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Oral Therapeutic Tool for Speech and Feeding Therapies

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Outline

- Introduction
- System Model
- Our Approach
- Results
- Conclusion

Introduction

- One in twelve children ages 3–17 has had a disorder related to voice, speech, language or swallow in the past 12 months
- Only half of them receive proper intervention

How to Address Problems

- **Feeding therapy** helps children who have difficulties in sucking, chewing, feeding or swallowing.
- **Speech therapy** is a treatment to problems with the actual production of sounds or problem understanding or putting words together to communicate ideas.
- The sooner these problems are addressed for children, and they are treated, the better they grow and have better outcomes.

Problem

- Speech and feeding disorders can only be identified until children have reached the ages at which various speech and feeding abilities are expected.

- Children under the age of approximately 30 months to 36 months are often difficult to evaluate because they may be reluctant or unable to engage in formal standardized tests of their speech and feeding skills

Current Solution

- Parents' observation
- Doctors' recommendation
- Biological Tests

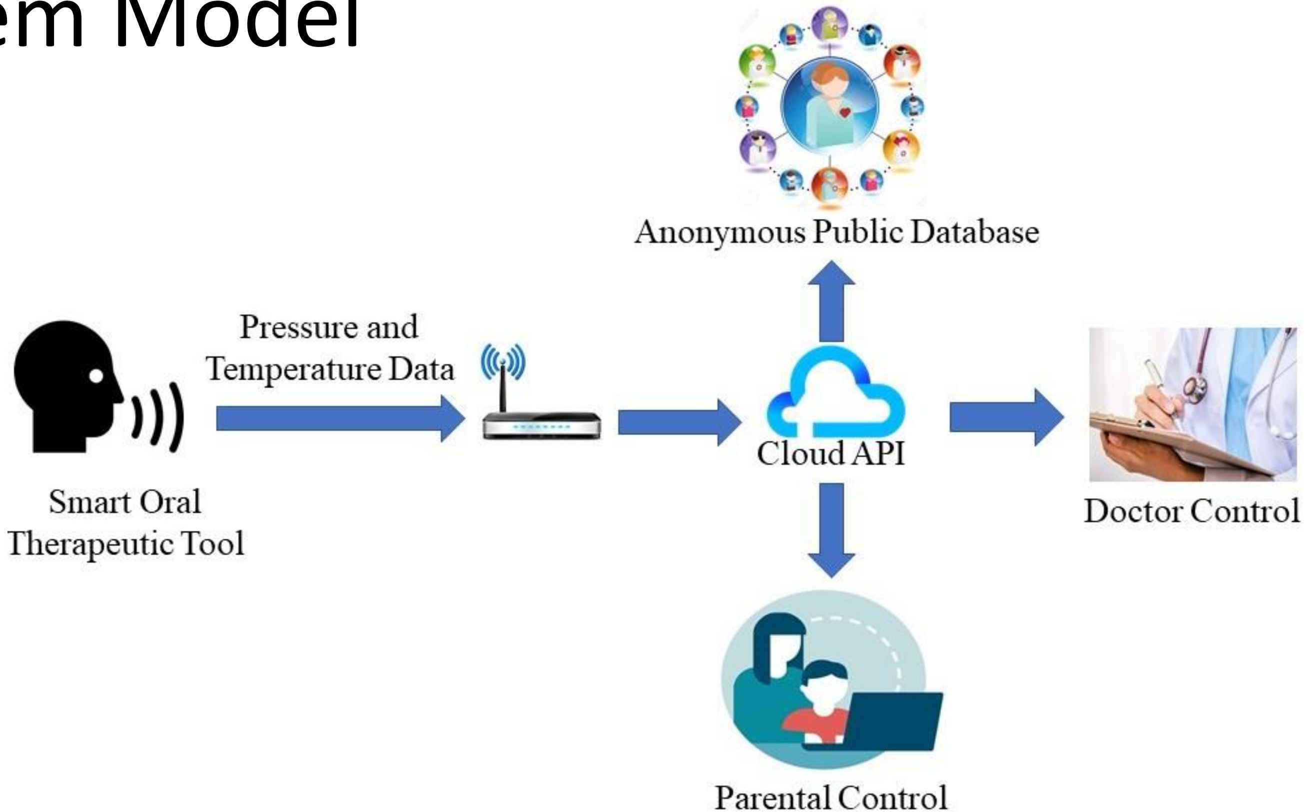
- Fail: False positive or negative
- Fail: Intervention Delay
- Fail: Follow up and Efficiency

Objective

- Develop a tool by integrating sensors and Wi-Fi-enabled microcontroller with into therapeutic tools

- Develop an algorithm to overcome the sensory issues which are related to the practice times so that it can give better feedback on the patients’ progress.

System Model

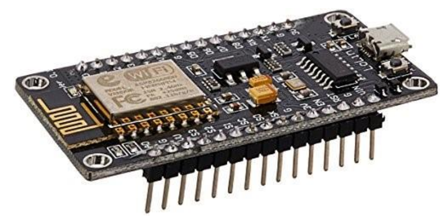


Data Gathering

- Sensors
- Microcontroller
- Vibration motor

Round Force Sensitive Resistor

NodeMCU ESP8266 Microcontroller

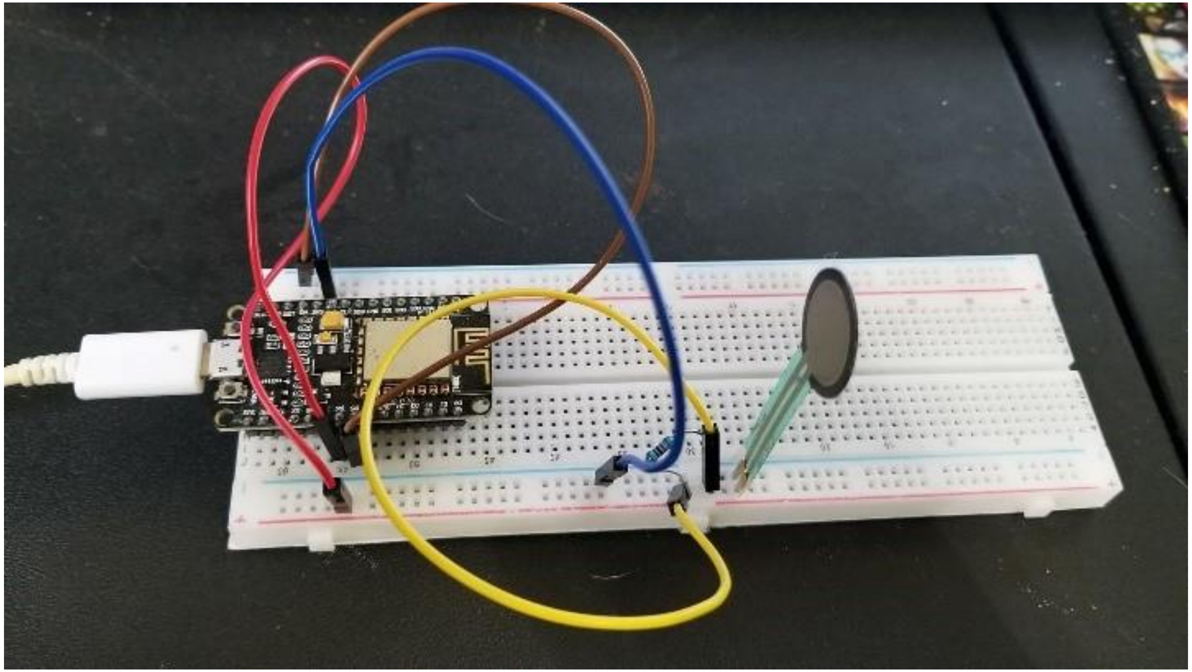


Vibrating Mini Motor Disc

Readability

- App
- Graph
- Progress over time

Proof of Concept

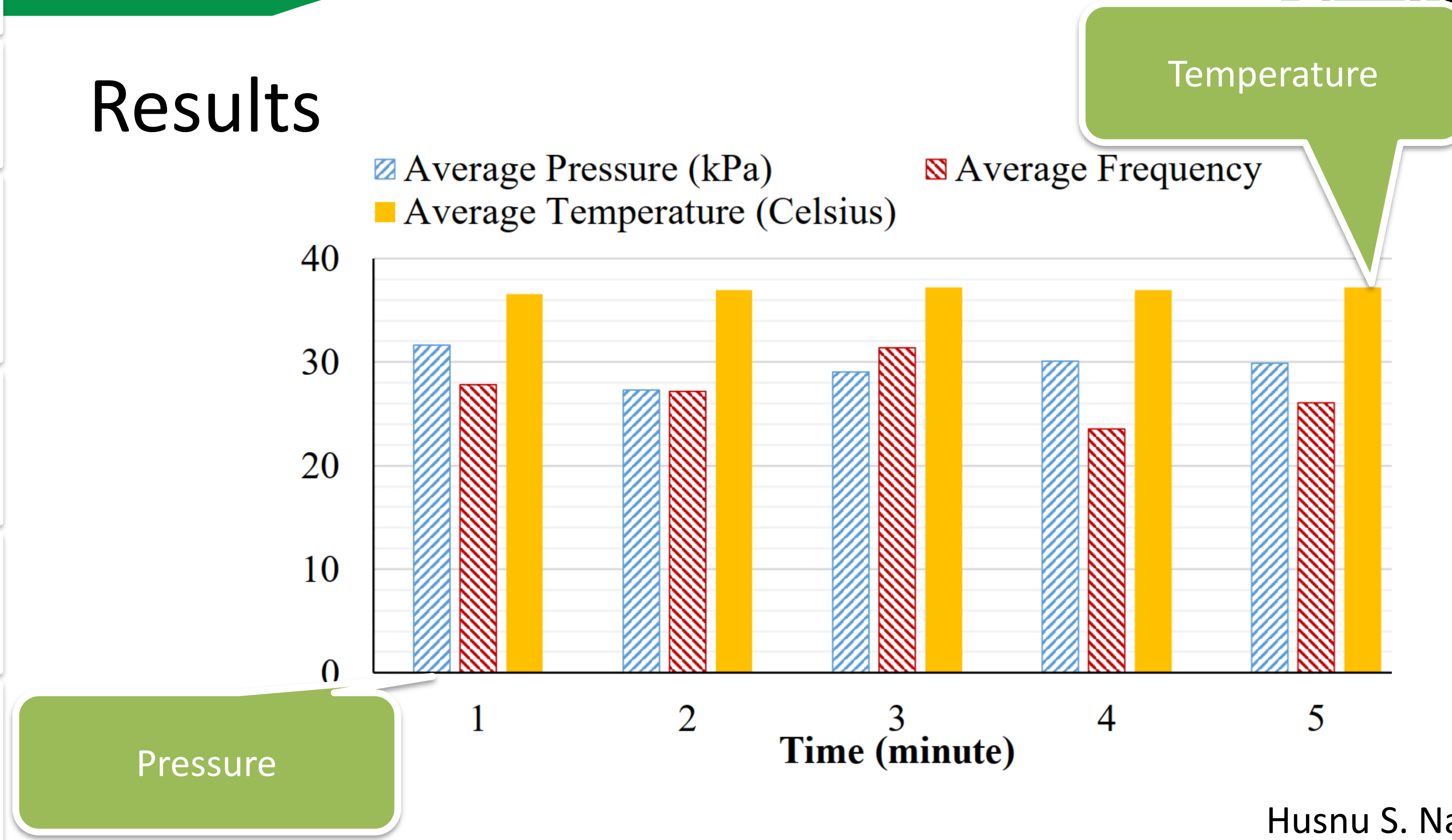


Algorithm

Algorithm 1 Algorithm for data analysis for personalization

Input: Collected data [] {For each minute}
Report: Reports for each minute [] {Report can be custom range}
Initialization :
x = calculateIndividualizedThresholdsforSenses() {From initial practice and average of the previous collected data}
y = findSlownessAndWeaknessTimeInMinute() {Speed decrement in every minute from the previous collected data}
LOOP Process
for $i = 0$ to $collectedDatalength$ **do**
  if $(|data[i] - y| \leq x)$ **then**
    Reports[i] = Need Improvement
  else if $(|data[i] - y| == x)$ **then**
    Reports[i] = No Changes
  else if $(|data[i] - y| >= 2 * x)$ **then**
    Reports[i] = High Sensitivity
  else
    Reports[i] = Regular Improvement
  end if
end for
return $Reports$

Results


Average Pressure (kPa)
Average Frequency
Average Temperature (Celsius)
40
30
20
10
0
1
2
3
4
5
Time (minute)
Temperature
Pressure

MARSHALL

Results

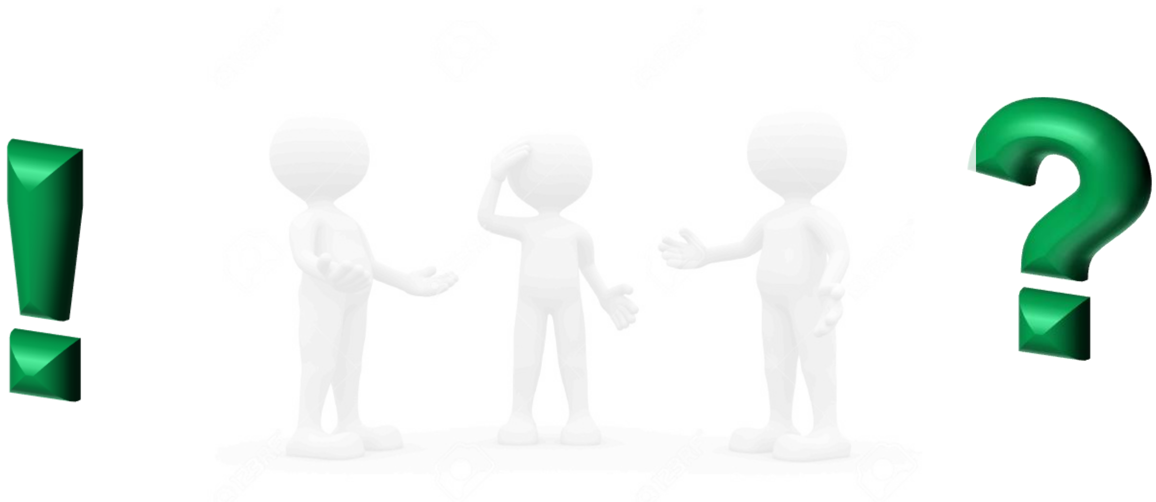
Temperature

Time (Minute)	Average Pressure (kPa) (The pressure was averaged in each minute)					Average Frequency (Number of time pressure was applied in one minute)					Average Temperature (Celsius)				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	31.64					27.83					36.54				
2	29.18	25.42				26.14	28.14				37.22	36.68			
3	31.56	26.85	28.77			32.01	27.15	34.88			37.05	37.44	37.21		
4	27.95	34.75	30.12	27.56		24.1	24.46	23.75	21.77		36.71	36.96	37.21	37.01	
5	32.5	33.0	29.3	27.7	27.0	26.6	28.4	28.6	21.1	25.5	37.2	37.3	37.0	37.4	37.2

Pressure

Conclusion

- Developed a model to easily monitor and track the progress of the patients.
- The proof of concept model and a simple algorithm are completed and tested in the cloud API under various network environments.
- Tested the device for different time intervals during the day to test its stability and reliability



Thank You

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Oral Therapeutic Tool for Speech and Feeding Therapies

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Abstract

It is important for toddlers to develop speech skills as well as eating and chewing skills. However, many children find difficulty in performing these tasks, which often prevent their growth and skills development. Currently, many exercises and tools can help children with these problems. However, most of them have low quality, easy to break, no responsive, and not user-friendly. For example, parents and therapists may give the tools to their child to practice, but they would not know if their children are making progress. Therefore, we develop a tool by integrating sensors and Wi-Fi-enabled microcontroller into a therapeutic tool and develop an algorithm to overcome the sensory issues which are related to the practice times so that it can give better feedback on the patients' progress. By the help of this tool, parents and therapists can monitor the patients' progress in real time and assess whether these exercises are effective.

Introduction

According to research from Center for Disease Control and Prevention, one in twelve children ages 3–17 has had a disorder related to voice, speech, language or swallow in the past 12 months, and only half of them receive proper intervention [1]. However, speech and feeding disorders can only be identified until children have reached the ages at which various speech and feeding abilities are expected. However, children under the age of approximately 30 months to 36 months are often difficult to evaluate because they may be reluctant or unable to engage in formal standardized tests of their speech and feeding skills [2]. ***Therefore, we need a device that is not only a toy for children but also can help them exercise their oral functions and monitor the progress of them by using the Wi-Fi enabled microcontroller and sensors.***

Delay in the communication can also affect other developments.

System Model

Fig. 1 demonstrates a simple example of how this device captures the information and send it to the cloud.

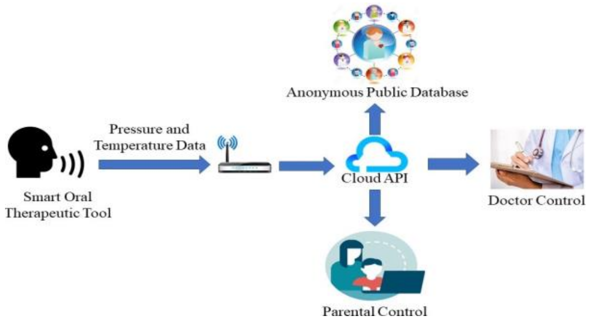

Fig 1: Therapeutic Tool's System Model

Hardware

Sensors: The Round Force-Sensitive Resistor (FSR) - Interlink 402 (Fig. 2) allows us to detect physical pressure at low cost. It has a resistor that changes its resistive value (in ohms) depending on how much it is pressed. These sensors are relatively affordable, consume low power, and are easy to use.

Fig 2: Round Force Sensitive Resistor

Vibrate Motors: The devices are also be combined with medical vibrating oral motors that helps provide tactile oral cues, direct the articulators, stimulate the oral muscle, increase oral awareness and tone, decrease mouth stuffing, drooling, oral defensiveness, and texture aversions.

Fig 3: Vibrating Mini Motor Disc

Microcontroller: NodeMCU is the most viable choice for this project with robust CPU, affordable, built-in Wi-Fi compatibility, minimal power consumption. Despite the size of just a quarter, this microcontroller is powerful enough to control, modify, and gather data from many sensors at the same time.

Fig 4: NodeMCU ESP8266 Microcontroller.

Algorithm and GUI

The data after being collected and processed in the client side will be sent to the Cloud API. As currently, we are using the free service of Swagger API [4] to host our database and service. The biggest advantage of using a third party Cloud API service is the scalability. As the number of users increases, the cloud service will scale accordingly without worrying about the hardware. In the cloud, Algorithm 1 will assess the performance and effectiveness of the therapy exercises based on the pressure, intensity, and temperature that collected through the sensors.

Algorithm 1 Algorithm for data analysis for personalization

```
Input: Collected data [] {For each minute}
Report: Reports for each minute [] {Report can be custom
    range}
    Initialization :
x = calculateIndividualizedThresholdsforSenses() {From
    initial practice and average of the previous collected data}
y = findSlownessAndWeaknessTimeInMinute() {Speed
    decrement in every minute from the previous collected
    data}
    LOOP Process
for i = 0 to collectedDatalength do
    if (|data[i] − y| ≤ x) then
        Reports[i] = Need Improvement
    else if (|data[i] − y| == x) then
        Reports[i] = No Changes
    else if (|data[i] − y| >= 2 ∗ x) then
        Reports[i] = High Sensitivity
    else
        Reports[i] = Regular Improvement
    end if
end for
return Reports
```

Algorithm 1 is used to analyze and personalize the collected data for the recommendation to therapists.

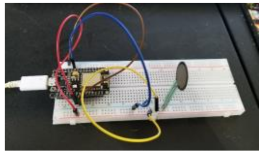

Fig. 5: IoT Therapeutic Tool Proof of Concept Model.

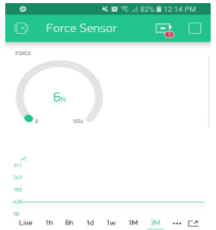

Fig. 6: Graphical User Interface of Pressure Sensor.

Fig. 5 shows the proof of concept of this device, with the force sensor and the NodeMCU microcontroller. Since the NodeMCU has the ability to connect to the WiFi, it can send the data directly into the cloud, and we can receive the real time data sensor through the mobile application app like the demonstration in Fig. 6.

Result & Analysis

Table I shows us the data recorded from an eight-year-old child exercised oral therapy with our tool at different time intervals.

Time (Minute)	Average Pressure (kPa) (The pressure was averaged in each minute)					Average Frequency (Number of time pressure was applied in one minute)					Average Temperature (Celsius)				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	31.64					27.83					36.54				
2	29.18	25.42				26.14	28.14				37.22	36.68			
3	31.56	26.85	28.77			32.01	27.15	34.88			37.05	37.44	37.21		
4	27.95	34.75	30.12	27.56		24.1	24.46	23.75	21.77		36.71	36.96	37.21	37.01	
5	32.5	33.0	29.3	27.7	27.0	26.6	28.4	28.6	21.1	25.5	37.2	37.3	37.0	37.4	37.2

Table I: Average pressure, frequency, temperature in different time intervals

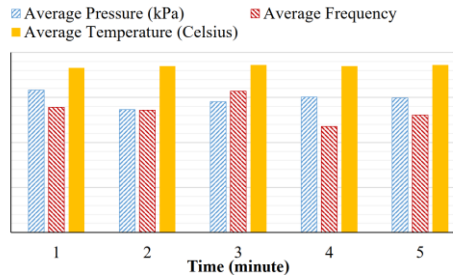

Fig. 7: The average results for each session duration splitting the session to minute.

Conclusion and Future Work

We have developed a prototype speech and feeding therapy tool to easily monitor and track the progress of the patients. The proof of concept model is completed and tested in the cloud API under various network environments. We also test the device for different time intervals during the day to test its stability and reliability. The value of this project is not just the concept but also its practical and economic aspects. Besides buying a NodeMCU for just $5 and all other sensors for only $4, all the software and library we are using for this project is available online, and they are completely free and works consistently.

In the future, we will work on securing and encrypting the transmission line and database of patient's health information. Furthermore, testing is also an essential part of this project. After addressing those problems, we will test the prototype for various conditions such as user experience, reliability, durability. Moreover, we will try to integrate the tool into a small, compacted device like the Fig 8.

Fig. 8: Non IoT Ark's Z-VIBE Vibrating Oral Motor Tool without [5]

References

[1] Communication disorders and use of intervention services among children aged 3 17 years: United states, 2012. [Online]. Available: www.cdc.gov/nchs/data/databriefs/db205.htm

[2] Language development in toddlers 30-36 months. [Online]. Available: www.home-speech-home.com/language-development-in-toddlers- 30-36-months.html

[3] Determining the regulatory status of components of a food contact material. [Online]. Available: https://www.fda.gov/food/ingredientspackaginglabeling/packagingfcs/regulatorystatusfoodcontactmaterial/default.htm

[4] Swagger. [Online]. Available: https://swagger.io/

[5] ARK's Z-Vibe vibrating oral motor tool. [Online]. Available: www.arktherapeutic.com/arks-z-vibe-vibrating-oral-motor-tool/