

Designing a Product to Reduce the Stress Level in Injection Operation for Children undergoing Treatment

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Abstract

Stress significantly affects children, particularly in hospital settings. Addressing and managing stress effectively can reduce psychological harm and improve a child's quality of life. The research began with a literature review on mental health dimensions and stress factors in children under treatment. This was followed by case studies that included interviews and questionnaires for a deeper investigation. The research examined stress management strategies such as raising stress awareness offering various suggestions for stress control, creating entertainment options for children, and identifying their needs and goals. The study utilized the Design Thinking methodology, a repetitive approach that continuously refines insights to address core issues. This method is based on a five-step model proposed by the Hasso Plattner Institute of Design at Stanford, guiding the process from problem-solving to ideation. This study presents the development of a musical syringe cover with lighting, designed to reduce children's anxiety during injections by incorporating distraction elements such as sound and visual stimuli. The results demonstrate that the musical syringe cover significantly reduces stress and improves young patients' cooperation during injections.

Keywords

Treatment, Children's Behavior, Product Design, Injections, Stress and Anxiety.

Introduction

In this research, the goal is to design a product that reduces the amount of stress and fear in children under treatment to make it easier for the hospital staff to perform treatment operations and reduce the tension created in the treatment environment. The current research will be of an applied-developmental type and will be placed in the category of applied studies, for this purpose, after conducting library and written studies, we will enter the stage of field studies. The most important tools for collecting the required data were questionnaires, interviews, and observations. The statistical population consisted of doctors, nurses, parents, and their children, who were selected voluntarily and in a non-random manner. The data were analyzed with the help of children's design principles. The proposed concept is then evaluated and modified through a demonstration and discussion of the prototype and questionnaire. Medical injections have significantly exceeded the need and reached figures that cannot be justified by medical standards. Hospitalization causes fear and anxiety in children. This can be an important factor for experts, who believe that a child hospitalized in a hospital is exposed to various threats (Wong & Whaley, 2012), including separation from parents, lack of a reliable person, physical injury, pain, and delayed recovery (Jones et al., 2021). In this research, the aim of designing a product with the approach of reducing the amount of stress and fear in children undergoing treatment was to facilitate the operation. Treatment by medical staff and reduction of tension created in the therapy environment: The current research will be of the applied-developmental type and will be placed in the category of applied studies. After conducting the library and written studies, we entered the field study stage. The most important compilation tool. In the practical part, based on library studies and field research, creative ideas were presented. The proposed plan will then be evaluated and modified through demonstration and discussion of the prototype and questionnaire.

Materials and Methods

The research method in this article is of the applied-developmental type, and the collection of materials is through interviews, questionnaires, and libraries. Questionnaires and interviews were conducted both online and face-to-face, and the desired information was obtained through the parents of these children, who were also observers of their children's behavior. In this process of conducting this research, the design thinking method of the Stanford Design School was used. Design thinking is a creative way to find innovative solutions. This iterative, non-linear method involves five steps for problem-solving Hasso Plattner (2018), These five steps were:

1. Empathy – observing and understanding user needs
2. Problem definition – identifying the core issues
3. Ideation – brainstorming diverse solutions
4. Prototyping – developing basic models
5. Testing – refining the model based on user feedback.

In this research, observing children during injections helped uncover critical stress triggers, leading to the development of a functional design. In the first stage, called empathy, it is necessary to research the user and determine their real needs, which is generally done through direct observation, so that the index can put himself in the user's place and observe his problems closely (Foster, 2019). The second stage is called the problem-determination stage. In this section, the information obtained in the empathy stage is carefully examined and the real problem is identified. In fact, this stage is the stage of fully knowing the user and understanding his/her exact needs (IDEO and Riverdale). In this stage, a list of design dos and don'ts is obtained, which is applied in the ideation stage. In this research, through direct observation of children and how they behave in the conditions in which they are placed, it is possible to understand the basic (injection) problems of children facing these conditions.

It is important to note that these five steps are not always sequential; they do not have to follow any particular order and can often occur in parallel and repeat repeatedly. Thus, these stages should be understood as the different modes that contribute to a project (Gwangwava, 2021).

By liaising with the children's department at Baqiyatullah Hospital, it was possible to contact the parents of these children and observe and examine their behavior during the injection process. As previously stated, a list of design dos and don'ts will be compiled through direct observation of the children, interviews with therapists, and questionnaires. The third stage is ideation. At the beginning of this stage, ideas are generated in a divergent manner to produce a wide range of ideas. Subsequently, the most promising ideas are chosen through the convergence process and various creative techniques can be employed for ideation. The fourth stage is the modeling stage, which should be performed using the most basic tools to create a practical model of the desired product. The fifth stage is the testing phase, in which the user is presented with the model, which is continually adjusted to their requirements.

Stress and anxiety in children are serious mental health issues, although the symptoms of these conditions in children may differ from those of adults. Prolonged or extreme stress can have serious and unpleasant repercussions at any age, but these issues are especially pertinent during childhood since the brain and body are still developing. This can impede the growth process. In this section, the child and the unique features of this stage are first discussed, followed by an explanation of the key concepts related to treatment, children's behavior, product design, injection, stress, and anxiety (Beesdo et al., 2009).

Further research was conducted to explore factors that are effective in reducing children's stress and anxiety, such as the effect of the environment and product, doctor, family, and other related elements. Lastly, strategies for reducing stress and anxiety in children are discussed. One of the most effective solutions to the aforementioned cases is to divert the mind by providing entertaining devices for children and using cartoon characters in the design of syringes, an issue that has not been given enough consideration in Iran and the existing examples.

Injections are one of the most common treatment methods used in medicine. Nearly 16 billion injections are prescribed annually in third-world countries. In some areas, the use of injections has significantly exceeded their needs and reached levels that cannot be justified by medical standards (Shiva & Shiva, 2008). Children are often afraid of syringes and even deny the existence of pain due to the fear of injection. These children experience pain as an unavoidable part of their childhood (Irani et al., 2016).

Research Background

In the context of research conducted in our country, several studies have explored topics related to pain management during injections in children. For instance: A study by Tavakolian et al. (2020) found that non-pharmacological methods have a greater impact on pain control during injections in children compared to pharmacological approaches. These non-drug methods, such as distraction techniques, are more cost-effective. Another investigation by Rastgarian et al. (2020) focused on the effects of various distraction techniques on pain resulting from intravenous injections. Their findings indicated that using distraction techniques can reduce the negative experience of painful procedures and stress in children who undergo frequent injections during diagnosis, treatment, and disease management. Ebrahim Poor et al. (2015) studied anxiety related to insulin injections in children with type 1 diabetes. Their goal was to determine the level of anxiety associated with insulin injections. Understanding this anxiety is crucial for effective management. On a global scale, researchers have explored behavioral patterns in children facing injection-related pain. For example, a study by (Orenius et al., 2018). investigated needle phobia in children and adolescents. The aim was to comprehensively understand needle phobia, considering disease characteristics, prevalence, epidemiology, diagnosis, and practical treatment methods. In summary, research in this area has contributed valuable insights into pain management during injections in children. By optimizing product features and evaluating device characteristics, we can continue to enhance the overall experience for young patients.

Building upon these previous studies, our research applied a user-centered design approach to develop a novel medical device. The following section details the methodology, including participant selection, data collection tools, and the iterative design process.

Research Tools

At this stage, the most important tools for collecting information are questionnaires and interviews, which, information collected in two ways, online and face-to-face. Also, with the cooperation of doctors, it is possible to visit the injection process of children in person. As a result, the most important tools are questionnaires and interviews conducted through a virtual platform and presence in the center.

Data Analysis

In this section, an analysis of the research data based on the information obtained from the existing research process is presented. The research process used in this study was the design-thinking process of the Stanford School of Design (Brown, 2008). Also, the analysis of the questionnaires and the definition of the persona have been done under the guidance of the research supervisor, and the interviews conducted with counselors and psychotherapists have also been attached in this section. In the next section, the stages of the design thinking process are presented. It should be noted that, as stated in this section, design thinking is not a linear process, and at each stage, it is possible to return to the previous stages in order to define the problem in the best way.

Interview

To conduct and complete the empathy phase as best as possible, an interview was conducted with two pediatricians to examine this issue from a psychological perspective. These two doctors were selected from two different medical centers in Tehran. In this section, the opinions of every expert concerning the available methods for reducing children's fear and anxiety during injection operations are examined.

Questionnaire

It should be mentioned that for the empathy phase of this project to be carried out well, the questionnaire questions were complementary to the children's visit sessions. The questionnaire contains 34 questions, in which different psychological aspects of the child and the way they are entertained are assessed. This questionnaire consists of three sections: in each section, the child's perception level, the child's fun and play level, the child's interactive level, and the mentioned conditions are evaluated.

Statistical Population

The target population of this study was 4–6-year-old children at Baqiyatullah Hospital in Tehran. For this study, participants were chosen within a month and a half by referring to the children's department of Baqiyatullah Hospital in an accessible manner with informed consent. Furthermore, since children of this age are not able to read, write, or even assess their own behavior, the parents of these children were heavily involved in this research, and the necessary data were collected and analyzed. Interviews were conducted with two pediatricians during treatment to gain valuable insights from their experiences over the years. Furthermore, the parents of these children were contacted through face-to-face and online questionnaires, and the children's injections were monitored and verified during a session. However, the photos were not included because the parents refused to provide their consent.

Questionnaire Data Analysis Method

Data analysis included three parts: questionnaire data analysis, interview analysis, and face-to-face analysis of how children are injected. The volume of quantitative samples was calculated using Cochran's formula (Woolson et al., 1986). It is based on surveys conducted by 45 people, and using this formula, the minimum statistical sample size should be 34.44 samples. The calculations were performed with an error of 5%.

Classification of Children by Age – Summary

The study categorized children into three age groups: 4, 5, and 6 years old, with an equal distribution of 15 children in each group. Behavioral responses varied based on age, with older children showing slightly better adaptability to the medical environment. However, fear of injections remained prevalent across all age groups, emphasizing the need for distraction-based interventions to reduce stress.

Analysis of Questionnaire Data

According to the topics mentioned in this section regarding the research method, 45 parents were questioned, and the qualitative results were analyzed. Of these, 25 were male and 24 were female. Among the investigated children, 15 were six years old, 15 were five years old, and 15 were four years old. After completing the field research, the following results were obtained:

Assessment of the Child's Level of Perception

The questionnaire results provided key insights into children's awareness and reactions in medical settings. 84% recognized the therapeutic environment, but 45% sought parental comfort due to anxiety. While 74% adapted easily to treatment chairs, 24% felt restless, and 7.17% showed physical resistance during injections.

Crying (94%) was the most common reaction to pain, though 74% calmed down quickly. Distraction techniques proved effective, with 94% responding to visual cues and 91% to their names.

Regarding play preferences, 72% preferred digital entertainment over books, and 98% were attracted to toys with lights and sounds. 80% favored group activities, while 65% preferred sedentary games. These findings shaped the development of a child-friendly syringe cover to reduce stress and enhance cooperation.

Responses were grouped based on age categories (4, 5, and 6 years old), emotional reactions (crying, hesitation, cooperation), and preference for sensory distractions (sound, light, interactive play). Younger children (ages 4-5) showed a greater reliance on interactive sound-based distractions, while older children responded more positively to visual stimuli distractions.

Personas

Introduction of Different User Groups in the Form of Personas

The personalities of the three children were evaluated. Furthermore, the identities of the children were kept anonymous at the request of their parents, and out of respect for their wishes, the children's names were also fictitious.

Table 1: *Personas.*

	MOHAMMAD	SARA	MAISA
Age	6 Years Old	5 Years Old	4 Years Old
Gender	Boy	Girl	Girl
Custody	Father	Parents	Parents
The Child's Interest	Noisy exciting games Digital games Interested in superheroes Play with friends Cartoons	Intellectual games/puzzles Digital games Barbie doll Painting Cartoons	Musical /luminous toy Children's happy music Barbie doll Children's poetry Animals

After introducing and examining personas for research users, it is possible to express the differences and commonalities between them. The table lists the factors that make these three personas different from each other, and the table of commonalities lists the factors that are the same in all or most of the three personas.

Table 2: *Uncommon aspects of personas.*

Uncommon Aspects
Differentiation in children's behavior when attending medical centers
Differentiation in the type of children's entertainment
Distinction in personality traits
Differences in the amount of involvement with toys
Difference in an understanding of treatment operation (injection)
Difference in interests
Distinction in communicating with others

Table 3: *Common aspects of personas.*

Common Aspects
Shared interest in playing with toys
Common interest in watching animation and cartoons
Shared need or effort to calm other children in the therapeutic setting
Commonality in the lack of ease of communicating with others (strangers)
Shared interest in animated games
Shared interest in playing with parents

Results

Issues Identified from the questionnaire

- Children's lack of knowledge about being in the treatment environment and the injection process
- Lack of appropriate treatment tools for children in terms of color, form, etc.
- Lack of various entertainment devices according to the gender and age of the child
- Lack of a suitable seat for the child
- Absence of essential factors in the design of the environment for children (physical/psychological)
- The inability of some personnel and doctors to communicate properly with children in order to reduce their stress and anxiety

Ideal Final Results (IFR)

This list will ultimately help optimize and select the best ideas in the next phase, and the most consistent items should be used in the design.

- A fun product for children
- A combination of several types of fun devices for children (electronic and non-electronic toys)
- The attractiveness of phosphorescent and gaudy colors in toys for children, but with the choice of colors that match the psychology of colors for children
- A Fun product with light and sound to attract children
- A Fun product with a minimum amount of movement for the child's interest
- A group entertainment device, for example, a device where children and parents can play a role together.
- User-oriented material with the estimation of the lowest limit of damage (children)
- Product without harmful and rough surfaces and without sharp edges

Evaluations

The effectiveness of the musical syringe cover was assessed through parental feedback, behavioral observations, and prototype testing in clinical settings.

- Parental & Medical Feedback: 82% of parents reported reduced anxiety in their children, while pediatricians noted increased cooperation during injections.
- Behavioral Observations: The product successfully distracted children, leading to less crying, reduced resistance, and quicker recovery post-injection.
- Prototype Testing: Medical staff found the design easy to use, safe, and durable, with no major concerns regarding its implementation.
- Limitations: Suggestions included more character designs, expanded hospital trials, and long-term impact studies.

Overall, the product proved to be an effective, engaging, and practical solution for reducing injection-related stress in children, with potential for further improvements and wider adoption.

Ideas and Initial Studies

Idea generation has two phases: purposeful and aimless. Initially, ideation was unrestricted. Ideation became more purposeful as more information, images, and main words were gathered. Some ideas were not mentioned because of page limits and being far from project goals. Strengths were considered when the ideas were finished. Divergent ideas were collected through brainstorming. Kids are scared of needles and deny pain due to the fear of injections. This makes pain an unavoidable aspect of childhood.

Ideation Process

The first idea shown in [Figure 1](#) is the body of the silicone syringe. The syringe reservoir on the right side is drained from the reservoir through a flexible conduit on the left side and through the needle. The injection and use of this syringe include pressing the index finger on the liquid reservoir on the right side of the heart, pressing the left thumb, and exiting the body by pressing and draining the injected liquid. The concept was developed using a persuasive design approach. After use, the syringe needle is removed, and the heart syringe is given to the child and the child's parents. The heart is a symbol of human health.

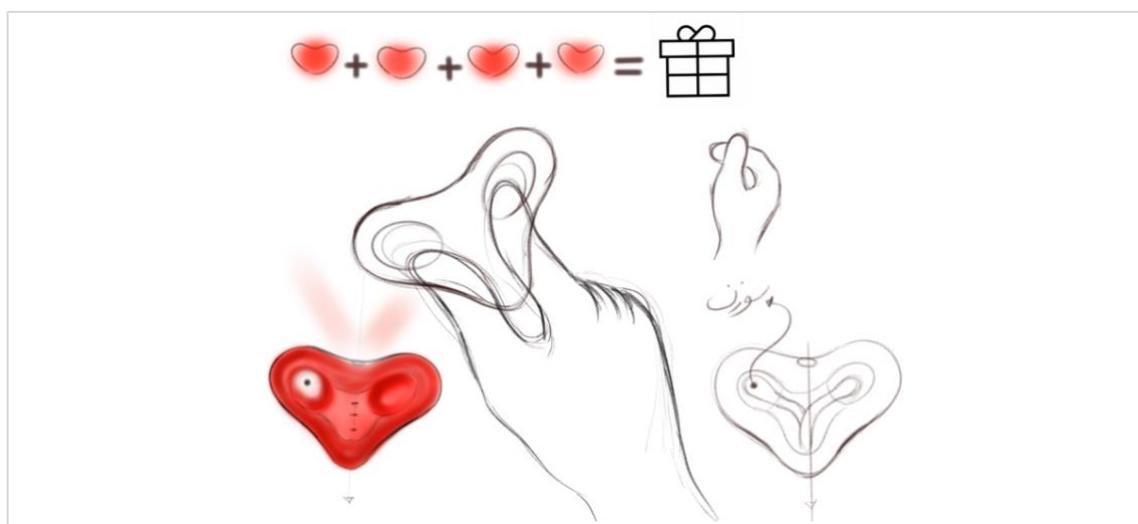


Figure 1: Initial ideas (concept 1).

In this design (doll needle) [Figure 2](#), the child's hand is placed between the doll's body and the doll's movable head, and on the other hand, the doll's head and hand cover the injection site and the needle to reduce the child's fear. After injection, the syringe needle was separated from the plastic doll, and a doll syringe was given to the child as a reward. The wedding syringe is produced in different colors and characters, and during the injection, the child's opinion can be considered when choosing the desired syringe and doll. The child's cooperation with the nurse and the concealment of the needle can greatly reduce the child's stress.



Figure 2: Initial ideas (concept 2).



Figure 3: Initial ideas (concept 3).

Figure 3 shows a doll-like syringe with a movable head that injects with a relatively suitable grip. The doll-like appearance of these syringes is somewhat amusing and reduces children’s anxiety.

The Selected Concept

After introducing and analyzing the three concepts discussed in the preceding section, it is possible to compare and contrast them based on the criteria provided, and a metric can be established for evaluation and selection. The final concept (Figure 4) is a musical syringe with lighting, which has a more suitable finger grip than the previous designs, making it easier to use. This design is more enjoyable. During the injection, after pressing a button on the back of the syringe, it lights up and plays music. The syringe simply fits inside the body, and after each use, only the syringe is removed from the body of the doll and thrown away. In addition, the needle series of the syringe fits inside the disposable folding plastic case, which makes the child unable to see the needle and the entry of the needle into his body, and prevents the child from being frightened Figure 5.

Based on the observational data and parental feedback, the initial prototype with limited sound features was modified to include interactive musical elements. Similarly, user hesitation about the visibility of the needle led to the development of a concealed silicone needle cover.



Figure 4: Final design.

Figure 5 shows the sectional view and position of the syringe. The thin and disposable silicone coating prevented the needle from being seen and prevented fear during the injection, and the needle gradually moved and entered the child's body (Figure 6). How to place the doll's head and body on the syringe is shown in Figure 7.

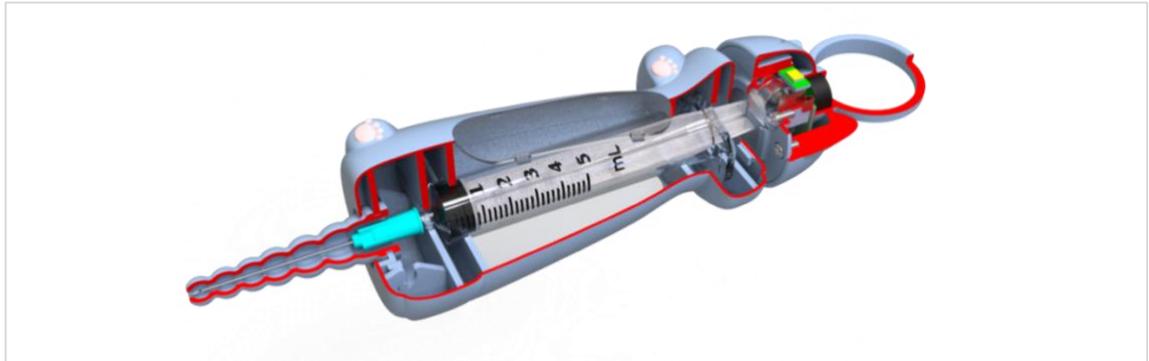


Figure 5: Section view.

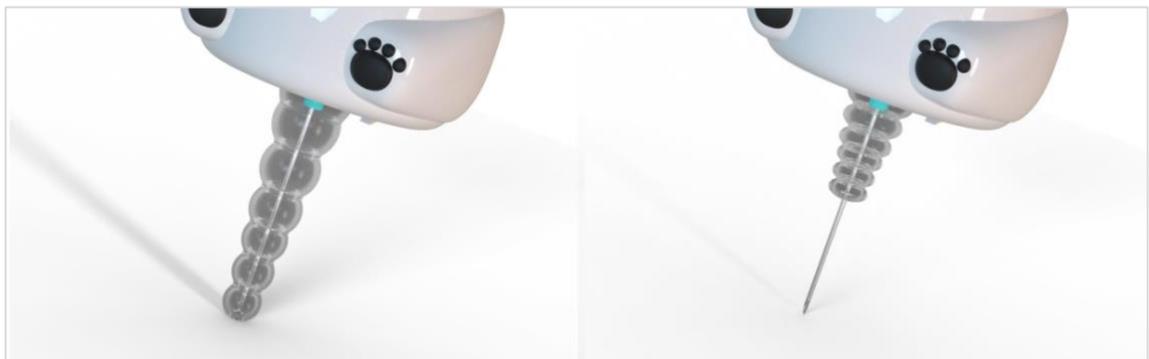


Figure 6: Silicone cover for needle.



Figure 7: 3D exploded view of the product.

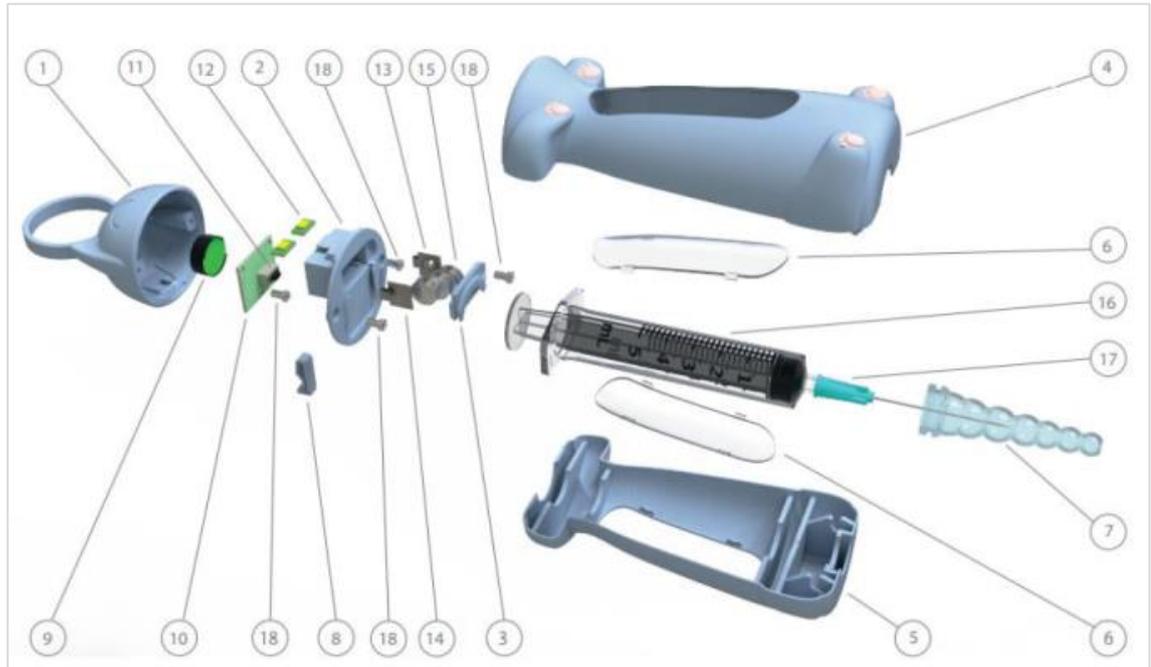


Figure 8: 3D exploded view.

Table 4: BOM chart.

	Name of the piece	Num	Material	Construction Method	Reason for use	Explanation
1	Main body	1	ABS	Injection	Performance and fun	handle and piston
2	Cap	1	ABS	Injection	-	
3	Battery cover	1	ABS	Injection	Battery holder	
4	Body number 2, the front design of the character	1	ABS	Injection	-	
5	Body number 3, the back design of the character	1	ABS	Injection	-	
6	Transparent screen	1	ABS	Injection	Seeing the syringe	Transparent part
7	needle cover	1	Silicon	Injection	Hiding the needle	Translucent
8	On and off button	1	ABS	Injection	-	-
9	electronic buzzer	1	-	-	Sound production	-
10	Electric board	1	-	-	Electric control circuit	-
11	On/off key	1	-	-	Turn on command	-
12	LED	1	-	-	creating light	-
13	Positive pole plate	1	Steel	Worksheet	-	-
14	Negative pole plate	1	Steel	Worksheet	-	-
15	Battery	1	Lithium		Energy supply	-
16	Syringe	1	ABS	Injection	-	-
17	Needle	1	Steel	Injection	-	-
18	Twist	4	Steel	Twisting	-	-



Figure 9: Product prototype.



Figure 10: Product test and checking the child's interest in the syringe doll frame.

Discussion

The research in this paper focuses on addressing stress and anxiety in children undergoing medical injections. Needle phobia is prevalent among most young patients, leading to greater distress, physical resistance, and long-term adverse attitudes toward medical treatment. Employing the Design Thinking method, this research sought to develop a child-friendly medical device that reduces fear and enhances the treatment process.

The most significant result of the research was the effectiveness of distraction techniques in alleviating anxiety among children. This study confirms previous research by [Tavakolian et al. \(2020\)](#) showing that sensory distractions (lights, sounds, animations) effectively reduce children's medical anxiety.

However, further testing is needed to explore long-term behavioral impacts and adaptation across different hospital environments. The questionnaire outcomes also emphasized that children are more accepting of active toys and entertainment-focused distractions during medical procedures. The most recent syringe cover to incorporate lighting and the concealed needle was a possible solution. Not only does this distraction take the attention of the child away from what is happening with the injection, but it keeps the child away from seeing the needle, one of the root causes of the fear. The interactive elements, such as blinking lights and smiling sounds, make the experience appealing as well so that the medical intervention appears less scary.

In addition to the design of the product, the study highlighted the caregivers' and medical staffs' interventions in soothing children's distress. Communication, emotional support, and a child-friendly environment are paramount in establishing a sense of security among children undergoing medical procedures. The study agrees with previous research on non-pharmacological pain reduction, testifying to the effectiveness of behavioral distraction strategies as compared to purely medical interventions.

Although the encouraging results are of considerable promise, more testing and refining are necessary before universal acceptance and application of the proposed design are feasible. Consideration for differences in cultures, hospital administration policy, and issues of materials safety must also be incorporated for the greatest usability. Further research is required to see how these developments may be incorporated into other feared medical procedures to help children better. Observations from prototype testing reinforced the need for non-threatening, child-friendly visuals. This resulted in refining the final design to incorporate softer colors and familiar cartoon-like aesthetics.

Conclusion

The study in this research aimed at reducing children's anxiety and stress during medical injections by designing a musical syringe cover with light and a concealed needle. Through questionnaires, interviews, and observations, the study indicated considerable behavioral indicators and coping mechanisms that influence the reaction of children to injections. The findings highlighted distraction techniques as well as child-centered hospital environments to enable anxiety alleviation.

The projected design offers a non-pharmacological, interactive treatment that is able to enhance children's medical experiences by including play elements, visual stimulation, and reassurance. Although initial results indicate its potential as an efficient remedy, further clinical trials and feedback from users are required in order to fine-tune the product and assess its long-term impact in alleviating medical anxiety. This study highlights how interactive medical tools can transform a child's medical experience. By integrating playful elements into syringe design, we offer a practical, non-pharmacological solution to reduce stress and improve cooperation. Future research should focus on long-term effectiveness and large-scale implementation in pediatric healthcare.

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