PortaVax

Connecting rural communities with life saving vaccines worldwide.
Overview

HUG Solutions is focused on developing a reusable device that extends the effective storage time for ultra-low temperature vaccines during last-mile transportation. Our product **PortaVax** will improve vaccine access in smaller low-income communities in hard-to-reach rural areas by improving the vaccine cold chain. It maintains the ultra-cold mRNA storage temperature for up to 100 hours without requiring any electricity and uses significantly less dry ice than existing thermal shippers. The robust shell of **PortaVax** protects the vaccines throughout difficult rural transportation conditions. The device has been designed for transporting a small number of vaccines to remote areas with less than 10,000 people.

**Key Terms**

**Cold Chain**: Universal term referring to the temperature regulated vaccine supply chain.

**Jodhpur School of Public Health (JSPH)**: Team of doctors based in Rajasthan, India, that HUG Solutions connected with to get expert input on **PortaVax**.

**Last-Mile**: Refers to the final stretch of the delivery route of vaccines to a specific location, where they will be administered. The distance of this stretch is not actually one mile.

**mRNA Vaccine**: Recently implemented vaccine technology in which mRNA is delivered to human cells resulting in the production of a specific type of protein, which triggers an immune response. Both of the current mRNA vaccines used to fight the COVID-19 virus require ultra-low temperatures for storage.

Table of Contents

The Problem 3
The HUG Solution - **PortaVax** 4
Preliminary Results 5
Initial Requirements vs. Results 7
Looking to the Future 8
The Team 9
The Problem

The COVID-19 pandemic has highlighted the importance of effective vaccine distribution. Many are familiar with the challenges of vaccine roll-out in the United States. From manufacturing to distribution and administration, all aspects of the process seem to have an abundance of challenges. Developed countries have strong internal infrastructure in place to ensure reliable vaccination, even with these challenging issues. However, lower and middle income countries face larger barriers to vaccination, especially in the context of smaller, rural communities.

A crucial piece of vaccine distribution in rural areas of the world is maintenance of the cold chain. Maintaining the cold chain becomes increasingly difficult as the vaccination gets closer to the end user, especially in the “last-mile”. For example, in rural areas, vaccines may be transported to villages in the back of a truck, on a motorbike, or by foot. In these conditions, the use of large scale refrigeration devices is not feasible, yet the vaccines must continue to stay within required temperature ranges.

mRNA technology is emerging as a promising new form of vaccine as it can be quickly manufactured. Two of the COVID-19 vaccines being used are mRNA vaccines, and many future vaccines and other therapeutics will likely be mRNA based technology. These mRNA vaccines additionally challenge the cold chain as they must be stored at ultra-cold temperatures, between -20 and -80°C. Current infrastructure to maintain such low temperatures is only available on large scales or requires reliable access to the electric grid.

Current Solutions

The devices in the existing rural distribution network are designed to maintain higher temperatures.

New state of the art ultra-low temperature coolers cost $7000 - $14,000. This cost may be prohibitive for small rural clinics, and even with the capital to access these devices, many of the rural regions do not have reliable electricity to consistently maintain the temperatures needed.

The thermal shippers currently being used for the COVID-19 vaccine are too heavy to carry and are not robust enough to survive outside of the mass distribution network. The number of vaccines in each shipper is also often too large for a rural vaccination campaign.
The HUG Solution - PortaVax

Our team has partnered with JSPH, who has provided valuable insight on product requirements and design. Our life saving device relies on the cooling power of dry ice to maintain the ultra-low temperatures required for mRNA vaccine storage during transit. PortaVax can maintain these temperatures for up to 4 days, while using only a fraction of the dry ice required in the current transportation of vaccine shipments.

Our thoughtfully engineered and efficiently insulated design allows for the transportation of up to 50 vials of vaccine (250 doses) through extreme environments to reach even the most remote communities around the globe. We believe that PortaVax is an ideal solution to the world’s cold chain challenges when it comes to rural distribution of vital vaccines.

PortaVax truly is portable. It can be carried safely and comfortably in a backpack for access anywhere - whether that be a nursing home in a small town, or a remote village in a developing country, days away from a hospital.

250 doses per device is the ideal number of vaccines for rural distribution. It allows the entire payload of vaccines to be administered upon arrival. If more vaccines are needed or for larger scale distribution, additional PortaVaxes can be transported together on a pallet or in a box.
Preliminary Results

The main objective of our testing this spring was to simulate the operating conditions of the PortaVax device to determine just how long the lifetime of dry ice could be extended and the minimum internal temperature that could be sustained for a significant period of time. (For background, typically coolers maintain a dry ice sublimation rate of approximately 5 lbs for every 24 hours.)

To test these metrics, PortaVax was loaded with vaccine vials, dry ice, and sensing equipment, and was placed in an insulated environment that was designed to maintain a constant ambient temperature (as shown in the photo above). Inside the purple insulation, a space heater was used for maintaining a constant ambient temperature of approximately 27°C. The final round of thermal testing included placing PortaVax in an insulated cooler with regular ice at an average ambient temperature of 4°C to simulate the device being stored in a refrigerator.

*Claire and Evan working together to set up one of the temperature tests.*
The results of his testing were promising. At average ambient temperatures of 27.3°C, 26.2°C, and 4°C, the **PortaVax** prototype maintained an internal temperature lower than -60°C for approximately 3.49 days, 3.54 days, and 4.04 days, respectively.

*Thermal testing showed that at approximately 27°C, the internal temperature does not climb above -60°C for nearly 3.5 days. At 4°C, the internal temperature did not exceed -60°C for over 4 days.*

These results were significant for several reasons. The published storage temperature for the Pfizer COVID-19 vaccine is -70°C ± 10°C. This means that the **PortaVax** prototype maintained the required storage temperature for approximately 3.5-4 days with only 2.5 kg of dry ice. That is plenty of time to deliver and administer 250 doses in an organized vaccine campaign, according to current vaccine distribution information from JSPH.

Although similar, the most recent prototype was not produced with the same materials or manufacturing methods that are planned for the final product. An updated prototype that is more similar to our marketable product will be produced and tested in the field. Wireless temperature sensing, robustness, and user interface will all be addressed and tested with the next generation prototype.
Initial Requirements vs. Results

While maintaining the proper storage temperature for the mRNA vaccines was the focus of this project, we designed PortaVax around several other important factors, summarized below.

**Time & Temperature**
The PortaVax temperature requirement for maintaining the internal temperature (between -80 and -60°C) was initially set for 5 days, based on interviews with JSPH. The current prototype only lasted 3.5-4 days. Therefore, this requirement was not fulfilled by the most recent prototype. However, future iterations of the device will meet the temperature maintenance specifications by increasing the internal volume of the device to hold more dry ice and improving insulation.

**Mass**
The initial mass requirement for PortaVax when fully loaded was specified to be less than 15 kg total, with the mass of dry ice being less than 5 kg. The current prototype is less than 10 kg fully loaded with 2.5 kg of dry ice. This requirement was fulfilled by the most recent prototype and will be easily achieved in future models.

**Robustness**
The initial requirements for PortaVax with regard to robustness were that it had to pass an IP54 (water resistance) test and a 1m drop test. Due to material selection and prototype modifications for thermal testing, neither of these standards were tested with the most recent prototype. The next generation will include both of these tests.

**Estimated Cost for Manufacturing**
The cost of producing PortaVax was initially specified to be less than $400 including material and manufacturing. This requirement was fulfilled by the most recent prototype and will also be satisfied by the final product, which we project to cost $300.
Looking to the Future

We have already made progress in attaining pre-seed funding for our company. HUG Solutions won CU’s New Venture Challenge (NVC). We placed second in the NVC Impact Prize Night and won a small amount of funding from CU Boulder’s Get Seed Funding. Collectively this places the company’s current net worth at $60,000, giving us a lot of forward momentum.

To continue our mission and bring PortaVax to market, we will be seeking additional seed funding investments from government grants and angel investors. This funding will be used for research and development, testing, and manufacturing overhead for a production run. HUG Solutions will market PortaVax to governments and aid organizations working in rural, low-income areas. Based on our partnership with JSPH, we will expand to our beachhead market, the Indian Government, which will distribute these devices to local health clinics. We plan to form more connections with governments and aid organizations, such as the Gates Foundation and USAID, which will allow HUG Solutions to bring PortaVax to the global market. The primary end user of PortaVax is the rural health clinics that serve populations without access to electricity (770 million people in 2019 and predicted to be 600 million in 2023).

HUG Solutions has filed provisional patent applications for PortaVax and is patent pending. Over the summer we plan to enter our company into CU’s own startup accelerator Catalyze CU. Additionally, we plan to get PortaVax into the hands of doctors at JSPH to get more feedback for the development of our next prototype.
The Team

HUG Solutions was co-founded by five mechanical engineering students with extensive global engineering and business experience. This experience and the support of mentors and advisors with expertise in medical device start-ups, entrepreneurship, design, and manufacturing, has equipped the team with a wealth of knowledge and drive to take PortaVax to the next level. Our advisors include Dr. Param Singh, an inventor of the first artificial human heart, and Tim Ruybal, a plastics expert working at one of the best plastics manufacturers in the country, right here in Colorado.

Claire Meyer  Project Manager
Claire was the Project Manager for Engineers Without Borders CU Guatemala where she led the design and implementation of a water conduction project in rural Guatemala and worked as a research assistant studying the contributors to air pollution in Ghana. These experiences taught her how to work internationally, the difficulties of working in rural communities, and how to navigate a team through unexpected challenges.

Evan Kirk  Logistics Manager
Evan has been involved with Engineers Without Borders CU Nepal for the majority of his undergraduate career, worked as a part time research assistant in the CU mechanical engineering department studying the impact of the COVID-19 stay-at-home order on outdoor air quality, and has experience working as a nurse assistant. These were all critical drivers for coordinating the project logistics and motivating the team to focus on global healthcare accessibility.

Brayden Shelley  Financial Manager
Brayden brings his entrepreneurial vision and drive to develop HUG Solutions into a global tech company. His wide skill set ranging from design to finance to engineering management provides a strong basis to build upon. Paired with his experience as a three-time exchange student and world traveler, his minor in Global Engineering taught him how to work internationally with people of various cultures.

Erik Skooglund  CAD & Manufacturing Engineer
Erik is our lead manufacturing and CAD engineer. He brings an eye for design and knowledge of manufacturing, having worked in the manufacturing industry for almost 2 years. He enjoys working with SolidWorks and other CAD programs and has a passion for learning how to turn ideas and computer models into physical prototypes and products.

Gary Yu  Systems & Testing Engineer
Gary contributes his skills on both the engineering and business sides. He shares his vision as an entrepreneur and applies knowledge from both the business minor and his other start-up into product development. His engineering skills have aided the team throughout the testing process. His multi-cultural background provides him a mindset to think globally.