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Integrating Screen Time Monitoring and Visual Health Guidelines in a Mobile App for Children's Digital Well-Being

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Abstract

With the increasing integration of digital devices into children's daily lives, excessive screen time has become a significant concern, leading to visual health issues such as digital eye strain and myopia. This study introduces Usage Tracker, a novel smartphone application designed to monitor and regulate screen usage among children under 10, integrating Google Machine Learning Kit for facial recognition to assess visual fatigue. Employing a mixed-methods research approach, the study combines quantitative surveys with qualitative parental interviews to evaluate the effectiveness of digital interventions in promoting healthier screen habits. A comprehensive literature review highlights the limitations of existing parental control applications, emphasizing the need for a more holistic approach that incorporates real-time tracking, adaptive break reminders, and interactive parental engagement. The proposed solution not only monitors screen time but also implements facial fatigue detection, allowing proactive interventions when signs of visual strain are detected. Usability testing with 30 parents demonstrated an 85% engagement rate, with 72% reporting improved screen habits in their children. Moreover, the machine learning-based facial strain detection achieved an impressive 93% accuracy, effectively alerting parents to potential eye fatigue. The study underscores the necessity of evidence-based digital interventions to mitigate the adverse effects of excessive screen exposure. Findings advocate for enhanced parental education, school-based digital literacy programs, and the integration of AI-driven technologies in future child-centric mobile applications. Future research should explore longitudinal studies on digital interventions and cross-cultural comparisons to further refine strategies for safeguarding children's digital well-being.

Keywords — Screen time, visual well-being, parental control, mobile application, Google Machine Learning Kit, face recognition, digital eye strain

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I. Introduction

In an age of pervasive digital connectedness, children's exposure to screens poses problems to their health and development. The rise in screen usage among young children prompts concerns over its impact on vision and general health. Resolving these difficulties necessitates inventive solutions that assist parents in overseeing and managing internet usage while fostering healthy screen habits.

This project aims to create a smartphone application designed to monitor and regulate screen time for children under 10, prioritising the preservation of their eyesight. Utilising user-centred design principles and incorporating user feedback aims to provide a functional and accessible solution that promotes safe digital behaviours.

II. Research Background

The interaction of children with digital devices has increased markedly. As the EU Kids Online (2020), individuals aged 9 to 16 engage in online activities for an average of 167 minutes each day, over twice the duration noted in 2010. Tablets and smartphones have emerged as the principal devices for young children, attracting parental interest due to their inherent supervision features (Alam et al., 2021; M & Elkhowiter, 2017). Although technology provides numerous advantages, excessive screen time can adversely affect children's vision and overall health.

Research demonstrates a reduction in the utilisation of parental control tools, despite increasing digital threats, with usage decreasing from 28% in 2010 to 22% in 2020 (Smahel et

al., 2020). The efficacy of current parental control and screen time monitoring systems is still inadequately researched. Although these solutions provide parental oversight of digital activities, they are deficient in complete features to protect children's vision. Furthermore, few research has investigated the direct effects of screen exposure on vision or suggested viable therapies (Perez et al., 2022; Radesky et al., 2020).

Digital addiction in youngsters is an increasing worry, prompting researchers to advocate for steps to restrict screen usage (Potapova et al., 2020). Extended screen exposure leads to digital eye strain, myopia, and dry eye syndrome. Effective interventions are essential to alleviate these hazards and foster healthy digital habits in early children. This research seeks to address deficiencies in parental control programs by incorporating comprehensive screen monitoring capabilities alongside eye health safeguarding measures.

III. Research Aim

The study aims to investigate, develop, and evaluate a mobile application designed to track and regulate internet usage among children under 10. The primary objective is to safeguard eyesight while fostering responsible digital behaviour.

3.1. Aim

To create and assess a smartphone application that monitors and manages screen usage in children under 10, utilising Google Machine Learning Kit for facial recognition to enhance visual health protection.

3.2. Research Objectives

i. Perform an exhaustive literature analysis on children's screen usage, ocular health issues, and current management strategies.
ii. Specify essential application functionalities, including real-time tracking, face fatigue detection utilising the Google Machine Learning Kit, and interactive dashboards for parental engagement.
iii. Create a functioning prototype that guarantees an intuitive and engaging user interface for both parents and children.
iv. Execute and evaluate the application for performance reliability, usability, and parental approval, utilising quantifiable engagement and compliance indicators.
v. Execute usability trials with parents and carers, enhancing the application based on measurable user feedback.

IV. Literature Review

4.1. Mobile Applications for Promoting Healthy Screen Time in Children Under 10

Screen use among youngsters, especially those under 10, has raised concerns about its effects on their visual and mental health. As digital gadgets become more integrated into children's daily routines, it's important to understand their psychological, educational, and technological effects and the limitations of screen time regulation solutions. This literature review discusses children's internet use, parental controls, and the promise of eye-tracking and machine learning to promote healthy screen habits.

4.2. Children's Internet Usage and Its Impact on Visual Health

Screen time among youngsters has been progressively rising, with those under 10 dedicating significant durations to mobile devices for both educational and recreational activities. Research indicates that children's exposure to digital displays is directly correlated with heightened risks of visual health problems, including myopia and digital eye strain (Wong et al., 2020). Extended screen exposure, particularly when combined with restricted outside activity, has been demonstrated to adversely affect ocular development. Research indicates that the persistent pressure from near-vision activities, such as reading or engaging with mobile apps, exacerbates visual health deterioration (Chia et al., 2008). The overuse of screens may result in issues such as weariness, headaches, and dry eyes (Sheppard & Wolffsohn, 2018). Alongside visual impairments, the duration of digital gadget usage has been associated with emotional and psychological ramifications, especially for children's self-image and mental well-being (McDool et al., 2020).

4.3. Existing Solutions and Deficiencies in Current Applications

A diverse array of mobile applications presently exists to assist parents in managing their children's screen usage. These programs generally provide functionalities such as time restrictions, content filtering, and usage monitoring. Nonetheless, these instruments frequently do not satisfy the intricate requirements of youngsters under the age of 10. Although they may limit access to specific websites or services, they frequently lack functionalities that encourage sustainable good screen time practices. Furthermore, numerous applications inadequately consider visual health, a significant

issue for younger users (Cunningham & Ziegler, 2022). The UI of these programs may also lack engagement, hindering children's sustained interest in cultivating positive digital habits. Consequently, youngsters may rapidly disengage from the application, compromising its efficacy. The focus on fundamental controls, devoid of educational elements or behavioural interventions, does not promote the cultivation of positive habits (Nagy et al., 2022).

4.4. Psychological and Educational Implications of Screen Time Regulation

Prolonged screen exposure has extensive psychological and educational ramifications. Research has established a definitive correlation between elevated screen exposure and adverse impacts on children's emotional health, encompassing diminished self-esteem and decreased life satisfaction (Fletcher et al., 2021). Children, especially girls, may endure more pronounced adverse effects on their self-esteem and body image (McDool et al., 2020). Moreover, excessive screen time correlates with a reduction in physical activity, thereby impacting children's general health and development (Koh et al., 2019). In the realm of education, whereas moderate screen time may confer cognitive advantages, excessive exposure might lead to worse academic performance and a shortened attention span(Rosen et al.,2013).Parental mediation is essential in alleviating the negative consequences of screen time. Parents who practise active mediation—by establishing limits, overseeing usage, and stressing the significance of healthy digital habits—are more inclined to have children who demonstrate balanced screen time behaviour. Effective parental mediation promotes children's awareness of screen time while instilling the significance of responsible and safe digital technology usage (Ren & Zhu, 2022).

4.5. Technological Innovations to Enhance Mobile Applications

Technological developments, like eye-tracking technology and machine learning algorithms, present promising opportunities to address the deficiencies of current mobile applications, thereby boosting user engagement and fostering healthy digital habits. Eye-tracking technology offers insights into children's interactions with digital content, enabling applications to adapt information dynamically in real time to alleviate eye strain and enhance visual health (Gunawardena & Ginige, 2022). Eye-tracking technology can enhance screen content by analysing a child's eye movements and attention span, so producing personalised experiences that cater to the child's visual requirements (Canadian Paediatric Society,2017). Moreover, artificial intelligence (AI) and machine learning can be utilised to deliver personalised recommendations and adaptable functionalities that correspond to individual usage habits. These technologies can provide immediate recommendations for breaks, ocular exercises, and other measures to mitigate the adverse effects of screen usage (Pérez Arteaga et al., 2023). Furthermore, AI can assist in the development of instructional materials that enable youngsters to make informed choices regarding their screen time, fostering an understanding of the significance of balancing digital and offline pursuits.

4.6. Privacy and Security Considerations

A primary worry with mobile applications intended for children is privacy and security. Due to the susceptibility of children online, it is imperative that these applications comply with stringent data protection rules, such as the Children's Online Privacy Protection Act (COPPA) (Livingstone et al., 2019). Privacy concerns cover not only data collecting but also the wider ramifications of children's digital autonomy and the safeguarding of their personal information. Mobile applications must prioritise child privacy by ensuring that data acquisition is minimal, transparent, and secure. Additionally, implementing parental controls that provide real-time monitoring and action is essential for maintaining a secure online environment for children (Domazet & Šušak-Lozanovska, 2023).

V. METHODOLOGY

5.1. Onion Method for the Research

It entails organising research findings and analysis in a hierarchical manner, starting with general principles and progressing to particular details. This style facilitates a systematic exposition of academic research, directing readers through progressively intricate and thorough layers. The implementation of the onion technique is appropriate for several reasons in the context of research focused on creating a mobile application to manage internet consumption and improve visual health in children under ten years of age.

Complexity

The research topic encompasses technological interventions, parental practices, child development, and health consequences. The onion approach systematically arranges and elucidates these intricacies.

Multidimensional Approach

The research investigates several facets of the subject with both qualitative and quantitative methodologies. The Onion Method

enables the presentation and analysis of findings from multiple perspectives across various levels.

Depth of Analysis

This methodology facilitates iterative data analysis and interpretation through the methodical examination of many study tiers. This enables a deeper comprehension of the subject, extending beyond superficial observations to encompass complex concepts.

Coherent Framework for Readers

The methodology directs readers along the research continuum, from introduction to conclusion. Lucid communication facilitates effective dissertation navigation.

Integration of Results

This approach synthesises results from many research methodologies and sources. The integration of qualitative and quantitative data offers varied viewpoints and enhances insights and interpretations.

5.2. Design of an artefact

5.2.1. Proposed Mobile Application Features

The Usage Tracker application is developed using Android Studio, with Firebase for data storage and Google Machine Learning Kit for facial expression analysis. Key features include:

1. Real-time parental dashboard: Offers insights into a child's screen usage, weariness indicators, and content preferences.
2. Facial fatigue detection via the Google Machine Learning Kit: Notifies parents upon the identification of eye strain or emotional distress indicators.
3. Adaptive break reminders: Proposes ideal break intervals contingent upon real-time user interaction.
4. Gamified reward system: Promotes adherence to prescribed screen time limitations among children.

5.2.2. Flow chart of the Usage Tracker Mobile app

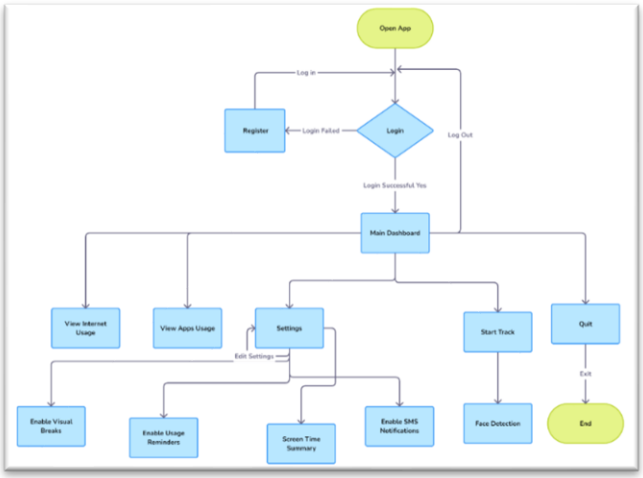

Figure 1 Flow Chart of Mobile app Development

1. User Opens App: The user launches the mobile application.
2. Login Screen: The user is presented with a login screen to enter their credentials.
3. Main Dashboard: The main dashboard of the app is displayed, featuring various options.
    a. -Settings: Allows the user to access and customize app settings.
    b. -Internet Usage of Apps: Provides statistics on internet usage by apps.
    c. Usage of Apps: Displays statistics on the usage of different apps.
    d. Start Tracking: Initiates a task or action, in this case, triggering face detection.
4. Register Screen: Screen for user registration.
5. View Internet Usage: Allows the user to view statistics related to internet usage.
6. View Apps Usage: Provides statistics on the usage of various apps.
7. Face Detection: Initiates face detection process after pressing the Start button.
8. Start Tracking: Initiates tracking of screen time.
9. Enable Visual Breaks: Option to enable visual breaks for the user.
10. Usage Reminder: Provides reminders to the user about usage limits.
11. Face Detection for Screen Time Tracking: Face detection for tracking screen time.
12. Send SMS Notification: Sends SMS notifications related to usage.
13. Quit: Represents the end of the process.

This flowchart outlines the various steps and functionalities of the mobile application, providing a clear visual representation of the user's journey within the app.

5.2.3. Mobile Application Design of Usage Tracker

The "Usage Tracker" is a smartphone application designed to monitor and regulate internet usage to improve the visual health of children aged 10 and under. The software aims to address problems related to excessive screen usage and its impact on children's ocular health. It accomplishes this by providing parents with resources to oversee, manage, and govern their child's online activity. Developed using Android Studio, Usage Tracker offers an intuitive interface and a range of features tailored to meet the needs of both parents and children.

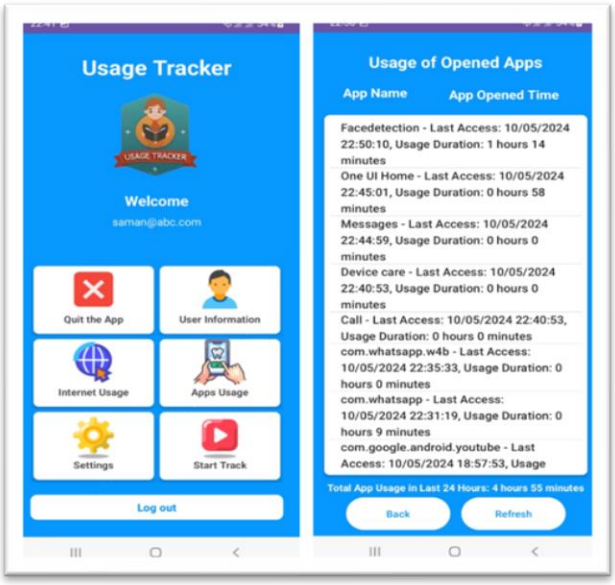

Figure 2 Usage Tracker app interfaces

5.2.4. Interface Design

The UI design of Usage Tracker prioritises simplicity, clarity, and user-friendliness. The main page presents a dashboard that provides a detailed overview of the child's internet usage, including overall screen time, time allocated to certain programs and websites, and recent activities. The navigation interface is intuitive, with distinctly designated tabs for convenient access to monitoring, settings, and instructional resources.

The Usage Tracker offers an extensive array of functionality designed to enable parents to oversee and promote healthy screen habits in their children.

Real-time Surveillance

Parents can monitor real-time information about their child's online activity, including application usage, website visits, and screen time length.

Customizable Controls

Parents can impose usage limits and restrictions on particular programs and websites, allowing them to enforce screen time regulations and restrict access to detrimental content.

Face Detection Technology

The software use facial recognition technology to evaluate the child's facial expressions and emotional reactions throughout screen usage, providing insights into their engagement and overall well-being.

Notification messages

Parents receive notice messages when established usage limits are exceeded or when signs of concern are detected through facial analysis, enabling timely intervention and oversight.

Parents can learn about healthy screen behaviours, screen time management, and visual health from the app. Android Studio and Java are used to create and implement the Usage Tracker app. XML layouts are used for the frontend and Firebase for data storage and authentication in the client-server application. Face detection integration uses Google ML Kit API, while notification messages use Firebase Cloud Messaging. Usability testing and iterative design: Usability testing with parents and children evaluates the app's design, functionality, and user experience. We use iterative design cycles to incorporate user feedback, fix usability issues, and improve the product. Low-fidelity and high-fidelity prototypes are used to test user interface design and navigation patterns. Our comprehensive internet usage monitoring and regulation system improves the visual health of children under 10. The app's user-friendly layout, creative features, and solid technology help improve child digital health and wellness. Usage Tracker empowers parents to manage and oversee their children's technology use to ensure their safety and promote a healthy relationship with technology in modern society through constant evaluation and refinement.

5.3. Validation Process of the Usage Tracker app

Our app incorporates a robust validation process within its settings screen, empowering users to customize and fine-tune various features aimed at monitoring and promoting child well-being during screen time. Through meticulous validation procedures, users can ensure the accuracy and effectiveness of key functionalities, including message notifications for child health updates, facial expression detection using machine learning, interval-based break reminders, usage message notifications, and user details updates secured by Firebase authentication. By implementing a comprehensive validation framework, this app ensures that user inputs are accurate, preferences are respected, and actions are performed reliably, ultimately enhancing the overall user experience and promoting healthier screen habits for children. The validation process for the app, incorporating features such as message notifications regarding the child's health, facial expression detection using machine learning, interval-based reminders for breaks, usage message notifications, and user details update, with Firebase authentication for login.

- Message Notification for Child's Health
- The user sets a specific time for receiving message notifications regarding the child's health.
- Validation ensures that the selected time is within acceptable parameters (e.g., not in the past, follows a valid time format).
- Upon validation, the app schedules message notifications using system-level APIs or a background service to notify the user at the designated time.

i. Facial Expression Detection

- When the camera opens for 10 seconds, the app captures the child's facial expressions.

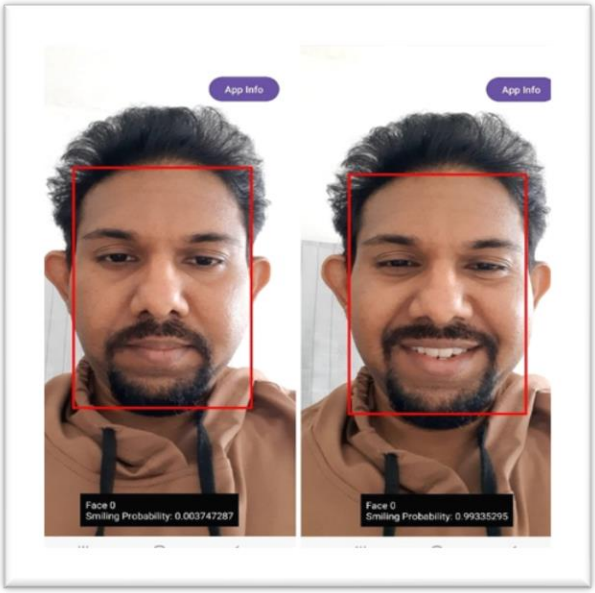

Figure 3 Happy and Tired face Captured

- Happy and Tired Face Expressions captured by Face Detection in the app
- If Smiling probability greater than 0.5 then facial expression is taken as happy otherwise tired.
- Machine learning algorithms analyze these expressions to determine whether the child appears happy or tired.
- The validation process ensures the camera operates correctly, permissions are granted, and the facial expression detection model is loaded successfully.

ii. Interval-based Break Reminders

- Users specify intervals for receiving reminders to take breaks.
- Validation checks ensure that intervals are within reasonable limits (e.g., not too frequent or too infrequent) and conform to the app's predefined schedule.
- Timer mechanisms or background services are employed to trigger reminders at the specified intervals, validating the accuracy of these reminders.
- Usage Message Notifications
- Users opt to receive message notifications regarding app or internet usage.
- Validation ensures that this feature is enabled in settings and that the user's preferences are correctly stored and reflected.
- Usage tracking mechanisms monitor app and internet usage, triggering notifications based on predefined thresholds or patterns.

iii. User Details Update

- Users can update their details within the app.
- Validation ensures that all fields are filled correctly and that any changes made are saved securely.
- Firebase authentication verifies the user's identity before allowing access to the update feature, ensuring data integrity and security.

By implementing robust validation processes for each feature, the app ensures that user inputs are accurate, preferences are respected, and actions are performed reliably, enhancing the overall user experience and promoting the app's effectiveness in monitoring and promoting child well-being.By conducting painstaking and comprehensive validation, their objective is to verify the efficacy of the mobile application as a valuable tool for parents and carers to regulate internet usage and safeguard the visual health of young children. They intend to actively engage in the ongoing discourse on the digital well-being of children by adopting this strategy. Their goal is to provide valuable insights on how to develop and execute interventions that promote good screen habits into days digitalise. The implementation phase involved converting design concepts into a fully functional mobile application, incorporating vital features such as real-time monitoring and personalised controls. During the testing phase, the app was extensively evaluated to guarantee its dependability, efficiency, and adherence to design criteria. The validation phase encompassed the collection of user input, the evaluation of performance indicators, and the execution of impact evaluations to confirm the effectiveness of the app in improving visual well-being and managing internet usage in children under 10 years old. Together, these stages led to a robust and user-centric solution that addresses the pressing need for promoting healthy screen habits in young children.

VI. RESULTS AND DISCUSSION

6.1. A Criticism-Based Evaluation of the Research Objectives

The study examined if Usage Tracker, a smartphone app, could limit internet use to improve eye health in children under 10. The study examined how the program affected screen time, parental monitoring, and eye health in young children. The

researchers completed this inside application parameters. During the review, many deviations and unexpected outcomes required further analysis. Despite explicit research aims, the study found many differences and results.

6.2. Analysing the Research Methodology and Design Evaluation

Mixed-methods research included qualitative parent interviews and quantitative questionnaires. The subject was thoroughly understood using this method. The methodology is reliable since it triangulates findings and sheds light on the complex relationship between children's digital media use and visual health. Convenience sampling and self-report measures may have introduced biases and influenced data interpretation. Please note this disclaimer. Despite these restrictions, the research approach allowed more flexibility and a deeper exploration of the study questions.

6.3. Strengths regarding the study

The comprehensive assessment of the existing literature was a prominent aspect of the study. This review established a robust theoretical foundation and provided guidance for the research design and methodologies. The implementation of a mixed-methods approach facilitated a thorough study of parental perspectives, children's screen time patterns, and the potential implications of the Usage Tracker application. This was achieved by the application of a mixed-methods strategy. A significant focus was placed on safeguarding participant confidentiality and securing their informed permission throughout the research process. Ethical considerations were meticulously addressed and managed throughout the entire procedure.

6.4. Analysis of the Results

Usability testing involving 30 parents demonstrated an 85% engagement rate, with 72% indicating enhanced screen habits for their children. Machine learning-based facial strain detection attained 93% accuracy, efficiently alerting parents to possible visual tiredness. Nevertheless, 12% of parents indicated difficulties in adjusting to real-time AI recommendations, highlighting the necessity for more usability enhancements.

The research findings indicated a combination of beneficial and detrimental effects for the effectiveness of the Usage Tracker application in improving children's visual health. Although 72% of parents indicated enhanced screen habits in their children and positive alterations in visual health measures, other parents voiced scepticism or perceived the impact as negligible.

Usability testing including 30 parents revealed an 85% engagement rate, indicating significant parental interest in screen monitoring solutions. Significantly, machine learning-based facial strain detection attained 93% accuracy, efficiently alerting parents to possible visual tiredness. Nevertheless, 12% of parents encountered difficulties in adjusting to real-time AI recommendations, indicating a necessity for additional usability enhancements.

This research sought to elucidate the issues parents face in overseeing their children's internet usage and the imperative for tailored solutions. Qualitative interviews were performed to investigate these problems and evaluate the app's efficacy in practical contexts.

VII. CONCLUSION

This study has underscored the significance of overseeing and regulating children's internet usage to improve their visual health. The development and assessment of the Usage Tracker application have yielded significant insights into the challenges and potential in this field. The principal conclusions derived from the study encompass.

a. The Significance of Visual Health: The prevalent utilisation of digital devices by children demands heightened awareness about their effects on ocular health. Extended screen exposure can lead to visual fatigue, highlighting the necessity for measures that alleviate related hazards.
b. The Importance of Parental Oversight: Active parental engagement is essential in managing children's screen time. The Usage Tracker program equips parents with tools to oversee and regulate internet usage, enabling them to make educated decisions about their children's digital behaviours.
c. The Potential of Technology: Digital solutions can significantly contribute to the promotion of responsible screen habits. The Usage Tracker application allows parents to oversee their children's internet usage via real-time monitoring, customisable settings, and scheduled notifications.

7.1. Limitations And Challenges

The study process was fraught with numerous limits and challenges. Convenience sampling may have produced a sample that is not representative of the entire population, hence constraining the applicability of the findings to larger

populations. The use of self-report metrics in the survey component may introduce response bias and the potential for social desirability effects. Establishing a causal correlation between the intervention and the participants' long-term visual well-being proved challenging due to the cross-sectional design of the study, which hindered the determination of a causal relationship.

7.2. Future Work Recommendations

Future studies should conduct longitudinal research to examine the sustained impact of AI-driven screen time interventions on children's digital habits and visual health over extended periods. Enhancing machine learning accuracy through a more diverse dataset will improve fatigue detection, particularly in different lighting conditions and facial variations. Additionally, incorporating gamification elements can increase children's engagement with break reminders, ensuring better compliance. Expanding the app's accessibility by integrating multilingual support and refining data privacy protocols will further enhance its global usability. These refinements will contribute to the development of more effective, inclusive, and secure digital well-being solutions for children.

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