air pollution inside the home.

In recent years health scientists and engineering groups have collaborated to try to resolve the global health issue of indoor air pollution from biomass combustion. Together they have disseminated several different models of stoves designed to be locally sustainable. Active programs all over the globe are mitigating the health hazard by providing stoves to underprivileged families. The stove designs are made to be less hazardous to the primary users of the stoves by removing the smoke from the breathing area and to be more fuel-efficient by using less wood. A simple chimney can make a substantial improvement on the amount of toxic materials women and children are breathing from the fire. A better-designed heating chamber greatly reduces the amount of fuel required. With common goals in mind, the scientific community has been actively combating a global health issue that involves several other world issues like global climate change, poverty, and the social status of women.

The people using the open pit fires are predominately women. Because their days are completely occupied with cooking for their families there is no time for the pursuit of opportunities outside the home. Education levels of women can be directly linked to the progression of a society in terms of economic growth and global influence. If women are trapped in the kitchen for multiple hours a day it leaves no opportunity for them to go receive an education or hold a job. As long as the social norm of underdeveloped and developing nations remains unchanged to where a woman's place is in the kitchen, nations will never progress into becoming a developed nation. Any simple change to cooking methods would help free up time for women and allow them to seek further life opportunities outside the home.

Gloria has been the primary cook in her home since she was 14 years old. She barely received a second grade education, and her daily routine rarely contains change. She is content with her life and her family, but could there have been anything else existing for her outside of El Fortín? If she
lived in a developed nation she could have gone to college, become a doctor, and found a cure for cancer. However, she will most likely stay in El Fortín and never hold a job outside of her kitchen. If only the opportunity was presented to her to get out of the kitchen and pursue life to the fullest. Simple engineering interventions would free up her time and aid in the advance of women’s status in developing nations. A chimney could better her overall health, and an efficient stove chamber could sustain the health of our planet.

Global climate change has been a political debate ongoing for the past decade. There is no debate that carbon emissions (carbon dioxide and methane) are contributing to the global phenomenon of climate change. A source of carbon emissions often going unrecognized is the carbon being emitted from burning wood. A seasonal campfire does not have a significant influence on global climate change, but a fire producing food and heat for more than 3 billion people everyday makes a tremendous impact and is a significant percentage of total carbon emissions. The essential fire filling households and earth with smoke also forces users to be dependent upon a constant fuel supply.

A typical fuel supply used for open fires is wood. Wood comes from trees, and trees are a gift from Mother Nature transforming a portion of the carbon dioxide from human emissions into oxygen. When the people of underdeveloped nations are constantly forced to use trees surrounding their homes as fuel, it rapidly becomes more and more difficult to find shade in the area. Then the people are subject to purchasing wood from their local logger who has no training on sustainable logging practices or methods. The reoccurring process is causing deforestation on a local level, and the women are left with no other option but to continue using wood as their fuel source.

The global community recognizes all of the issues related to indoor air pollution and, stove-by-stove, is attempting to improve lives and the environment. Change in woman’s health and status will not occur overnight. Through the continued involvement from governments, communities, and individuals a marked bettering of a life can be seen on a microscopic level. As these movements continue to improve and expand, so will the quality of life for the women affected.
An Intervention Project

For the past two years, I have had the opportunity to be involved with such an intervention program as a researcher and field worker with a group from Colorado State University (CSU). In 2008, CSU teamed up with non-profit organization, Trees, Water, and People. The Trees, Water, and People organization’s goal is to promote human health while being globally sustainable. Together we developed a program alongside a Nicaraguan stove manufacturing company, Proleña, and a Nicaraguan women’s group, La Casa de La Mujer, which subsidized 126 cook stoves to families of El Fortín, Nicaragua. The cook stoves were designed to be more fuel-efficient and, more importantly, had chimneys removing the toxic smoke from inside the house.

The CSU research team I participated in was there to specifically assess changes in exposure and health of the women and children in the household. The assessment involved tracking down all of the 126 houses dispersed throughout the dirt roads of El Fortín and collecting health end-points on all of the participants such as blood pressure and lung function. Exposure equipment was left at each one of these homes to determine how much of the hazardous smoke is present in the homes. Our scientific study helped to improve the lives and well being of over 100 families in El Fortín.

The women were exceedingly grateful for their new cook stoves. Their thankfulness was evident through their embrace and hospitality to our research team. A few of the women were brought to tears after seeing our team once their new stoves were installed. The women could not express in words the amount of gratitude they felt towards our team- as many of members of our team did not speak Spanish. Their hugs, kisses on the cheeks, and offerings of what little food they had were many displays observed. The emotional reaction from the women was an unexpected result incapable of description through scientific objectivity. The research team was there to try and have a positive effect on exposures from toxic smoke and scientifically assess hazards of indoor air pollution. We had no idea the magnitude of impact such a project could provide on an individual scale. Each house had a different story, and each house required its individual attention to detail.

When we were at these homes we would pose a series of questions to the women about their health and would ask for their commentary on the new stoves they had received. A response heard from the women was they no longer had watering eyes and their chronic cough had been eliminated.
Many of the women had been cooking on an open pit fire for over 30 years. They had become accustomed to the fact their eyes were constantly watering. Their cough had become engrained into their lives as a part of their daily normal life. With the new stoves installed, they no longer had the constant strain of watering eyes or a cough hindering their capability to take a full breath. A cough and watering eyes is a nuisance to the overall quality of day-to-day life. However, not all women adopted the new stoves nor shared the same feelings about the new stoves.

Cooking in underdeveloped and developing nations is primarily a woman’s activity. Recipes and secrets of cooking are passed down for generations. A long time ago a great grandmother taught the grandmother how to cook, who then taught the mother how to cook, and soon enough the baby daughter will be learning the exact same methods of cooking. If all of these generations were taught on an open pit fire—an alteration to these methods would seem dreadfully strange. Tradition runs deep in cultures and maintaining cultural integrity is of great importance. The tradition of cooking on an open pit can bring back nostalgic memories of the old days or provide certain taste sensations a stove cannot. These types of sentiments and beliefs hinder in the complete adoption of a new stove and prevent the stove from removing the harmful pollutants.

The education level of people, women specifically, in underdeveloped and developing nations is extremely low. Some people may never step foot inside a school. The gap created by education levels makes the explanation of a health hazard to an indigenous population extremely difficult. A common reflection may be, “Why would a fire present for their whole lives be a source of hazardous health effects?” Their parents use to cook their food in this way, and so did their grandparents so it must not be bad. This notion would cause a family to never accept an outside intervention, so they would continue living their lives in the same conditions as the generations before them.

All of these considerations are critical when trying to provide a stove to an indigenous population. The people have to be educated on the dangers of indoor air pollution, willing to accept a change in their daily methods, and ready to start living a healthier life. When these points can be achieved a new stove can finally get to work and start removing the killer smoke from inside the home.
Air pollution from open pit fires

Women using open pit fires are forced to make due with the situations they have presented to them. Their open pit fires do not have built-in fans sucking out all the smells and smoke from the cooking area. This leaves the women at the mercy of their surroundings. Their kitchen could be located in another building, in an adjacent room, or in the middle of their living space. The location of the fire emitting smoke presents a health hazard to the cook as well as those who come in contact with the area. If a lack of air movement in area exists, then toxic substances will remain localized. In many cases, a one-room household serves as the living space, bedroom, and kitchen.

The walls of the kitchen create an enclosure not allowing for the smoke to escape like campfire smoke with the wind. Poor ventilation keeps the smoke entrapped in the house, saturating all of the walls with black soot from the exhaust. Constant recirculation creates an environment promoting the constant breathing and inhaling of smoke. A woman who is forced to live next to the fire and cook for hours everyday on the fire would never be able to evade it, and many harmful materials exist in this smoke that can lead to a laundry list of detrimental health effects.

Wood, coal, charcoal, animal dung, trash, and residue plant matter are common materials used in the construction of fires. When these biomass materials are combusted in a fire, not all of the materials are fully combusted in the flames. This leads to an impartial and inefficient combustion of the materials allowing several toxic agents to be released into the air for respiration. These agents include carbon monoxide, fine particulate matter, and other reactive oxygen species. Together these can lead to detrimental health effects.

The effects of carbon monoxide have been well documented. Every year in popular news, heartbreaking stories are exhibited of entire families who have died in their sleep after they had slept in a
home with a carbon monoxide (CO) leak. These heart wrenching stories have had such an effect it has pushed legislative bodies of developed nations to propose laws which require the installation of a CO monitor into every new house constructed. These laws have been made in an attempt to avoid further tragedies from occurring in the future.

The alarms being installed in new homes are designed to go off at 70 parts per million (ppm). Meaning for every 70 parts of CO present in the air there exists one million (1,000,000) parts of air. Exposure levels in Nicaragua were observed as high as 1300 ppm, and at the average house we saw levels greater than 150 ppm. Carbon monoxide is known to be lethal at levels of 800 ppm.

The reason CO is so toxic to humans is because it has a stronger attraction and hold to hemoglobin than oxygen while in the bloodstream. Hemoglobin is present in the red blood cells circulating the entire body distributing vital elements for cellular life. Hemoglobin is responsible for grabbing a hold of oxygen molecules and transporting oxygen to its destination in the body. Without oxygen we cannot survive. All of the organ systems, organs, tissues, and cells would not be able to function without the presence of oxygen. Therefore, when a person is exposed to carbon monoxide, it takes the place of oxygen in attaching to the hemoglobin because it has a higher affinity, or superior grasp. Once this occurs there is a depletion of oxygen being supplied to the body. Hypoxia is the term used to describe lack of oxygen being supplied to the body tissues, and upon extremely high exposures to CO death will ensue.

The women using open pit fires are being exposed to these lethal amounts of CO, but not for the amount of time required to cause hypoxia. Instead, these women are slowly depleting their entire body of oxygen. Carbon monoxide is acting like a very slow poison in the body. Symptoms these women will feel from the lack of oxygen supply are light-headedness, headache, and fatigue. Chronic low exposure to CO has also been linked to a shortened life span, and its poisonous effects are only amplified in the small children. Carbon monoxide is only one of the poisons present in smoke along with fine particulate matter and reactive oxygen species.

Fine particulate matter is solid material of a very small size. The particles
are less than 2.5 microns or 0.0025 millimeters or 0.0000025 meters. The reasoning behind this sizing designation is because it allows for the particles to be inhaled and travel to the deepest parts of the lung. In the deepest part of the lung lie the alveoli. The alveoli are tiny little air sacs which allow for the exchange of oxygen to occur between our lungs and our blood system.

During the impartial combustion of biomass tons of fine particulate matter is released with the smoke. When the women and children breathe the smoke it enters their respiratory system: meaning the mouth and nose, pathways from the mouth to the lungs, the lungs and the alveoli. Each part of the respiratory system has defenses against foreign particles preventing them from entering the lung.

Most of the respiratory system is lined with mucus capable of trapping particles. Once the particle is trapped in the mucus it can later be expelled with a cough or sneeze. In the deeper pathways of the lung exists special hair-like cells whose function is to push larger particles up the lungs. The minuscule substances move further and further up the respiratory tract until they reach a location where a cough or sneeze could clear the particle. If particulate matter manages to avoid all of these defenses it will travel to this deepest part of the lung, the alveoli.

Once the particulate matter reaches the alveolar destination the ability of the lung to clear itself of the material becomes very difficult. The body will recognize the particles as non-self and will initiate mechanism to try and clear it from the body. Physiological responses would then send immune cells to the particulate matter and these cells would attempt to remove it. This action causes swelling and inflammation of the lungs from all of the cellular activity occurring at the site of deposition of the particle. Once inflammation occurs the lung begins to lose its elasticity from the compromised alveoli, a type of pulmonary fibrosis. The elasticity of the lungs allows for respiration, and the compromised elasticity of the lung makes breathing a difficult task for the person being affected.

Common symptoms observed from the women who have had extended exposure to particulate matter are difficulty breathing while performing activities, a chronic cough, and overall fatigue. Women in Nicaragua mentioned how simple activities like walking down the street to pick up rice causes them to run out of breath. When simple movements become a source of exhaustion, life becomes increasingly stationary. Particulate matter has also been linked to cancer and cardiovascular complications, and still... other items are present in the smoke capable of inflicting harm. A fire is a complex chemical reaction producing thousands of toxic pollutants in the air around us, one specifically being reactive oxygen species.
Reactive oxygen species exist in smoke and can react with all molecules located in the body. While the fire is cooking up dinner several compounds are released in the smoke. As these agents come in contact with oxygen present in the air they become oxidized. Once these items become oxidized they become highly reactive. As these agents are inhaled, their reactivity allows them to react with any other molecule in the body and detrimental effects are capable of ensuing.

A common outcome from reactive oxygen species would be cancer through their disruption of DNA within a specific cell. DNA makes the blueprint and plans for our entire body. DNA is the building blocks for our bodies and cellular function. Disruption of the cellular DNA causes cell death. When a cell dies a series of events occur in order to try and salvage all entities and blueprints within the cell. While this self-preservation is occurring other cells are responding to soak up the salvaged parts from the dying cell.

Self-preservation of the cell would release specific parts of the DNA to the surrounding cells. When another cell uptakes the released DNA it adopts some of the dead cell’s traits. If there were slight mutations present in the DNA it can lead to further death of cells, or rapid proliferation of cells making the cells highly active. If the cell became highly active it could begin reproducing out of control creating a type of cancer. The cancer could then spread itself throughout the body without any defense mechanisms to hinder its reach. Eventually the woman becomes extremely ill because her normal functions of the body become compromised, and eventually death may occur. Cancer of the lungs is in extreme cases of exposures to reactive oxygen species, but current scientific knowledge indicates prolonged exposures may lead to such a cascade of events, like the development of lung cancer in the cooks of the house. Woman of El Fortín do not have the best access to health care, and an undiagnosed widespread cancer of the lungs is a lethal prognosis. Other toxins are present even prior to cooking for the women.

A common way used by the women to start the fire is by first igniting a piece of plastic. When plastics are combusted, volatile toxic fumes are released into the air. The extreme toxicity of these fumes can cause immediate nausea to the person being exposed. Meat packers use to have hot irons next to their work stations were they could wrap a piece of meat in plastic by burning the plastic to seal up the meat. New workers on the job would become ill the first few days of sealing until they developed a tolerance to the toxins, but this acquired tolerance did not mean cellular damage was no longer occurring. Workers who performed this task for several years developed a type of mental
incapacity rendering them not as mentally apt. After the link was made between plastic fumes and the debilitated workers, the burning of plastic was immediately stopped.

This same type of exposure is being repeated every time a woman ignites a fire with a piece of plastic. Granted her exposure is not the same as the workers who were inhaling burnt plastic all day, but development into a mental illness is only a matter of time duration considering their exposure. There is a definite link between a lifetime of burning plastic and gradual loss of mental capacity as demonstrated by the old meat packers.

There are many different chemicals and toxins present in a biomass fuel fire. Danger is present in every breath. A summer campfire presents little hazards as smoke is free to escape into the wild. Conversely, an open fire present inside a kitchen with encapsulating walls occurring three times a day is a health hazard for millions of families. So, developed nations are assisting in providing the simple interventions, like a chimney, to help mitigate these risks and improve the quality of lives for billions around the world. But, no matter how large the global change may be, it all must start at a local level.

A woman’s life changed

Gloria Elena now has her new stove. Her eyes are no longer watering and her cough has been alleviated. Walking no longer tires her as much as it once did and she can feel in her heart the improvement the new stove has had on her life. She now has more free time to perform tasks she desires. It may be too late for her to pursue opportunities outside the home, but the sky is the limit for her baby daughter to attend school and study hard. The quality of life has improved substantially for Gloria and her family who can go on living a life free of smoke in the kitchen.

Similar stories are occurring all over the world. As indoor air pollution gains global recognition as a major health hazard, more stove programs are being initiated. Local movements all over are decreasing the amount of carbon being emitted into the atmosphere through combustion efficiency, economic barriers are being overcome by allowing women to get out of their homes, and the overall human health scope is improving by getting
the smoke out of the kitchen. The human race only shares one globe, and our shared technology can improve the lives of billions who are sharing the same miracle of life like you and me.

A final day group picture with the students and faculty from CSU and our El Fortín volunteers and their children.