

## **Problem statement**

My grandmother was 77 years old, when diagnosed with COVID 19 pneumonia, in April 2021. After being hospitalised, while she showed initial improvement, her condition deteriorated. Admitted to the ICU, she was intubated due to respiratory distress. She was also diagnosed with seizures and neuromuscular weakness.

On 6<sup>th</sup> June she was put on invasive mechanical ventilation and on 14<sup>th</sup> June, Tracheostomy as her condition required long-term mechanical ventilation.

Due to prolonged mechanical ventilation and neuromuscular weakness, she was unable to speak or communicate through writing.

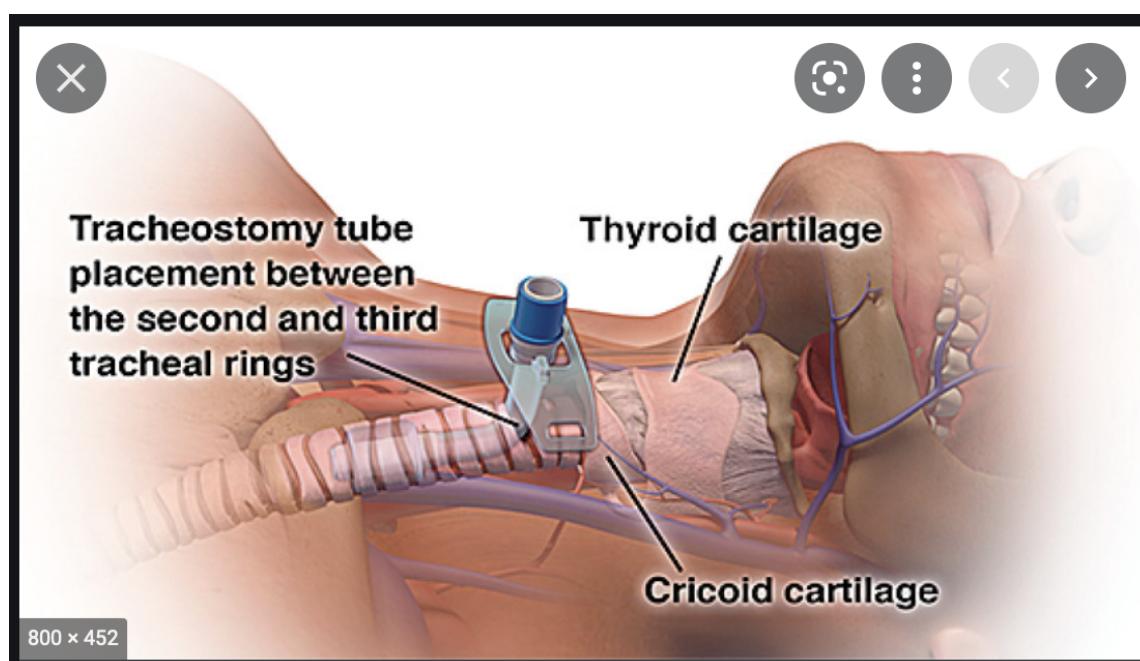
**Communication is an important expression of living.** It facilitates recovery and is critical for the psychological well-being of the patients. Inability to communicate can cause frustration, foster anxiety and fear, creating a feeling of isolation. It can also compromise the medical treatment because patients are unable to effectively describe their condition or problems.

I wanted to aid her recovery process through providing a solution that would help her communicate with family members, doctors, and nurses

## **Why is she not able to communicate?**

### **Tracheostomy**

Patients with Tracheostomy find it extremely difficult to speak. For a normal person speech is generated when air passes over the vocal cords at the back of the throat. But after a tracheostomy most of the air passes through the tracheostomy tube, then through the vocal cords.



The average time for mechanical ventilator liberation varies, based on the severity and type of illness or injury, but typically ranges from 16 to 37 days after intubation, for respiratory failure. If the patient fails to wean from ventilator dependence within 60 days, they will probably not do so later.

As mechanical ventilation weans off with lungs getting cured, there are devices and techniques for redirecting airflow to produce speech. Depending on the type of tube, width of trachea and condition of voice box, patients may be able to speak with the tube in place. Usually a speech therapist or a nurse trained in tracheostomy care, can suggest options for communicating and help train the patient to regain speech.

My grandmother's medical condition was indicative that it would take long before she could start speaking again.

### **Why could she not communicate through gestures?**

On 12<sup>th</sup> June an MRI of the brain showed acute infarcts from which it could be inferred her altered mental state and neuromuscular weakness. She was given a broad spectrum of antibiotics for Sepsis treatment, which also led to intermittent Gastrointestinal bleeding, making her weaker.

Prolonged treatment in the ICU, affects the patient's limbs and respiratory muscles movement. For my Grandma the age factor, lung damage due to covid and comorbidities made her condition more vulnerable. While she had a physiotherapist visit her thrice a day for faster mobilization along with neuromuscular electrical stimulation, the pace of recovery was very slow. Neuromuscular weakness also made gesturing difficult for her, thus hindering even that form of communication

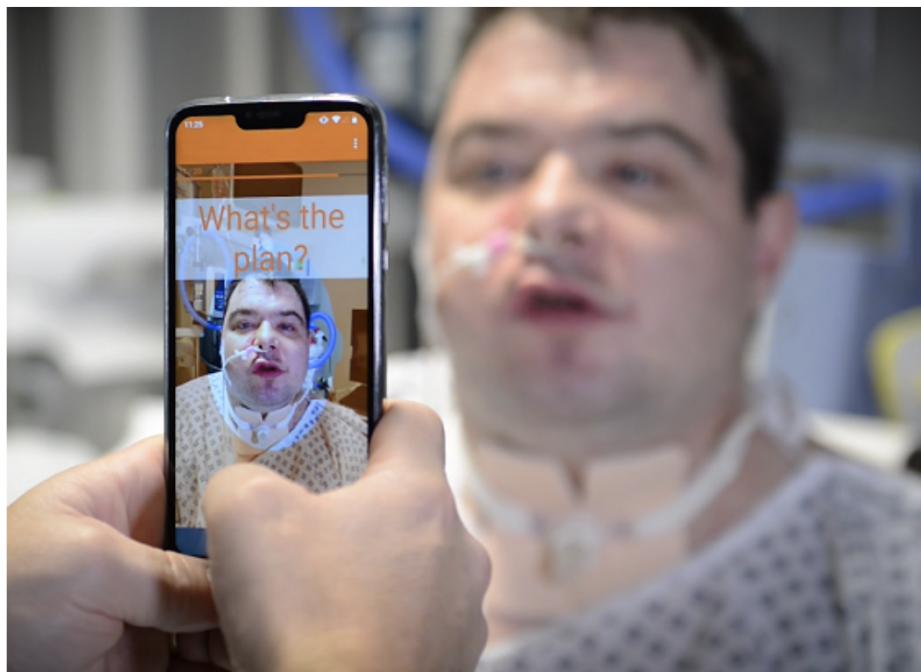
### **What about basic communication?**

#### **Lispings**

While meeting family members my Grandma tried very hard to use hand and lips movement wanting to communicate, but all in vain. Her anguish and frustration at not being able to speak was very visible.

We appointed two dedicated ICU nurses to attend to her 24 x 7. As trained nurses, they had a basic understanding of lip-reading translation. While they were not very proficient lip-readers they were able to decipher a few things my grandma wanted to express. Lip reading is more easily done when intubated via a tracheostomy rather than through endotracheal tube because then the lips are unimpeded.

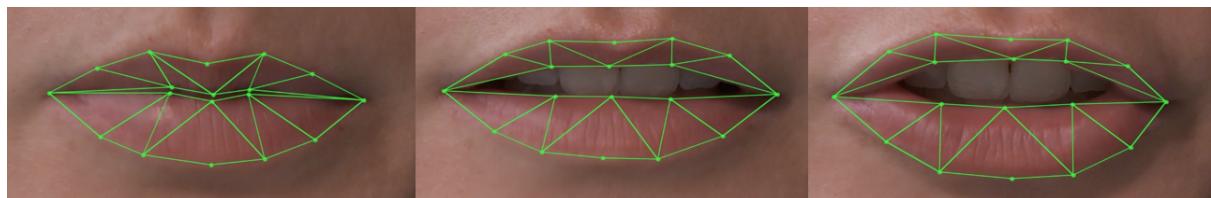
Research helped me identify other Lip Reading Translations (LRT) mode which could be used.. One such tool was SRAVI



**SRAVI (Speech recognition App for the Voice Impaired)** can recognise specific phrases by analysing lip movements. It can be used for communication without sound - especially for people with speech difficulties.

SRAVI is a mobile app that records a video of you mouthing a phrase. SRAVI was made through a partnership between [Liopa](#) and Lancashire Teaching Hospital Trust.

Using Liopa's lip reading technology, SRAVI is able to convert your silent lip movement into text for a carer or a family member to understand.



SRAVI helps communicate with people in an efficient and natural way. It can currently recognise 20 phrases, but this list can be expanded up to 50 and customised for different occasions.

SRAVI is being trialled in a pilot study with patients who have tracheostomies with the Lancashire Teaching Hospitals NHS Trust. The project is led by Consultant in Critical Care and Anaesthesia, Dr. Shondipon Laha. (<https://www.sravi>)

## My Work

I am working towards creating a device using ergonomics – like an iPad or a touch-board, which will help Tracheostomy patients like my grandmother, express basic needs with ease and minimum effort.

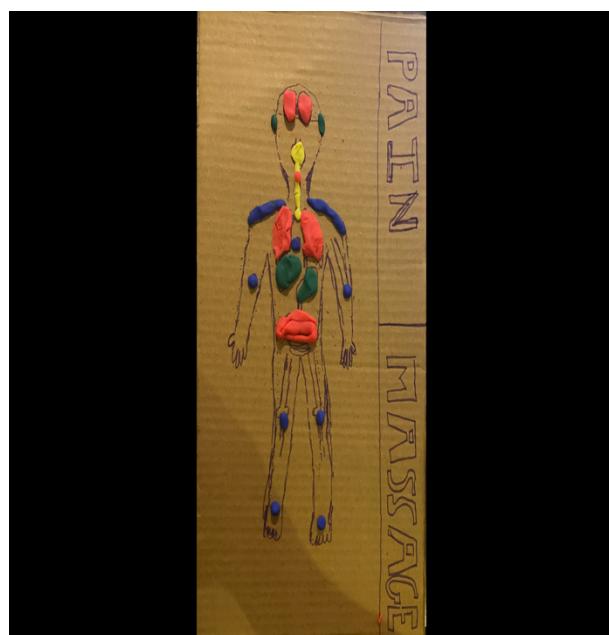
Having observed patients with tracheostomy, speaking to hospital nurses, and through my regular interaction with those affected by it - I realized that around 20% of the patient's vocabulary covers more than 80% of what they want to convey.

If I can create a device through which such patients can convey this 20%, then their communication will become much simpler. The device will be able to incorporate the most frequently used expressions and communication needs, such as – water, food, change body side, change diaper etc. It can even express emotional levels as - pain, helplessness or wanting love.

With mentoring from Maker's Asylum, I was able to follow a pragmatic approach to tackle this problem. Important considerations for the Project included:

### **Empathy**

An empathetic approach was critical as the project and outcomes were centred on patients in the ICU. I tried to gain understanding of the problem, while sitting with my grandmother for hours and also observing the needs of other tracheostomy patients in the ICU. Speaking with doctors, nurses and physiotherapists also helped me define the problem statement and potential outcomes.



(Physiotherapy was key part of her daily routine )

## **Brainstorming**

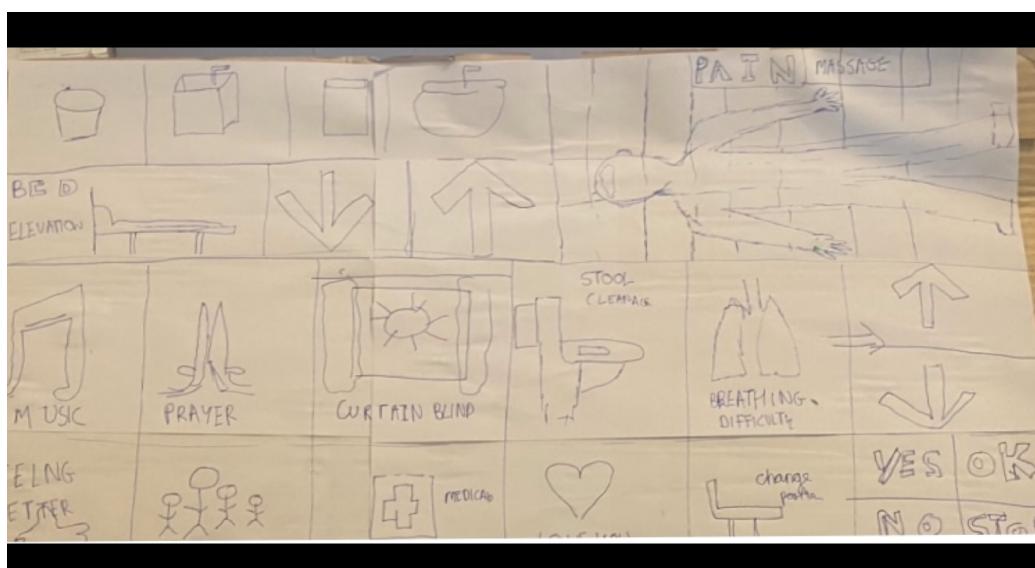
Patients in critical care face multiple challenges. They need constant life support equipment & medication. Having consulted with doctors and nurses about my grandma's physical & emotional needs I realised here "Less is more". That meant we needed to work towards capturing maximum output /communication with minimum inputs.

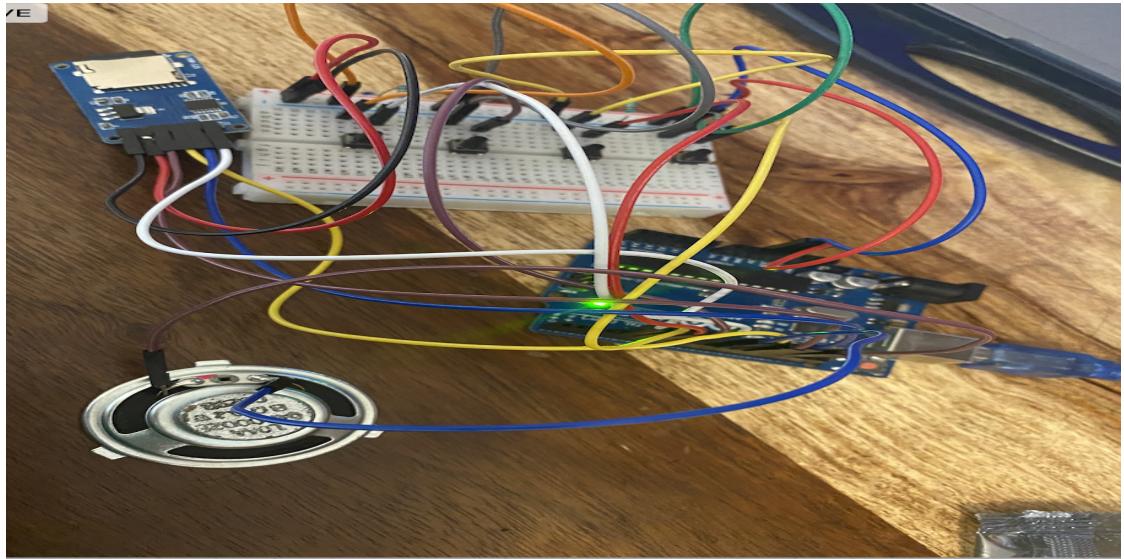


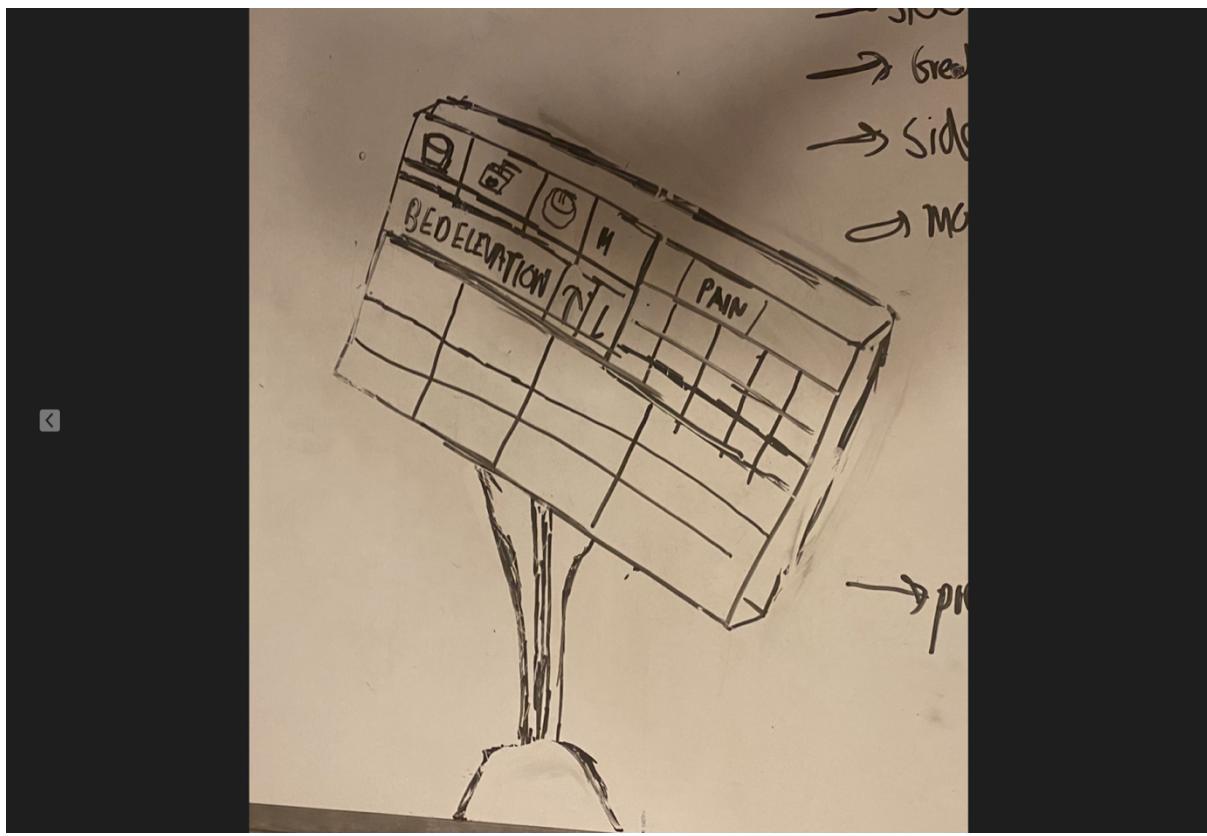
(Iterating to Cover 20% of vocabulary – LESS IS MORE)

## **Ideating**

Due to sepsis and GI bleeding, my grandma would be sedated for hours if not days. Through inputs from her nurses and observing her closely in the few hours she would be awake, I tried to capture the key requirements. Then validated these requirements through multiple conversations with doctors, nurses and family members of other patients







( First Rough Sketch of Device)

Capturing key commands which could be used by my grandma and ICU patients, on a rough sketch needed detail thinking. Unlike in other tabs where the design focus is on being sleek and to get a cool look, my focus was to create a design which was convenient to use and sensitive to the shaky hands of patients. It was important to have a large font size and big buttons to make it user friendly.



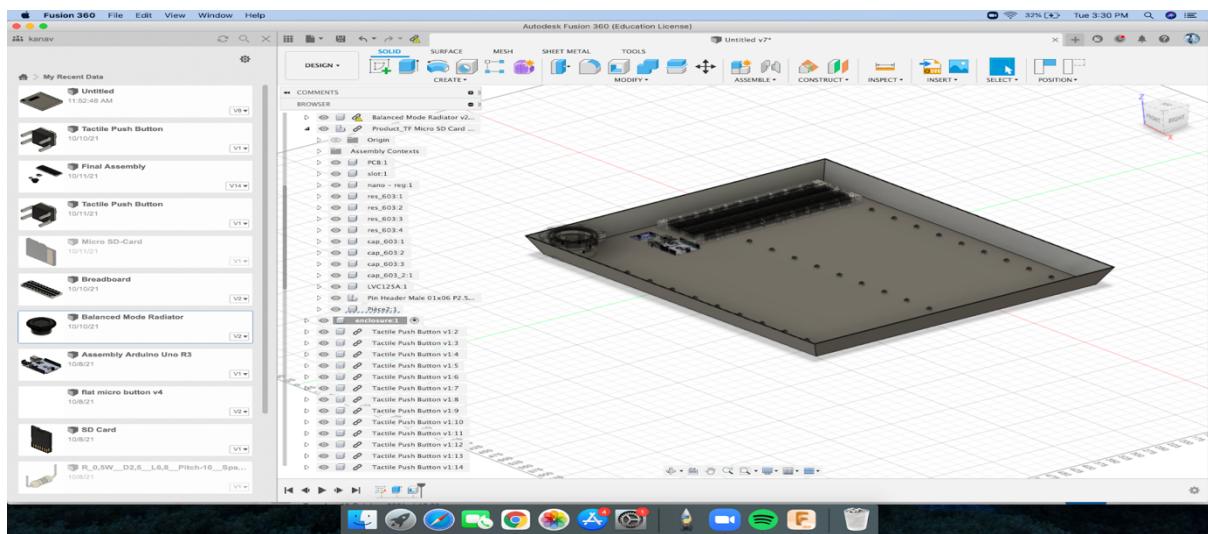
## **Prototyping**

YES	0	1	2	3	4	5	6	7	8	9	NO
New word	A	B	C	D	E	F	G	H	I	J	Start over
It starts with....	K	L	M	N	O	P	Q	R	S		I don't know
STOP	T	U	V	W	X	Y	Z				Thank you
HELP	Hungry	Hot	Hello		Cold	Thirsty		PAIN			
Suction	Bathroom	Bed Up	Bed down		Doctor	Nurse		Family			
Thank You	Toothbrush	Comb	Can't Breathe		Glasses	TV		Please			

(Crystallizing the vocabulary )

## **DESIGNING USING CAD-Fusion 360 :**

I worked on designing the prototype of the project using Fusing 360 and made a virtual model. I also worked on the prototyping and code of the project and over time kept improving the prototype.



(Pulling all the pieces together)

```

WavSW_ino | Arduino 1.0.3
File Edit Sketch Tools Help
WavSW_ino
#include <SD.h> // need to include the SD library
#define SD_ChipSelectPin 4 //using digital pin 4 on arduino nano 328
#include <TM8Pcm.h> // also need to include this library...

TM8Pcm tmrpcm; // create an object for use in this sketch
//char mychar;
int SW1;
int SW2;
int SW3;
int SW4;
void setup(){
pinMode(14,INPUT); //Define A0 as digital input.
pinMode(15,INPUT); //Define A1 as digital input.
pinMode(16,INPUT); //Define A2 as digital input.
pinMode(17,INPUT); //Define A3 as digital input.

tmrpcm.speakerPin = 9; //11 on Mega, 9 on Uno, Nano, etc

if (!SD.begin(SD_ChipSelectPin)) { // see if the card is present and can be initialized
return; // don't do anything more if not
}
tmrpca.volume(1);
tmrpca.play("1.wav"); //the sound file "1" will play each time the arduino powers up, or is reset
}

void loop(){
SW1=digitalRead(14);
SW2=digitalRead(15);
SW3=digitalRead(16);
SW4=digitalRead(17);

if (SW1 == LOW) { //if SW1 pressed then play file "6.wav"
tmrpca.play("6.wav");
} else if(SW2 == LOW){ //if SW2 pressed then play file "4.wav"
tmrpca.play("4.wav");
} else if(SW3 == LOW){ //if SW3 pressed then play file "5.wav"
}
}

```

Done Saving.

(coding the key aspects )



Having worked on this project for over 6 months now, it is very close to completion. The journey of making this project, from working on the basic problem statement to building a working model, was a very emotional one. I started this project with my grandma in mind.

Though she is no more, I really hope that in the future this will bring some comfort to other tracheostomy patients in the journey of their recovery.