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Navajo Healthy Hooghan Project: Reducing Household Air Pollution and Asthma Symptoms in Navajo Nation Children - NTU Testing

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Abstract: Respiratory illness in children has been associated with coal/wood stove indoor heating. The Healthy Hooghan Project (HHP) is a study to determine the level of PM2.5 particles in the homes of families on the Navajo Nation who have children with asthma and who use coal/wood stove heating. An important goal is also to evaluate whether the use of a box fan filter (BFF) can reduce indoor PM2.5 exposures and improve asthma outcomes. This pilot study is funded by the National Institute of Environmental Health Sciences (NIEHS) through the University of Arizona Southwest Environmental Health Sciences Center. A collaboration of Navajo Technical University (NTU), University of Arizona, University of Colorado, and University of California-Berkeley, we designed and manufactured the BFF air cleaner units at NTU and then field tested the systems to develop preliminary data for a future application to NIEHS for a definitive clinical trial to determine if BFF use can improve indoor air quality and respiratory outcomes for Diné children. I was part of the 2022 NTU summer pre-engineering program which educated students in the assembly and distribution of the BFF air cleaners. Then I continued my work and participated in the design and implementation of a digital system to track BFF use. This study was approved by the Navajo Nation Human Research Review Board (NNHRRB) and the University of Arizona Institutional Review Board (IRB).

Keywords: Healthy Hooghan Project; Box fan filter; HHIoT; Purple Air

1. Introduction

The Healthy Hooghan Project is an important initiative focused on improving the health and well-being of individuals in the Navajo Nation by addressing household air pollution [1]. Developed in collaboration with various stakeholders, including researchers, healthcare professionals, and community members, the project aims to reduce the prevalence of respiratory ailments, particularly among children, and promote overall better indoor air quality (IAQ) in Navajo households.

One of the primary goals of the Healthy Hooghan Project is to raise awareness about the health risks associated with household air pollution and provide education and resources to Navajo families.

This includes educating community members about the sources of indoor air pollution, such as traditional wood-burning stoves, improper ventilation, and the use of certain cooking fuels. By increasing awareness, the project seeks to empower individuals to make informed choices and adopt practices that promote cleaner and healthier indoor environments.

The project also focuses on implementing practical interventions to improve IAQ. This may involve the installation of improved cookstoves that produce fewer pollutants, promoting the use of cleaner cooking fuels, and encouraging proper ventilation practices to reduce the accumulation of harmful particles indoors. These interventions are designed to address the specific challenges faced by Navajo households and create sustainable changes that can have a positive impact on the respiratory health of community members.

In addition to education and interventions, the Healthy Hooghan Project emphasizes the importance of data collection and research. By conducting rigorous testing and monitoring of IAQ parameters in Navajo homes, researchers can gather valuable information about pollution levels, identify problem areas, and evaluate the effectiveness of implemented interventions. This data-driven approach helps guide future decision-

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making and ensures that strategies are tailored to the unique needs and circumstances of the Navajo community.

The Healthy Hooghan Project is not only focused on addressing the immediate health concerns related to household air pollution but also on promoting long-term sustainability and community resilience [2]. By collaborating with local organizations and individuals, the project aims to build capacity within the community and create a lasting impact. This may involve training community members in IAQ monitoring techniques, promoting local initiatives for cleaner energy alternatives, and fostering partnerships to ensure the continuation of efforts beyond the project's duration.

Overall, the Healthy Hooghan Project represents a comprehensive and multi-faceted approach to improving IAQ and respiratory health in the Navajo Nation. Through education, interventions, research, and community engagement, the project strives to create healthier living environments and contribute to the overall well-being of Navajo individuals and families.

The Reduction of Household Air Pollution and Asthma Symptoms in Navajo Nation Children (NTU Testing) is a significant endeavor aimed at addressing the challenges of household air pollution and its impact on asthma symptoms among children in the Navajo Nation. Developed in partnership with Navajo Technical University (NTU) and other stakeholders, this project focuses on conducting testing and implementing strategies to improve indoor air quality (IAQ) and reduce the prevalence and severity of asthma symptoms in Navajo children [3].

The primary objective of NTU Testing is to assess and quantify the levels of household air pollution in Navajo homes and its direct correlation with asthma symptoms among children. Through rigorous testing and monitoring of IAQ parameters, such as particulate matter (PM), volatile organic compounds (VOCs), and indoor allergens, the project aims to identify the sources and extent of pollution within households.

Using advanced monitoring equipment and techniques, researchers and technicians from NTU collect and analyze air samples from homes in the Navajo Nation. These samples provide valuable insights into the types and concentrations of pollutants present, allowing for a comprehensive understanding of the indoor environment and its impact on respiratory health.

Based on the findings from the testing phase, NTU Testing implements targeted interventions to reduce household air pollution and alleviate asthma symptoms [4]. This may involve providing education and resources to families on proper ventilation practices, promoting the use of cleaner cooking fuels and technologies, and addressing other potential sources of pollution specific to the Navajo cultural context.

By addressing the critical issue of household air pollution and its impact on asthma symptoms in Navajo Nation children, NTU Testing strives to improve the quality of life for affected individuals and contribute to the long-term health and well-being of the community.

2. Contextual Information

Air pollution poses a significant risk to global health, particularly in relation to respiratory conditions. It contributes to a staggering number of deaths annually, with both outdoor and indoor pollution playing a role. The development and prevalence of asthma, in particular, is influenced by a complex interaction between pollutant exposures and individual factors. Epigenetic changes, oxidative stress, and immune dysregulation are among the mechanisms through which pollutants can induce asthma [5].

The modern Western lifestyle, characterized by urbanization and increased indoor time, has led to greater exposure to polluted air. Children growing up in economically disadvantaged neighborhoods are especially vulnerable to the negative health impacts of pollution [6]. Understanding the principal polluting agents, their emission sources, and the epidemiological and mechanistic evidence linking environmental exposures to asthma is crucial for developing effective policies.

Compliance with international guidelines and regulations, along with pollutant source reduction methods, is essential for managing household air pollutants and reducing the global burden of disease. Raising awareness at various levels and building partnerships can contribute to mitigating household air pollution (HAP) [7]. The effectiveness of strategies aimed at creating healthier household environments should be evaluated in future studies.

Air pollution also plays a role in the development of respiratory allergies, affecting children in particular. Oxidative stress and compromised mucociliary clearance are among the mechanisms involved. Understanding pollutant particle size and air quality index can help assess the extent of airway involvement and guide appropriate interventions. A comprehensive approach involving communities, healthcare professionals, and individuals is necessary to improve air quality and alleviate the economic and psychological burden of respiratory allergies [8].

Research on epidemiological modeling highlights the diverse ways in which air pollution affects child health, including low birth weight, preterm birth, developmental delays, respiratory and cardiovascular issues, and anemia. While efforts such as India's national clean air program are commendable, a coordinated multi-sectoral approach is necessary to minimize the impact of air pollution on child health. Addressing air pollution requires science-backed policies, transitioning to clean energy, implementing emission reduction technologies, long-term governmental commitment, and citizen cooperation [9].

The interaction between outdoor air pollution, particularly ozone (O3) pollution, and the family environment can impact asthma exacerbations in children. Previous studies have focused on stress and its effects, but less attention has been given to support and whether psychosocial factors modify the association between pollution and health outcomes. Findings suggest that O3 exposure may modify the association between perceived support and asthma symptom frequency in adolescents living in high O3 pollution regions [10].

Urban air pollution, particularly in highly polluted areas like Delhi, India, has severe respiratory health effects on children. Comparisons with rural regions reveal the stark differences in prevalence of respiratory symptoms. Assessing respiratory health through structured questionnaires and personal interviews, along with air quality monitoring, provides valuable insights into the impact of air pollution on children's well-being [11].

Overall, these studies highlight the urgent need to address air pollution as a global health crisis. By implementing evidence-based policies, transitioning to cleaner energy sources, and fostering collaborations between stakeholders, we can effectively reduce the adverse effects of air pollution on respiratory health and improve the well-being of individuals, particularly children, in affected areas.

3. Proposed Techniques

The Navajo Healthy Hooghan Project is a significant initiative aimed at addressing household air pollution and reducing asthma symptoms among children in the Navajo Nation. Led by NTU (Navajo Technical University), this project focuses on testing and implementing effective strategies to improve indoor air quality (IAQ) and promote respiratory health in Navajo households.

The Navajo Nation faces unique challenges concerning IAQ, particularly due to the prevalent use of traditional wood-burning stoves and the limited access to modern heating and ventilation systems. These factors contribute to high levels of household air pollution, which significantly impact the health and well-being of children, leading to increased asthma rates and respiratory ailments.

The project's primary objective is to assess and mitigate the sources of indoor air pollution in Navajo households. Through extensive testing, researchers from NTU are examining various factors that contribute to poor IAQ, including the types of cooking fuels used, stove design, ventilation practices, and household behaviors.

NTU is working closely with Navajo families to install monitoring devices that measure air quality parameters such as particulate matter (PM), carbon monoxide (CO), and other pollutants. These devices collect real-time data to provide an accurate representation of the indoor air pollution levels and identify peak pollution events.

Furthermore, the project includes educational initiatives to raise awareness about the health impacts of poor IAQ and promote behavioral changes that can reduce pollution sources. Informational workshops and training sessions are conducted to educate Navajo households on proper ventilation practices, the use of cleaner cooking fuels, and the maintenance of heating systems to minimize pollution emissions.

NTU is collaborating with healthcare professionals and community leaders to implement targeted interventions to improve IAQ and mitigate asthma symptoms among Navajo children. These interventions may involve the installation of improved cookstoves, the promotion of alternative heating methods, and the provision of resources to support sustainable changes in household practices.

Through rigorous data collection and analysis, the Navajo Healthy Hooghan Project aims to evaluate the effectiveness of these interventions in reducing household air pollution and alleviating asthma symptoms among Navajo Nation children. The findings and lessons learned from this project will contribute to the development of evidence-based strategies for improving IAQ in similar communities.

By addressing the root causes of household air pollution and promoting healthier living environments, the Navajo Healthy Hooghan Project strives to enhance the quality of life for Navajo families and ensure the well-being of future generations. Through the collaborative efforts of NTU, community members, and healthcare professionals, this project represents a crucial step towards reducing respiratory ailments and creating healthier homes within the Navajo Nation.

The NTU Electrical Engineering Department helped to design the BFF systems using MIRV-13 filters and household box fans. Using the solidworks software program, it has been very beneficial for the carpentry team and I to continue the design using the ShopBot CNC machine. The NTU team built 10 BFF units to deliver to 10 families residing in Chinle, AZ. If proven in the field, this low-cost intervention could be an important first step to mitigating indoor air pollution and childhood asthma in the Navajo Nation, thus creating a holistic Healthy Hooghan. The enclosed boxed fan filter is low cost DIY project. These BFF air purifiers used at home could be effective at reducing exposure to PM2.5 indoors.

Air cleaning is accomplished by a MIRV-13 filter in series with a household box fan. The HHP BFF also uses two different monitoring systems, a data collection application and an air filtering system. The first system monitors the amount of air pollutants in the air utilizing a Purple Air® (PA) sensor. The second system monitors when the fan is turned on or off using a system based on the Internet of Things (IoT) concept. The NTU EE department created the IOT system including the circuit board and sensors and 3D printed sensor holders to collect data from the Box Fan Filters and designed/implemented the IoT system interface with the internet. The assembled BFF is placed in a wooden box enclosure with a mounted PA system and fan sensing IoT hardware/software system. After the unit is completed, NTU EE tested each system at NTU and had good results within the EE Mod. In the Fall of 2022, the HH Clinical Research Associates began installing the units in the participants' homes.

Healthy Hooghan Internet of Things (HHIoT):

HHIoT shown in Fig.1 combines the power of IoT technology and the goals of the Healthy Hooghan Project to create smarter, healthier living spaces that prioritize indoor air quality and the well-being of individuals, particularly those vulnerable to respiratory illnesses. The hardware monitors when the fan is on/off and at which speed. Data is collected via the cloud.

Fig.1. HHIoT Module

BOX FAN FILTER (BFF):

A BFF is an air filtering system shown in Fig.2 designed to remove indoor particulate matter (PM) from the air. It consists of a box fan and a filter media that captures and traps airborne particles, such as dust, pollen, pet dander, and other pollutants.

The BFF operates by drawing air through the filter media, which effectively captures and retains the particulate matter present in the air. The fan helps in circulating the air and increasing the filtration efficiency. The filter media used in a BFF is typically a high-efficiency particulate air (HEPA) filter or a similar type of filter with fine mesh or fibers that can capture even small particles.

By using a BFF, indoor air pollutants, including PM2.5 particles (particulate matter with a diameter of 2.5 micrometers or smaller), can be effectively reduced. PM2.5 particles are known to be harmful to human health, particularly to the respiratory system, and their removal can contribute to improved indoor air quality.

BFFs are often used in homes, offices, and other indoor environments where there is a need to reduce the presence of airborne particles. They can be portable and easily placed in different areas of a room or mounted to a window or wall. BFFs are relatively low-cost compared to other air purifying systems and can provide a cost-effective solution for improving indoor air quality.

The use of a BFF in the context of the Healthy Hooghan Project aims to evaluate its effectiveness in reducing indoor PM2.5 exposure and improving asthma outcomes, particularly in households that use coal/wood stove heating. The project involves studying the levels of PM2.5 particles in the homes of families on the Navajo Nation and assessing the impact of BFFs on indoor air quality and respiratory health.

Air filtering system that removes indoor particulate matter (PM) <2.5µm diameter.

Fig.2. Box Fan Filter (BFF)

Purple Air:

PurpleAir is a brand of air quality monitors that measures PM2.5 levels and provides real-time data on air quality. Measures the air quality in each environment. Its network of monitors helps individuals and communities monitor and understand the air quality in their surroundings, enabling them to take appropriate actions to protect their health and improve overall air quality.

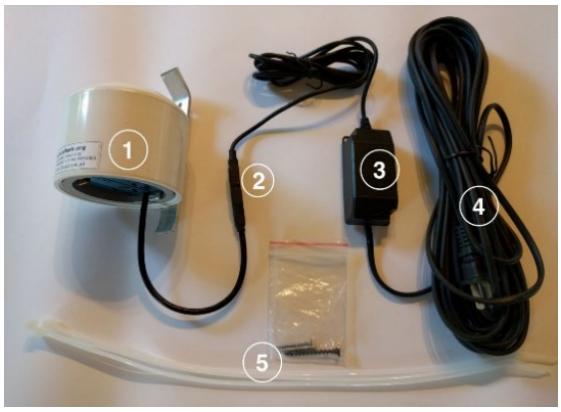
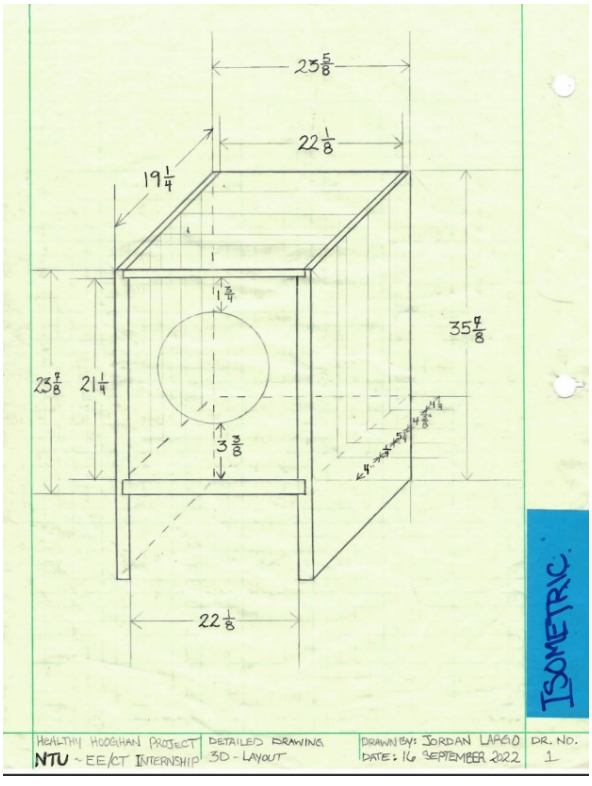


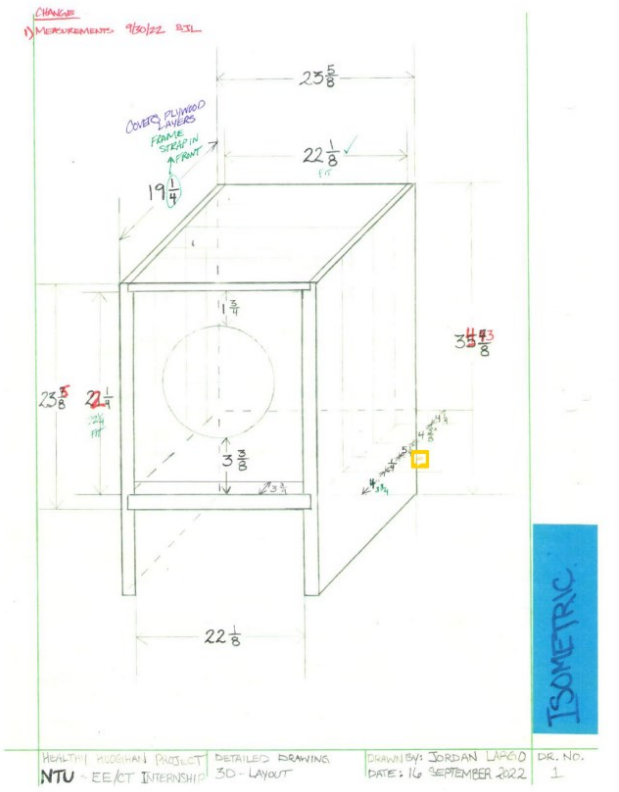
Fig.3. Measure of PurpleAir

Blueprints:

Blueprints of the wooden enclosure box shown in Fig.3 gives the better image in detail. The EE team helped with resizing the box to eliminate any air leaks.



(a)



(b)

Fig 4. Blueprints of the wooden enclosure box

4. Experimental Results

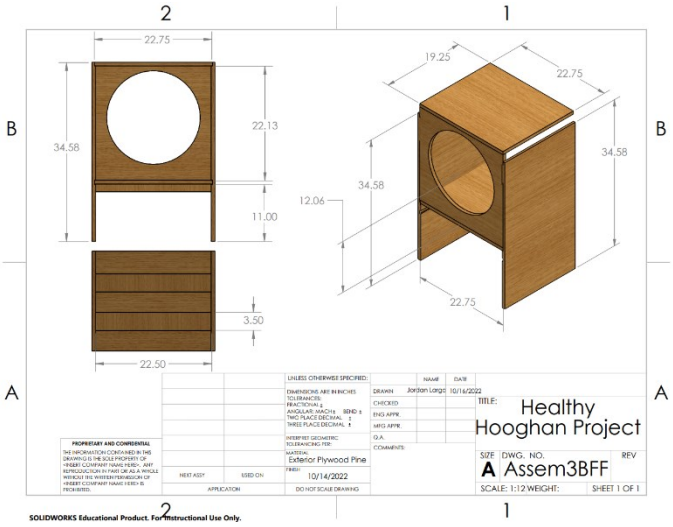
SolidWorks and AutoCAD are both widely used computer-aided design (CAD) software programs that serve different purposes. SolidWorks is a 3D CAD software primarily used for mechanical design and product development. It offers a range of tools for creating and modeling complex 3D parts and assemblies, performing simulations, and generating engineering drawings.

On the other hand, AutoCAD is a versatile 2D and 3D CAD software used across various industries for drafting, modeling, and creating detailed designs. It provides powerful tools for creating precise 2D drawings, architectural designs, and mechanical designs.

ShopBot CNC (Computer Numerical Control) machines are computer-controlled cutting systems used for various woodworking and fabrication applications. These machines utilize CAD files to guide the cutting tool and create precise cuts and shapes on various materials such as wood, plastic, and aluminum. While SolidWorks and AutoCAD can be used to design and create the CAD files for ShopBot CNC machines, each software has its own unique features and strengths. SolidWorks is known for its parametric modeling capabilities and simulation tools, which are useful for designing complex mechanical parts. AutoCAD, on the other hand, excels in creating precise 2D drawings and architectural designs.

To prepare designs for the ShopBot CNC machine, you would typically create or import a 2D or 3D model using SolidWorks or AutoCAD. The CAD file would then be exported in a format compatible with the ShopBot CNC software, such as DXF (Drawing Exchange Format) or G-code. The ShopBot CNC software interprets the CAD file and generates the toolpaths necessary for the CNC machine to cut or carve the material according to the design specifications.

This program has been beneficial to our project time management. We were able to use the ShopBot CNC Machine to speed up the building process.



The hardware model implementation of this prototype is still in the process. We have collected data from several participants. We were able to connect successfully to the purple air sensors and IOT. However, SD card data appears to be more robust and are now being evaluated at UA/SWEHSC.

This pilot study represents an effective collaboration of several academic partnerships and the

contribution of the NTU EE Department has been critical to its success. We continue to analyze data and BFF performance and look forward to reporting the results.

5. Conclusion

The Healthy Hooghan Project (HHP) addresses the respiratory illness risks associated with coal/wood stove indoor heating in children. This study focuses on assessing the levels of PM2.5 particles in the homes of families on the Navajo Nation who have children with asthma and rely on coal/wood stove heating. Additionally, the project aims to investigate the effectiveness of a box fan filter (BFF) in reducing indoor PM2.5 exposures and improving asthma outcomes. The prototype model of the proposed BFF air cleaners was built in SolidWorks AutoCAD. Building on that experience, this work continued to contribute by participating in the design and implementation of a digital system to monitor and track BFF utilization. This program has been beneficial to project time management. The proposed models support to use the ShopBot CNC Machine to speed up the building process.

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