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Data-Driven Technology for Children's Health and Wellbeing: A Systematic Review

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Data-Driven Technology for Children's Health and Wellbeing: A Systematic Review

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ABSTRACT

As data-driven health technologies such as mobile health apps, wearable devices, and smart medical devices advance and become more pervasive, the datafication of personal health research has grown substantially in recent years. However, the field has primarily focused on adult users, leaving a limited understanding of children's data practices and technology for managing their health and well-being. Given children's unique skills, needs, and experiences concerning technology use and self-care compared to adults, it is crucial to explore their perspectives on personal health datafication. Such inquiry will help bridge the knowledge gap and inform the development of age-appropriate, engaging, and effective health technologies that cater to children.

In this work, we first present an overview of the history of personal health datafication research, child development theories, and child-computer interaction studies, primarily focusing on HCI. Subsequently, we conducted a systematic literature review to understand the broader landscape and identify opportunities for future research on data-driven

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technology for children's health. We analyzed health datafication papers centered on children (birth to 18 years old) that appeared in ACM's library, IEEE Xplore, and PubMed from 2011 to 2021. This work contributes to the literature by (1) characterizing the trends in children's health datafication research, including identifying dimensions and study characteristics that received wide attention, as well as areas that are underexplored, (2) reflecting on key research themes to guide future health datafication research focused on children, and (3) providing recommendations for future research and design of data-driven technologies that support children's health and wellbeing.

1

Introduction

Data-driven health informatics technologies, such as mobile health apps and wearable devices, have become ubiquitous in people's daily lives, enabling personal health datafication. This process involves generating and utilizing health data like physical activity, sleep, symptoms, and medication use, which is then shared with various stakeholders, such as family members, friends, and clinicians, to achieve health and personal goals. Human-computer Interaction (HCI) research has extensively explored personal data production, distribution, and consumption, with various terminologies denoting this field of study, including quantified-self (Choe *et al.*, 2014; Lupton, 2016), self-tracking (Neff and Nafus, 2016), and personal informatics (Epstein *et al.*, 2015; Li *et al.*, 2010). As highlighted in a recent mapping review (Epstein *et al.*, 2020), despite 83% of self-tracking, quantified-self, and personal informatics literature in HCI focusing on health and wellness, the majority of research primarily targets adults, leaving a significant gap in understanding health tracking's role in children's health.

Young people in this generation, encompassing Millennials, Generation Z, and Generation Alpha, are growing up in an environment deeply intertwined with the internet and data-centric technologies. They are

increasingly anticipated to employ these digital and data-driven tools to maintain and enhance their health and well-being. However, multiple challenges persist when investigating children's health in this context. First, unlike adults, children primarily depend on their caregivers, typically their parents, to manage technology and health. Consequently, the selection of technological tools and the manner and timing of their usage is often determined and regulated by their parents at home (Blackwell *et al.*, 2016; Hiniker *et al.*, 2016) and by educators in school settings (Freeman and Neff, 2021). Second, the practices associated with the datafication of children's health diverge fundamentally from those of adults due to the distinct and rapidly evolving developmental stages that children experience and their varying levels of skills and literacy. For instance, young children may possess limited literacy abilities, rendering them incapable of comprehending large numerical values and connecting them to their health and wellness, as represented on wearable devices (Oygür *et al.*, 2021). Furthermore, they often exhibit underdeveloped motor skills, which can hinder their ability to execute common gestures, such as dragging and dropping, when interacting with devices like smartphones or tablets. In addition, children of different ages display unique preferences for technological support. While younger children may primarily rely on their parents for assistance, older children are generally more willing to seek validation and guidance from their peers (Freeman and Neff, 2021).

Given the pervasive influence of data-driven health technologies and the unique challenges associated with children's interaction with these tools, it is crucial to extend our understanding in this domain. We aim to delve deeper into children's health datafication practices, navigating the landscape of their technology use, caregiver involvement, and the distinct factors associated with their development and literacy. Our intention is to catalyze future innovations, improving the design and utility of health technologies tailored for children. To that end, we direct our investigation around the following three key research questions:

- How has the HCI community attempted to support children and their caregivers via data-driven health technologies, specifically considering health focus, tracking motivations, data types, data

tools, data collection methods, data users, and data representation?

- What are the standard practices in conducting research on children's health datafication, particularly in terms of research participants, age range of child participants, and research methodologies?
- What key themes have been prominent in HCI research pertaining to children's health datafication?

To answer these questions, we conducted a systematic literature review of HCI and health informatics publications centered on health tracking in children (birth to 18 years old). We retrieved papers from ACM's Library, PubMed, and IEEE Xplore between 2011 and 2021, as health datafication tools for children emerged and gained popularity during this period (Garun, 2018; Rosman, 2014). We qualitatively analyzed 57 papers, focusing on research foci, data tools, data collection and use, data representation, study characteristics, and research themes. We hope to provide a comprehensive overview as a foundation for future researchers aiming to explore, design, and assess data-driven approaches for promoting children's health and wellbeing.

Our analysis suggests that:

- Past research predominantly focused on wellness (e.g., physical activity) and type 1 diabetes, while other health domains (e.g., mental health, asthma) received comparatively less attention.
- Past research aimed to encourage positive behavior change, assist medical condition management, support collaboration between families and healthcare professionals, and foster learning moments for children and caregivers.
- Past research focused on three data categories: medical data, like symptoms and disease-specific information; wellness data, such as sleep, food, and physical activity; and context data (e.g., location), which provides information beyond numerical numbers and graphs.

- Past research incorporated a range of data tools, such as mobile phones, wearables, tablets, computers, and medical devices, with most requiring pairing for effective use.
- Past research focused on studying and designing mobile, tablet, or web-based applications, with fewer efforts to explore wearables and smart medical devices.
- Most data tools for children's health are not explicitly designed for children, and designs catered for children often focus on appearance rather than functionality, with many tools resembling adult-centric versions with added visual appeal.
- Automated data collection methods are primarily used for wellness data, while manual and semi-automated approaches are often necessary for medical conditions due to the complexity and subjectivity of the data involved.
- The use of children's health data extends beyond the individual level, involving other actors in the child's care ecosystem, like parents, family caregivers, healthcare providers, and teachers.
- Number-driven representations (e.g., numerical numbers and graphs) dominate commercial products, while research artifacts focus on other data representations like text and visual annotations, automated systems, and gamification for enhanced understanding and engagement.
- Past research primarily focused on school-age children and adolescents, with limited attention to infants and preschoolers; many adopted a "one size fits all" approach (e.g., recruiting children aged 6–18) to study and design technology for children's health.
- Past research predominantly explored five significant themes in children's health datafication research, including data work, learning, agency, parent-child relationships, and privacy and data sharing, highlighting the opportunities and challenges in each area and the potential for design efforts to address them.

Based on our review, we call for future HCI researchers to:

- Focus on collaborative work within the children's care ecosystem, examining the roles and perspectives of diverse actors involved in health datafication and addressing the complexities of information, infrastructure, care, data, and emotional work across various contexts and devices.
- Prioritize addressing developmental differences in children's health datafication tools, accommodating their evolving needs and literacy levels, and utilizing age-appropriate study methods to ensure effective engagement and meaningful outcomes in health technology development.
- Focus on designing health datafication tools that address both adult caregivers' and children's diverse motivations, emphasizing fun and engaging experiences for children while promoting learning, long-term wellness, and habit formation.
- Prioritize considering socio-economic status (SES), family structures and dynamics, and equity in health datafication tool design to ensure inclusivity and address the diverse needs of various family contexts.
- Enhance interdisciplinary collaboration with medical, engineering, education, and privacy fields to develop effective and safe datafication tools that support children's health, learning, and privacy while addressing real-world challenges and regulatory requirements.

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