Processbook

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Senior Capstone 2022
Industrial Design Ohio State

Drop: Children's Vital Monitoring Wearable Patch and System

drop

Welcom

Drop is a wearable hydration sensing patch allowing parents to track sick children's basic vitals. A complementary smartphone app supports the system by making the data easily understandable. Drop aims to accurately measure hydration non-invasively. When children are under the stress of a viral or chronic illness, hydration is a valuable and controllable factor for recovery. Parents are under a high level of stress while their children are sick, impeding on their ability to provide full levels of care. The system monitors hydration, temperature, and medication intake, alleviating caretaker's responsibility and providing actionable tasks to improve the child's health. Drop aims to reduce stress on parents and ensure improved hydration levels among children while they are sick.

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Project Prompt

Assigned by Priority Design Firm

Dehydration is a common yet significant problem many people face on a daily basis. Insufficient fluid intake is one of the primary causes of dull headache and migraine but also a risk factor for many more health issues. Dehydration can be the result of many factors, from engaging in intense physical activity to simply forgetting to drink. The good news is innovative technologies can now help people track their fluid intake. Yet there are still grounds to cover to see those technologies implemented and become a type of apparatus people want to engage with. To address this issue, we here seek ideas exploring implementation of hydration monitoring technology through wearable solution. Students are free to identify a relevant demographic (e.g., nurses, teachers, body builders, new moms...) and support this group with a product/service enabling them to understand and monitor their hydration levels. Specific challenge involve a wearable technology consider existing technology, as well as real world fabrication and manufacturing techniques can include a UX/UI component

Personal Focus

Developed from Secondary Research

Infants and toddlers with an illness are at higher risk for dehydration as they have high liquid output, and an inability to communicate their own thirst.

Secondary Research

Op-Ed

Secondary Research was conducted in topics such as the affects of dehydration on young children, wearable technology for children, hydration monitroing technology, and customizeable and creative designs for kids.

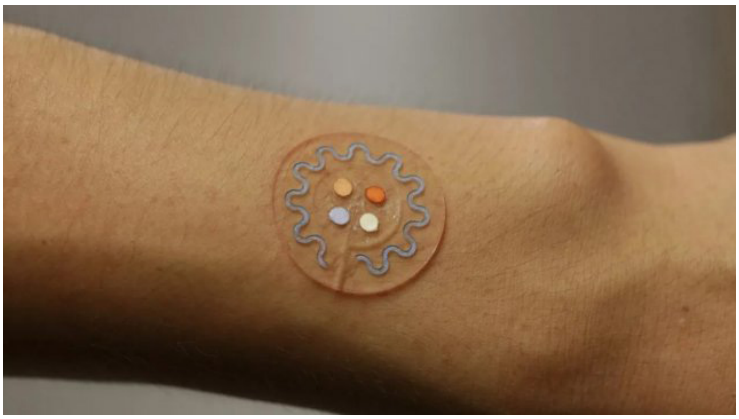
If you have cared for a young child while they're sick, you know how difficult it is. They're fussy, feverish, and fidgety, not to mention if you are cleaning up vomit and diarrhea every few hours. You're worried about medicine intake and keeping that fever down, but you're also home from work so you're entertaining them while simultaneously taking conference calls on your laptop. You're

told they need electrolytes and water but they're telling you their throat hurts too bad so you give them popsicles and their favorite juice. You don't know if that helps, but it quiets the cries for 5 minutes. You supply a fridge full of treats and mac and cheese, anything that they will get and keep down, no matter the nutrient content. There's no sleep, and as soon as they start to recover a few days later, the younger one coughs. There are a few rules most parents know help cool the fevers and soothe the aches. Sick days are full of wet wash clothes, medicine regimens, temperature checks, cool bathes, and as instructed by all doctors, fluids, fluids, fluids. Hydration is one of the most important factors of everyday and lifelong health. It affects one's body and brain from motor function and bowel movements to mental health and energy levels. When the body is already under the stress of a viral or chronic illness, hydration is at the forefront of treatment to sustain the body.

Dehydration is a loss of body fluids, which are made up of water and salts. It can cause headaches and low energy, long-term impacts such as chronic constipation, and in extreme circumstances hospitalization and kidney damage. When sick children vomit or have diarrhea, they can lose large amounts of salts and water from their bodies, and can become dehydrated very quickly.

Infants are particularly susceptible to the ill effects of dehydration because of their greater baseline fluid requirements (due to a higher metabolic rate), higher evaporative losses (due to a higher ratio of surface area to volume), and inability to communicate thirst or seek fluid. Infants and toddlers remain some of the most vulnerable groups, especially for dehydration, along with elderly persons who lack a sense of thirst as they age. It is the designer's job to protect and care for the vulnerable.

It can be so easy for parents to forget to provide their young child with adequate hydration, especially when they're sick. Most do not know the ideal water regimen which can range from 4 oz. to 8 cups a day and can greatly vary depending on health, body weight, and water output. Not to mention, that they have 100 things running through their head to take care of their child's health, including tracking medication intake, temperature, and many other concerning symptoms that can arise at any point. This influx of things to remember and treatments to administer causes parents additional stress and most report feelings of anxiety and being overwhelmed while their child is sick.



Technology Findings

Non-invasive electrode sensors to detect high levels of electrical conductance in perspiration proving high level of electrolytes and low level of hydra-

Requires as little as **0.15 µL/min/cm2** of liquid to make accurate readings.
-1 µL (microliter) is equal to a millionth of a liter.
-$1.50 per sensor

This particular sensor was developed at **Northwestern University** but many others of it's type exist on the current market

Smart Health Findings

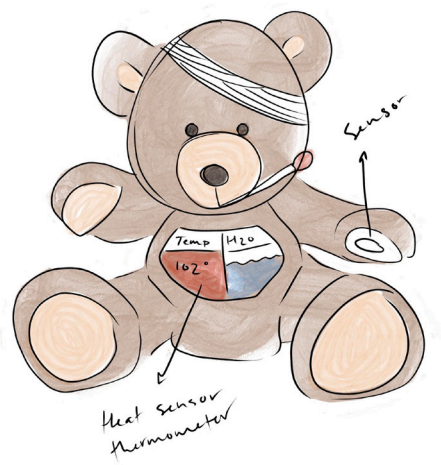
-Increased **interest and use** of smart-health devices
-Use of **profiles** to track child's health across a number of devices
-Requirement for **FDA approval** as a health device if you want to
-Give health recommendations
-Track specific health levels as they relate to "healthy and unhealthy"

Current Hydration Monitoring

Signs a child is dehydrated and may be at need for further medical help:
-Sunken eyes or fontanelle
-Low energy
-Dark colored urine
-No tears
-Fussiness
-Dry mouth
-Low number of diapers

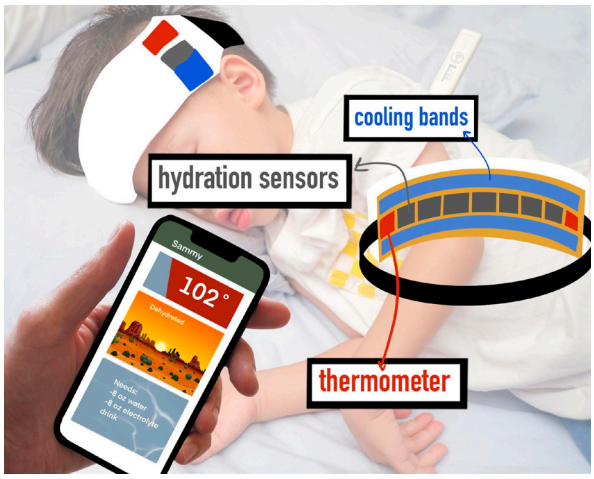
Conjectures

Reveal design elements and gaps in understanding. Design decisions were not made with practicality in mind but rather combining various elements and findings from Secondary Research. These findings were then further explored in Primary Research to push the boundaries of my understanding.



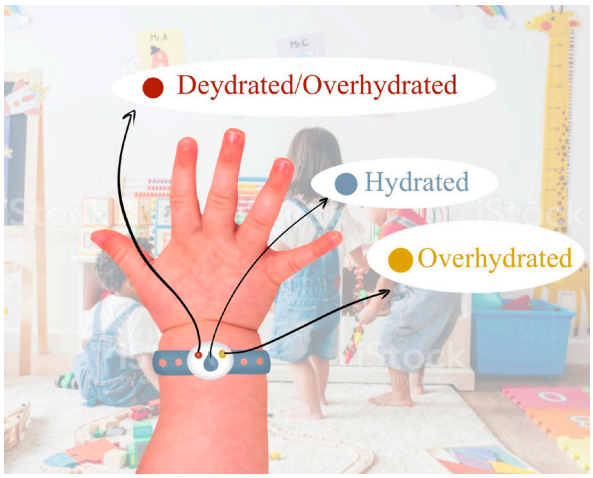
Takeaways:
-Focus on comfort item

Gaps revealed:
-Need easily washable material



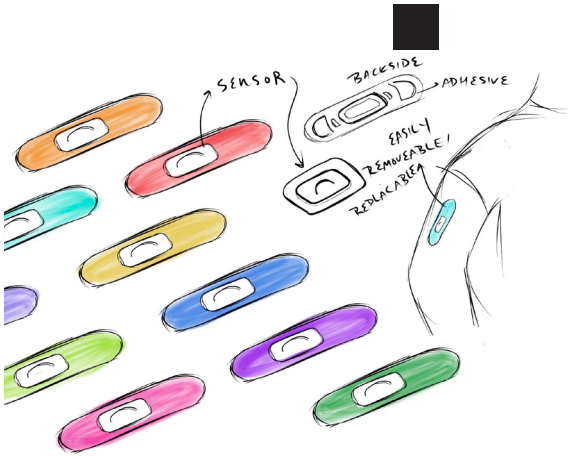
Takeaways:
-Cooling method (treatment)

Gaps revealed:
-Unlikeliness to wear due to uncomfort



Takeaways:
-Surface UI Result

Gaps revealed:
-Unlikeliness of longterm wear



Takeaways:
-Easy application and removal

Gaps revealed:
-Slight pain on removal

Primary Research

Caregivers of Young Sick Children

Survey:

Focus Group:

Parents and caretakers of young children, open to teachers, parents, nannies, babysitters, family members etc

-Columbus Nanny & Parent Facebook Page
-OSU Daycare Center
-Balanced Family Academy in Clintonville, OH
-Carol Nursery Preschool in Cleveland, OH

99 Responses
74 Moms
19 Dads
6 Caretakers

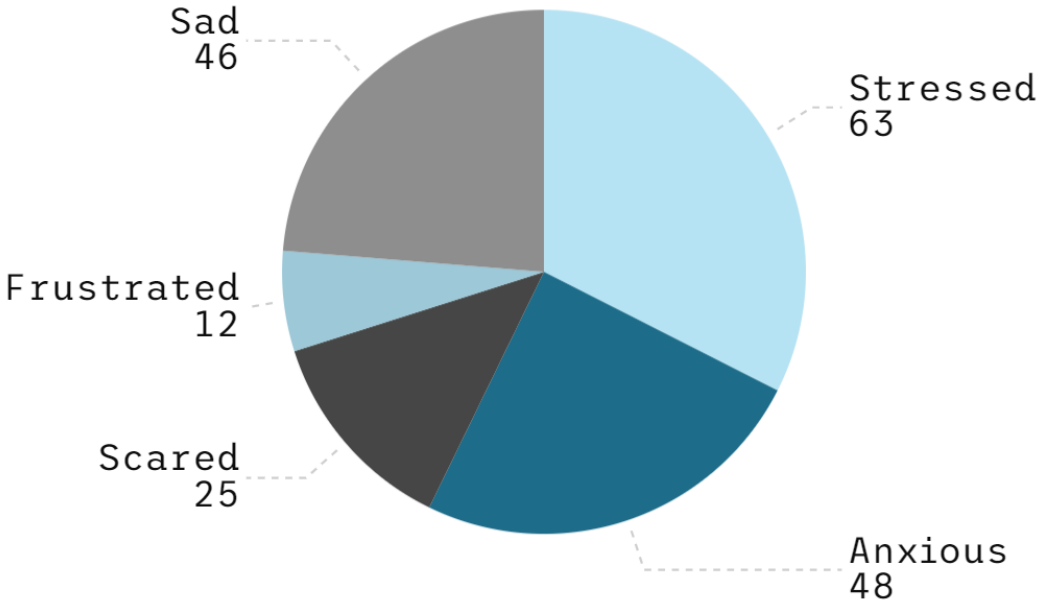
What are your go-to meals and snacks to prepare for your child when they are sick?

"Bananas, applesauce, rice, toast, crackers, soup, popsicles."
"Anything they will eat at that point. Popsicles, regular snacks (pretzels, Applesauce, goldfish, fruit)"
"Anything she'll eat - yogurts, fruit, crackers"
"I try ANYTHING. If she only wants blueberries and squid, I'd ply her with those."

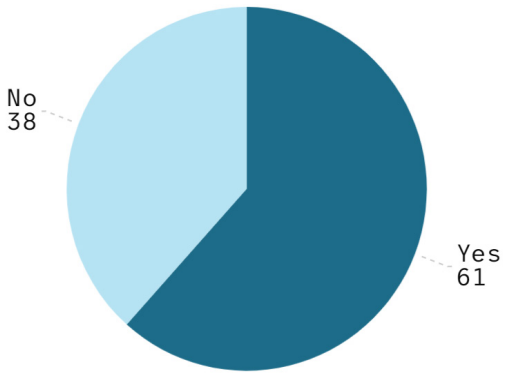
Your child is sick. You're heading to the store for supplies. What are 5-10 things that you know you will need on hand for the next few days?

"Medicine, snacks, depending on sickness maybe popsicles, thermometer"
"Childrens motrin, Childens Tylenol, all natural cold and cough herbal syrup, pedialyte, all natural chest rub"
"Pedialyte, whole milk, applesauce, child ibuprofen, crackers"
"Pedialite popsicles, Motrin/Tylenol, thermometer, jello, tissues, Gatorade"
"Medicine, thermometer, tissues, soup, sprite or ginger ale"

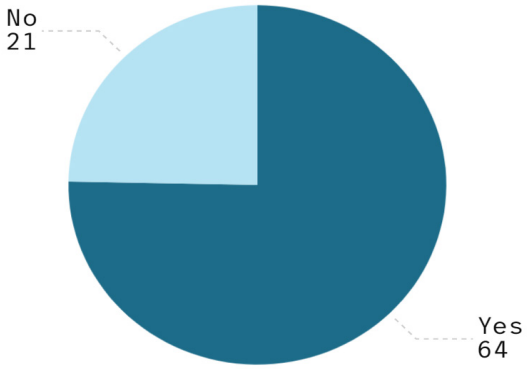
How do you feel when your child is sick?



Can you tell when your child is dehydrated?



If your child is throwing up or has diarrhea, do you do anything to monitor your child's hydration?



When questioned about their methods of tracking and deducing hydration, parents reported use of methods such as diaper counting, observation of dry mouth, and keeping track of how much water they provide.

Most were not aware of recommended amounts for their child's age.

Interviews

6 One-On-One Interviews with Parents from Balanced Family Academy in Clintonville, Ohio.

Questions:

You answered that you are/are not sure you could tell when your child is dehydrated, what are some tells that they are/are not dehydrated?

You answered that you do/do not monitor your child's water intake while they are sick. How do you do so?

Walk me through a typical day if you have a sick kid at home:

If your child has a fever, what do you do to cool it down?

If your child is having trouble eating or drinking, do you have any methods you use to help them consume food or drink?

Do you have any experience with smart technology? Ex: apple watches, smart thermometers
How do you use smart technology in your everyday life?

Do you use your smartphone to track your child's health or symptoms?

Are you ever worried about overhydration?

Is there anything else you would like to tell me about your child's health?

Notes on responses:

You answered that you are/are not sure you could tell when your child is dehydrated, what are some tells that they are dehydrated?
-Diapers. dr tells them this is a good cue. how many wet diapers. makes her worried that he's dehydrated when he's not
-If he doesn't have a wet diaper how will i know??
-Chaped lips, pale, "Mom sense"
-Fewer wet diapers, if he is sick and has diarrhea
-Watch water intake, tired

You answered that you do/do not monitor your child's water intake while they are sick. How do you do so?
-Keep track of how much you give her
-How many times is he nursing, fill up water bottle, 1 cup of water while sick

Walk me through a typical day if you have a sick kid at home:
-Chronic asthma, gets sick a lot, runny nose/cough, tired not active, tv and books and drawing, naps, rest, constant medication every few hours
-Woke up early coughing, Dad laid with him for a few hours, slight fever, trading responsibilities, honey cough syrup, monitoring water, favorite foods so they eat (he doesn't eat much when he's sick): soft foods
-monitor fever, tylenol if needed and popsicles, bed early, sleeps a lot when sick, minor cold still goes to daycare
-Voice sounds funny first, congestion, cough or sneeze, allergies or cold? feels hot, check temp, more fluids, favorite foods, rest time, lay down, tv time (force him to slow), explain why we're doing certain things, breathing is a big scare (family asthma, hot water for shower

If your child has a fever, what do you do to cool it down?
-Chewable tylenol/ibuprofen
-Motrin lasts longer than tylenol, have to have a fever for over 3 days for drs to care, wet washcloth

If your child is having trouble eating or drinking, do you have any methods you use to help them consume food or drink?
-Popsicles, favorite foods
-Popsicles, fruit
-Favorite foods, juice, sugary drinks, electrolytes

Do you have any experience with smart technology? Ex: apple watches, smart thermometers
How do you use smart technology in your everyday life?
-Apple watch
-Owlet, smart watch, iPhone
-Smart thermometer, smart outlet, fitness tracker

Do you use your smartphone to track your child's health or symptoms?
-Babyconnect
-Owlet
-Monitored more when infant (emphasized by multiple parents)

Are you ever worried about overhydration?
-No (unanimous)

Notable Interview Findings

> "I'm not too worried about [her hydration] now, but boy was I anxious when she was [an infant]."

PROVED
Focus on Infants

FOCUS
Additional focus on Toddlers
-Secondary research points to methods being beneficial and applicable to toddlers as well

> "They get whatever they want while they're sick. All concern about nutrition goes out the window."

PROVED
Stress leads to undertreatment

FOCUS
Reducing stress to improve quality of care.

> "I will say… I'm already a worrier. I would be worried that knowing his exact hydration would make me extremely anxious and I would over-

PROVED
Anxiety due to information delivery methods.

FOCUS
Healthy delivery methods

> "We use an app to track when we give him medicine that way we don't double-medicate him since we're both so busy."

PROVED
inconsistency in parent to parent treatment

FOCUS
Opportunity to alleviate inconsistencies due to busy schedules

Design Brief

Kaitlyn Smith Senior Capstone 2022

The Problem:

Hydration is one of the most important factors of everyday and lifelong health. It affects one's body and brain from motor function and bowel movements to mental health and energy levels. When the body is already under the stress of a viral or chronic illness, hydration needs to be at the forefront of treatment to sustain the body.

Children are some of the most susceptible to dehydration due to their body makeup as well as their ability to sense and communicate thirst.

Caretaker's of young children are balancing a multitude of information while caring for a sick infant. Hydration, temperature, and medication intake are three factors with large impacts on a child's health and recovery that caretakers track while the child is sick. Balancing this information and not always knowing the signs or repercussions of them leaves the caretaker anxious and stressed.

Innovative technologies can now help people track their fluid intake and other health factors. To address this issue, we will seek a solution exploring implementation of hydration and other health monitoring technology through a wearable solution.

Objective:

We aim to support parents with a product/service enabling them to understand and monitor and track their child's hydration and health levels.

Goal:

Provide peace of mind for parents and caretakers caring for sick children.

Provide accurate hydration and temperature tracking.

Sub-Goals:

Implement accurate technology in a comfortable, easy-to-use, minimally invasive wearable product.

Track multiple health elements to ease stress

Strategies:

Implement non-invasive electrode sensors to detect high levels of electrical conductance in perspiration proving high level of electrolytes and low level of hydration.

Include a temperature sensor to constantly track the child's temperature.

Provide a complementary app interface that displays hydration and temperature levels while allowing the caretaker to input notes and medication dosage on a profile accessible to other caretakers (co-parents, nannies etc.)

Offer variance of surface design for customization levels in parents.

Problem Statement:

To reduce anxiety and stress surrounding the caretaking of infants and toddlers, I aim to create a wearable technology product and paralleled system to monitor and track the child's health and symptoms while they are sick.

Process & Development

Early Brainstorming

Sensor placement brainstorming, system element consideration. At this point I was focused on narrowing down what elements were needed to accomplish my design brief and putting together a rough design to present for further Formative Assessments.

Further development focuses on sensor placement, patch shape and form, and begun to consider design elements of aesthetics and UI data results.

At this point in the design process, I was sure of the functions the patch needed to serve technologically and that I wanted the application to be as non-invasive and convenient as possible. I considered the use of surface results as seen on the far right of the sketch sheet, but this added unneccesary complications technologically for results that could be easily displayed on a smart phone.

Formative Assessment

At this point in the process, I had an understanding for the elements neccesary in my system, including the phsyical patch (of whatever form that would be) and the digital interface through means of a smartphone app to inform caretakers of the monitored data.

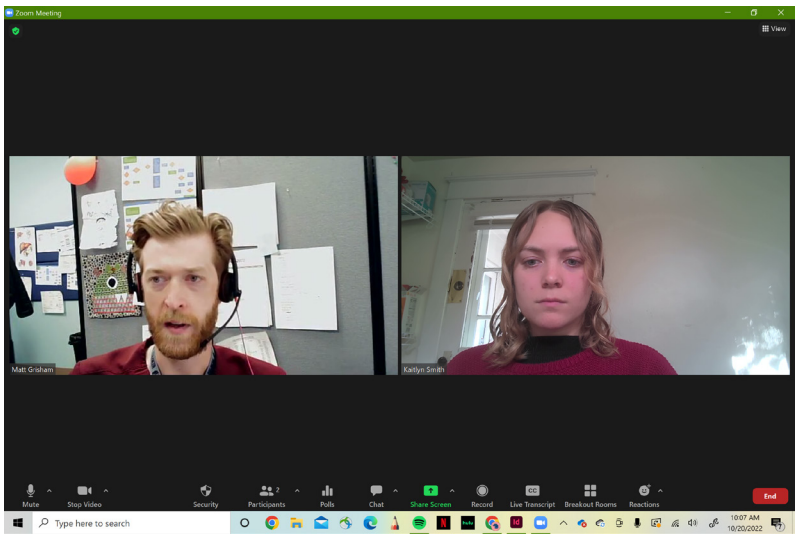
A big question that remained was

What is a healthy level of information to display to a parent?

My primary research had informed me that parents are extremely stressed and anxious while their children are sick, and that with too much knowledge at their fingertips, anxiety can be increased surrounding their child's well-being.

"I will say... I'm already a worrier. I would be worried that knowing his exact hydration would make me extremely anxious and I would overthink it."

This led to me to meet with a pediatrician, a caretaker that is greatly knowledgeable in the realm of dealing with anxious parents and providing the best care possible to young children while they are sick. The goal of the meeting was to establish healthy boundaries and determine what information to give to parents.



Recommendations:

-Establish a range for "healthy levels", within that range there can still be nudges to promote healthy hydration. Anything outside of that range, come up with a notification to suggest when it is time to see a primary care doctor.

-Be careful not to incorrectly reassure parents. If they are concerned, they should see a doctor.

-Alternative to sharing all data to a pediatrician: Offer a print out sheet for the parent to take with them when they see the primary care doctor detailing fever spikes and other symptoms they typically ask about.

Hydration Ranges

	0-6 Months	6-12 Months	1-2 Years	2-3 Years
Danger Zone	0-71.99%	0-71.99%	0-59.99%	0-59.99%
Dehydrated	72%-73.99%	72%-73.99%	60%-64.99%	60%-64.99%
Underhydrated	74% - 74.99%	74% - 74.99%	65%-69.99%	65%-69.99%
Hydrated	75-78%	75-78%	70%	70%
Overhydrated	>79%	>79%	>70%	>70%

Established healthy hydration ranges for infants and toddlers.

Additional Note:
Infants who are on formula do not drink water. Upon creating their profile, parents can check a box alerting the app of their child's feeding status. This will not alter the hydration levels or monitoring but program the app to use a different notification for them to provide formula not water.

These levels are not to be displayed to parents but are simply the statistics that will then be assigned to gentle nudges to be used as notifications through the interface.

Design Development Components

Decided Components up to this point consist of:

-Drop Shaped Patch consisting of:
-Sensors
-Adhesive Layer
-Top Fabric Layer

-Packaging
-Instruction Pamphlet
-App

Next:

-Material
-Color
-Pattern
-Production

Material Exploration

New 3M silicone adhesive helps improve medical devices intended for people with fragile skin.

2484 3M™ Single Coated Medical Film Tape with Hi-Tack Silicone Adhesive on Liner. The 2484 3M Hi-Tack Silicone Adhesive is breathable, conformable, enables up to a seven-day wear time and minimizes skin cell removal, making it the ideal candidate for applications on fragile skin.

Fabric Layer

The fabric layer needs to be breathable to maximize wear time for the child. The material and ink for designs also need to both be waterproof to survive the goal of 7-10 days.

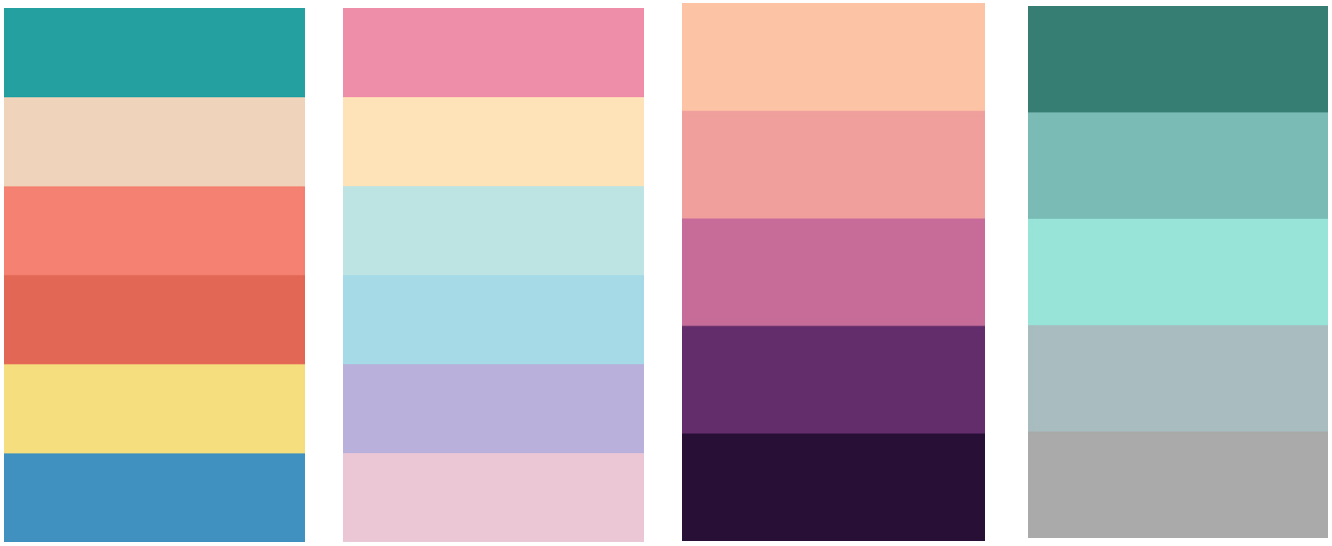
For prototyping, waterproof packcloth will be used and printed on with water-proof ink. In future production, thin, flexible rayon woven fabric would be ideal.

Color Study

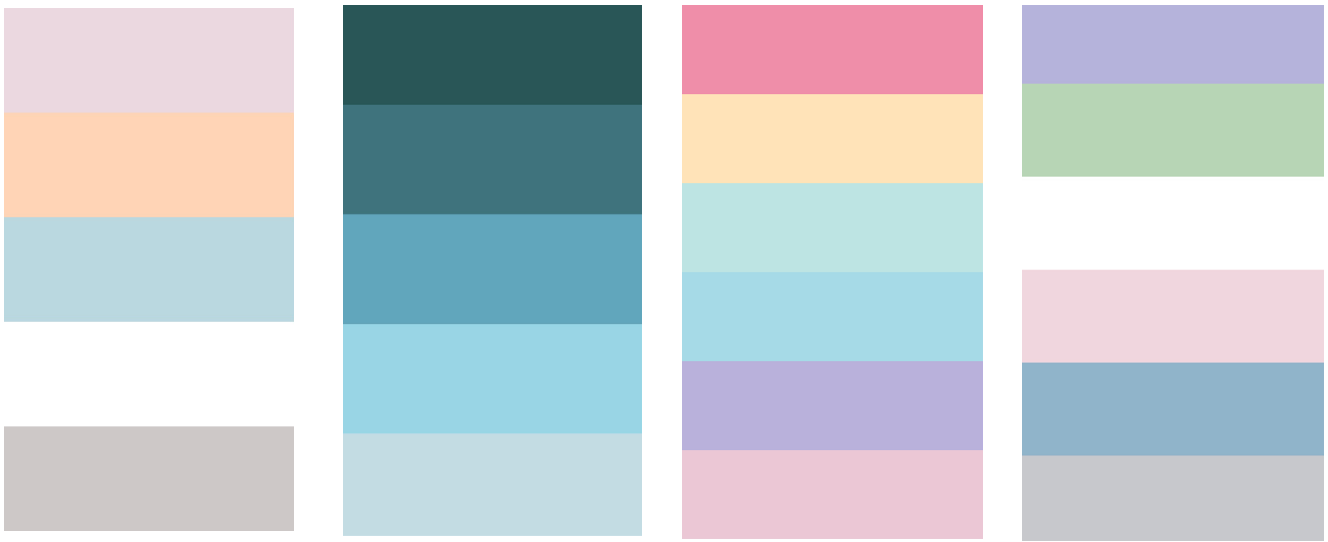
To assess the best color pallette to make users feel calm and stress-free while also being fun and playful to appeal to children.

Polled: 229

What color palette is the most fun?



What color palette is the most calming?

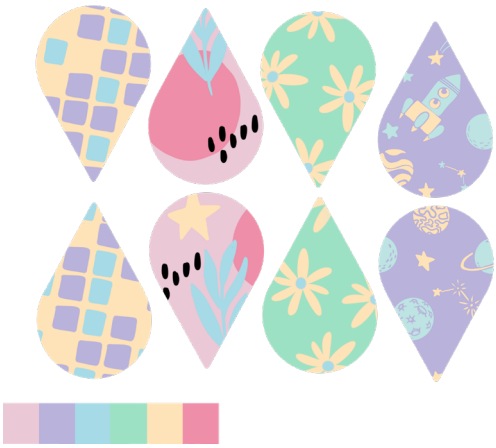


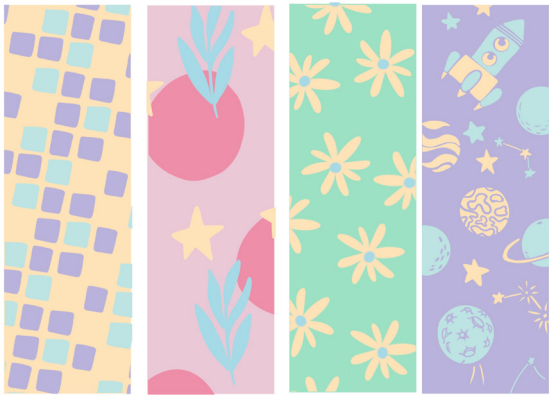
What color palette is both fun and calming?

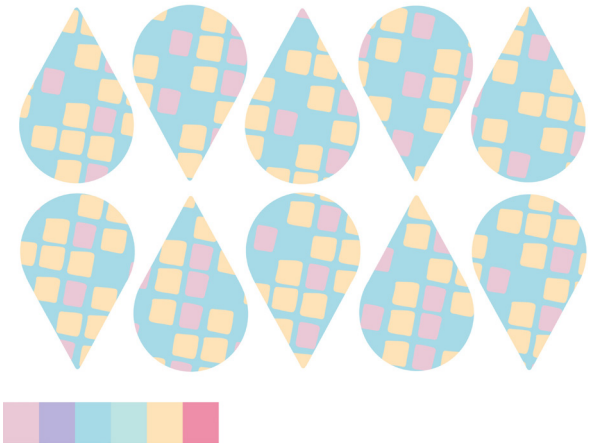
How do these color palette's make you feel?

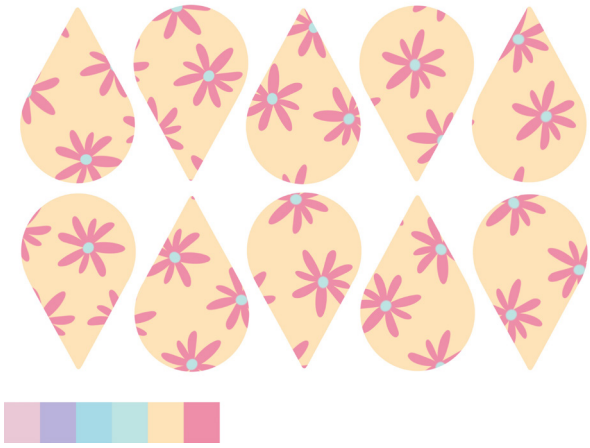
Pattern Development

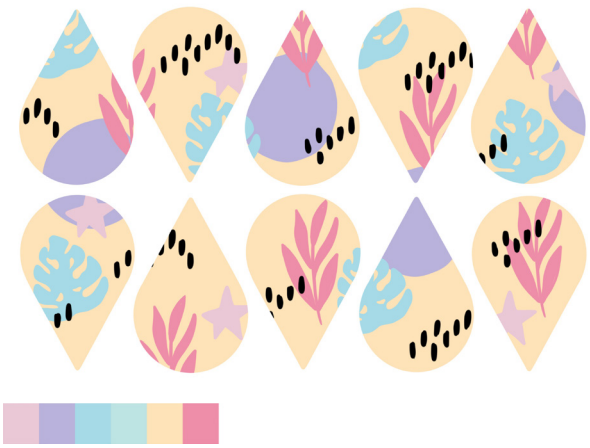
Created with the goal of being able to formulate unlimited unique patterns in the colors chosen for the pallette. Gives user variety of aesthetics while still falling in the brand language. Below is an example of variations for the 4 patterns created. This could be duplicated in infinite combinations







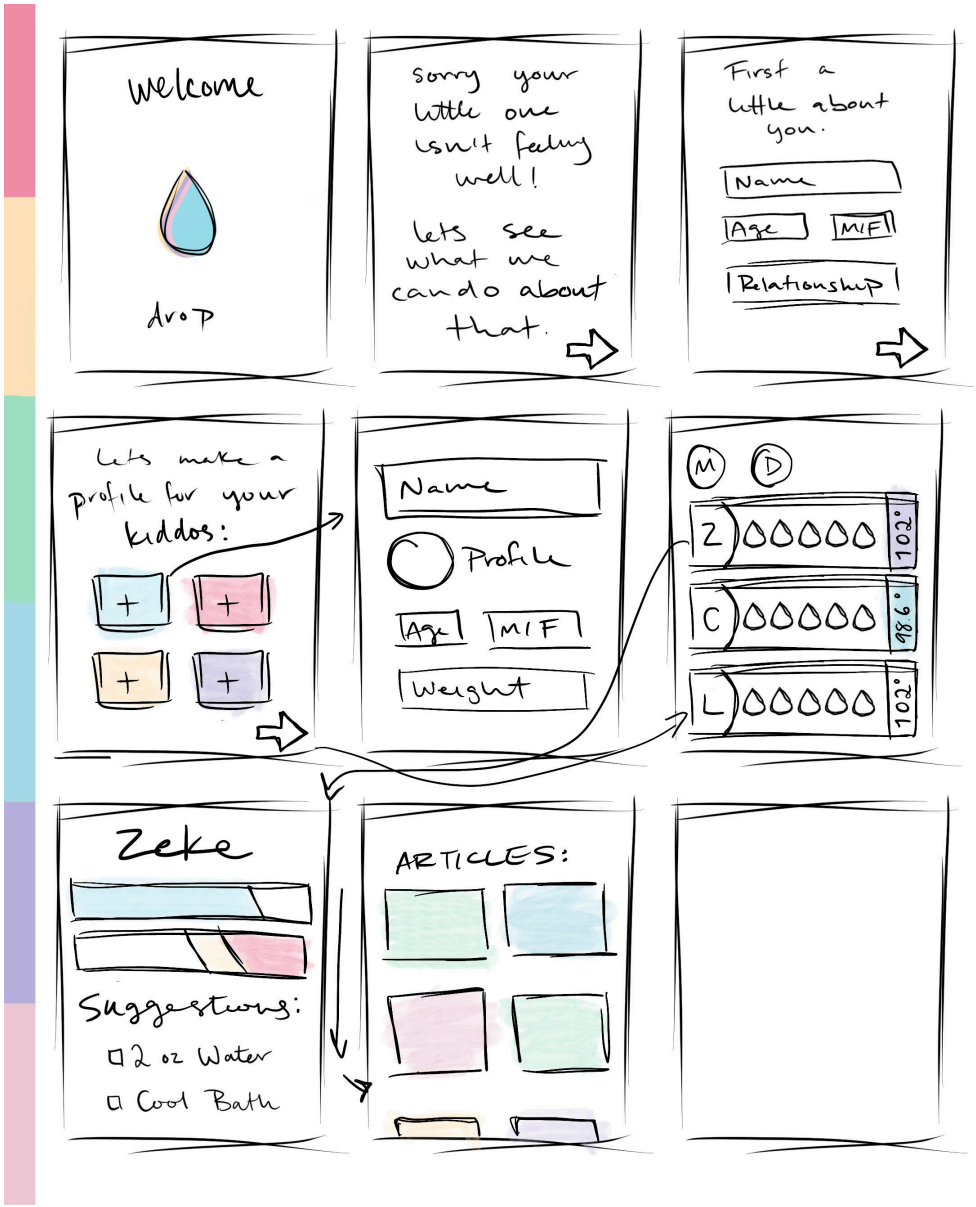




App Mockup

At this point in research and development, I had a pretty well-rounded understanding of the elements needed in the system. I began mocking-up the app interface the start to visualize the framework neccesary.

-Profile Creation
-Information Input
-Connect Sensor
-Data Display
-Care Suggestions
-Tips
-When to See Dr



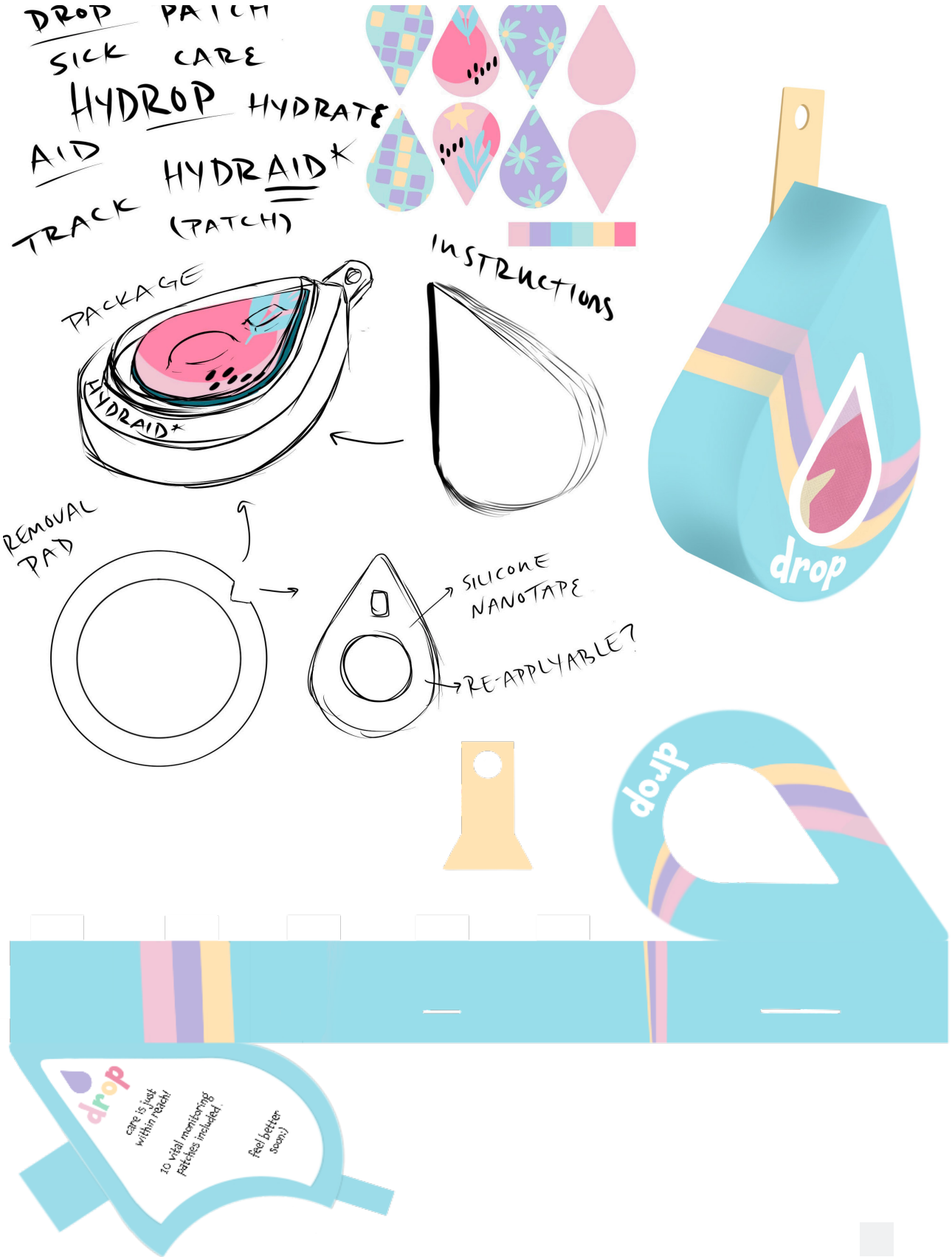
Feedback from Mock-Up:

"When my kids were little I always would go to the Cleveland Clinic webpage anytime I had a question. It would be nice to have that information all in one place."

"Seems easy to work!" "Will it give notifications when they need something?"

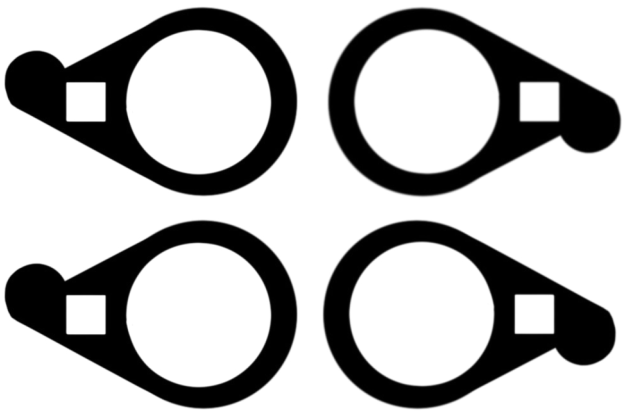
Further Product Development

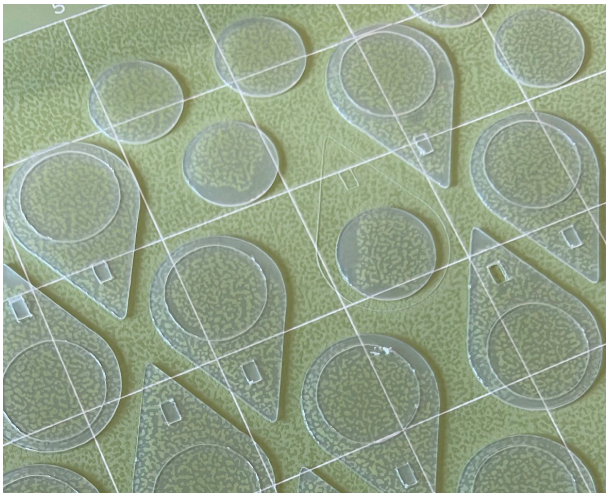
Package Sketch, Physical Product Element Consideration



Instruction Pamphlet

Adhesive Cut File





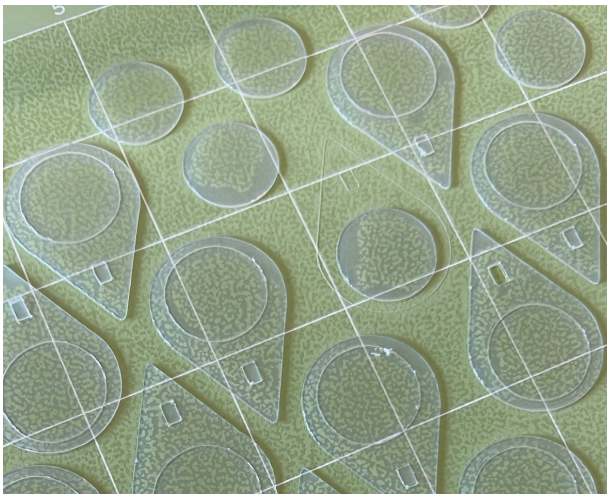
Prototype Production Process

Screenprinting and Cutting

Pattern screenprinted on Packcloth with waterproof ink.

Printed in two pattern variances.

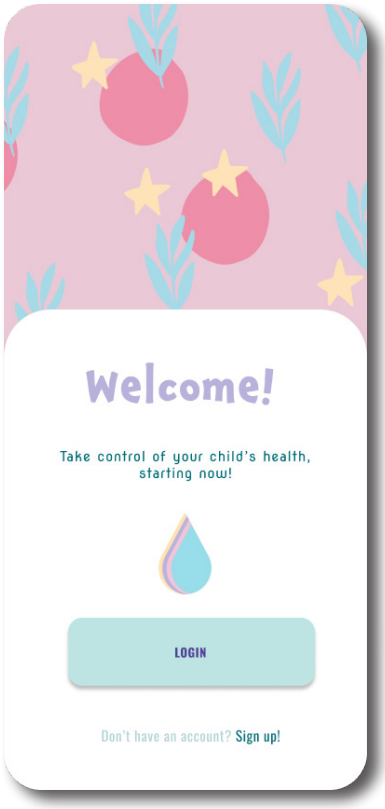
Fabric cut into drop shape.



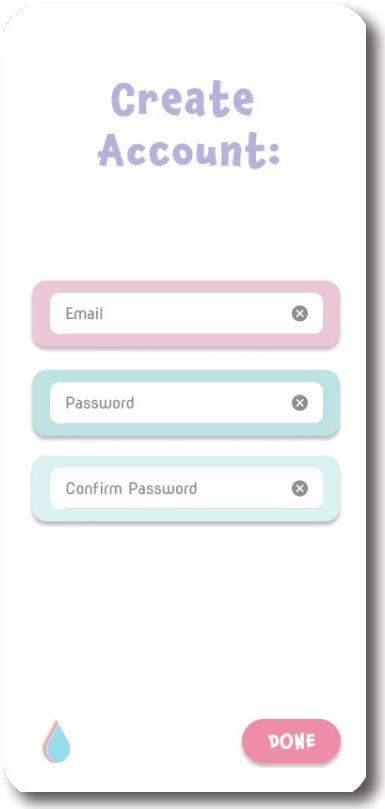
Assembled into patch with silicon sensor as filler for Microfluidic Sensor.

Assembled packaging prototype from cut file on Page 26.

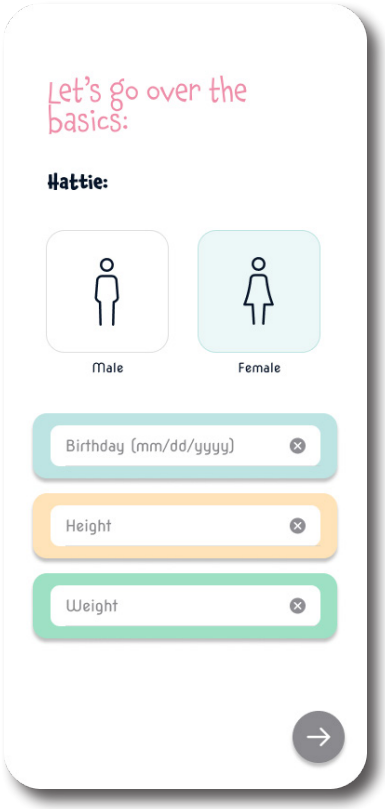
Printed and assembled Instruction Pamphlet



Welcome Page:



Create Account:



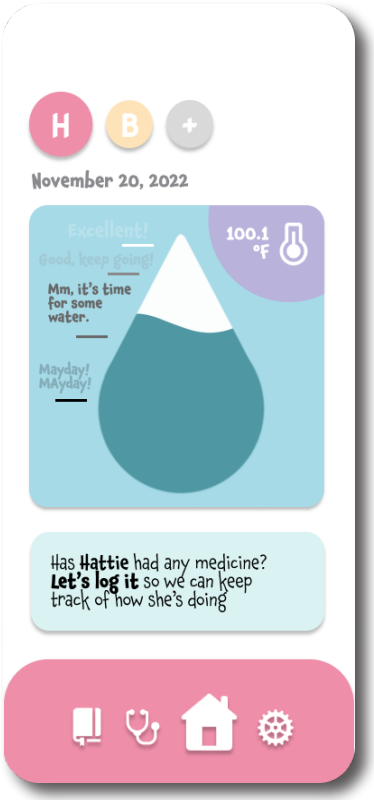
Create Profiles:

How To:

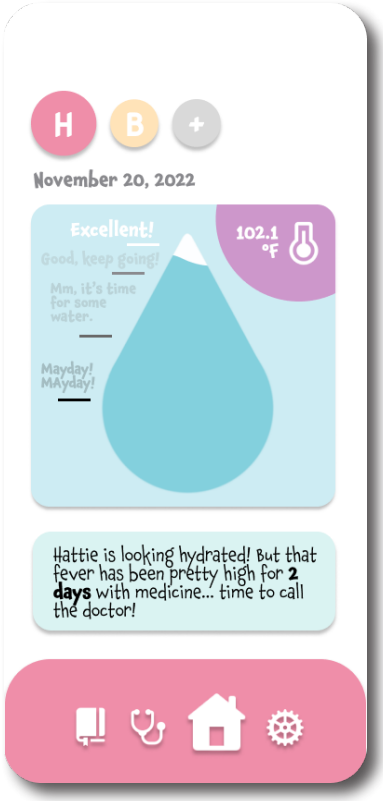
How To:

How To:

Scan Patch:

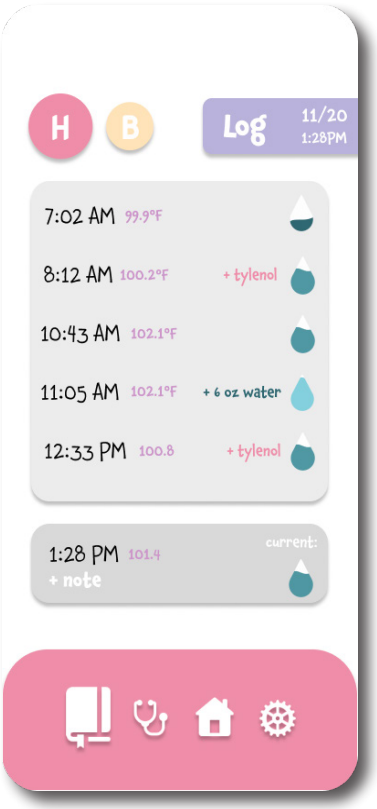


Home Page:



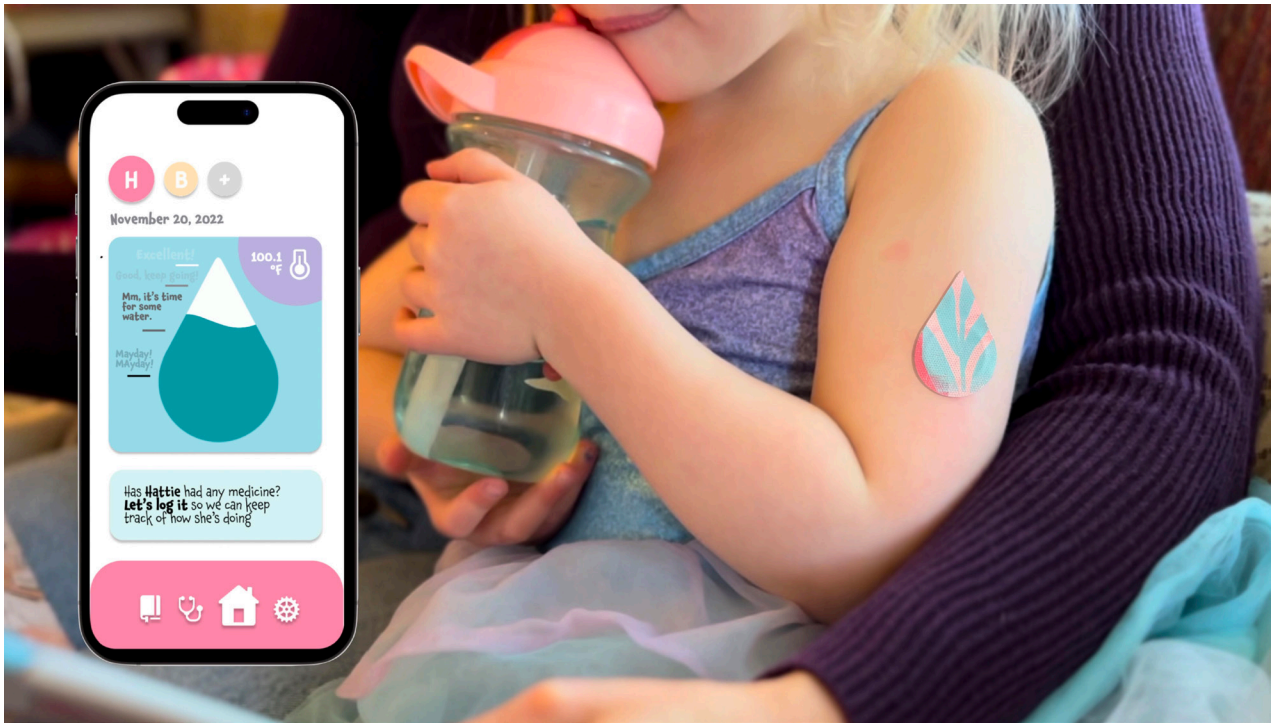
Home Page:

Dr Tab:



Log:

Log Input:



Drop

Children's Vital Monitoring Wearable Patch and System

Drop is a wearable hydration sensing patch allowing parents to track sick children's basic vitals. A complementary smartphone app supports the system by making the data easily understandable. Drop aims to accurately measure hydration non-invasively. When children are under the stress of a viral or chronic illness, hydration is a valuable and controllable factor for recovery. Parents are under a high level of stress while their children are sick, impeding on their ability to provide full levels of care. The system monitors hydration, temperature, and medication intake, alleviating caretaker's responsibility