

Exploring Information Needs for Tracking to Support Using Wheelchairs in Everyday Life

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Past research on wheelchair user tracking technologies has emphasized physical activity support, upper body pain alleviation, and accessibility mapping. However, little is known about what information users consider important in tracking to support their daily use of wheelchairs. To address this gap, we took a holistic view through an online survey (53 responses) and discovered the overall need to track beyond accessibility and physical activities, including a keen interest in monitoring 'wheelchair health', social causes, and concerns regarding data accountability for policy change. Our study contributes by delineating the unmet information needs in wheelchair tracking and advocating for more research interests to develop and design tracking tools in Human-Computer Interactions (HCI) that enrich the everyday experiences of wheelchair users.

CCS CONCEPTS • Human-centered computing ~Accessibility~Empirical studies in accessibility

Additional Keywords and Phrases: Personal Informatics, Tracking Technologies, Inclusive Design, Wheelchairs, Mobility Impairment, Survey, Accessibility

ACM Reference Format:

Wen Mo, Aneesha Singh, and Catherine Holloway. 2024. Exploring Information Needs for Tracking to Support Using Wheelchairs in Everyday Life. In *CHI '24: CHI Conference on Human Factors in Computing Systems (CHI '24)*, May 11–16, 2024, Hawaii, USA. ACM, New York, NY, USA, 10 pages. <https://doi.org/10.1145/3613905.3650933>

1 INTRODUCTION

In recent years, there has been a substantial growing number of research in the field of personal informatics (PI) [13] in Human-Computer Interaction (HCI) and tracking technologies, driven by a burgeoning interest in the social movement of the 'Quantified Self' (QS) [31] and the technological advancement of wearable devices (e.g., Apple Watch¹, Garmin² and Fitbit³). This expansive array of research focuses predominantly on health and fitness tracking while very few are dedicated to people with mobility impairments or wheelchair users [13, 36].

¹ <https://www.garmin.com/en-GB/c/wearables-smartwatches/>

² <https://www.fitbit.com/>

A few research efforts in HCI have been directed toward supporting physical activity [7, 8, 34] managing upper body pain [27], and enhancing accessibility by tracking wheelchair users' mobility [45]. Concurrently, there has been significant progress in crowd-sourced accessibility mapping [29, 35, 41] some through the approaches of tracking wheelchair users [38], aimed at accommodating diverse mobility needs and creating more inclusive environments. However, the specific and nuanced information needs of wheelchair users in their daily lives that can benefit from PI systems remain largely underexplored.

For instance, research rarely investigates how wheelchair users perceive the value of tracking detailed, day-to-day information such as how often and how long they use their wheelchair, the context in which it is used, feelings at that moment, and other granular-level longitudinal data. These timely-tracked and monitored data could provide a full picture and detailed accounts of how one uses a wheelchair, discovering hidden patterns and capturing moments one might have overlooked over time, which helps to reveal barriers and challenges in context. Additionally, in past research, wheelchair users are often only seen as informants and lack agency in collecting, accessing, or reviewing the data they can monitor and track themselves. A feeling of agency is crucial for wheelchair users as it gives them a sense of control over their assistive devices and lives, which is important for maintaining good physical and mental health.

Recognizing this critical research gap, our study took the first step, delving into the uncharted territory of tracking technologies from the perspective of wheelchair users. Through an online survey of 53 responses, we aimed to understand the unmet information tracking needs of wheelchair users. Our findings showed a pronounced interest in tracking aspects beyond mere accessibility and physical activities, such as monitoring 'wheelchair health,' a term that encapsulates the maintenance, and performance of the wheelchair. Moreover, the survey raised the question of how to employ tracking for social causes but safeguard data accountability, suggesting a need to leverage personal data for broader societal benefits and policy reforms. In light of these findings, our study sheds light on the overlooked information needs of wheelchair users but also calls for a more inclusive approach in the domain of PI and tracking technologies. As we move forward, the research community, technology developers, and policymakers should collaborate closely to create and implement PI systems that can improve the use of wheelchairs in everyday lives and also push for a more accessible and accountable society.

2 LITERATURE REVIEW

2.1 Personal Informatics and Tracking

The idea of self-tracking dates back to when people only used pen and paper to write journals. The advancement of sensing technologies has bloomed and digitalized the self-tracking practice, which led to the form of the community and the QS movement. As mobile phones and wearable devices become increasingly pervasive, technologies that support such tracking and reflecting practices continue to proliferate. People, not only 'Quantified Selfer', start to gather personal data from almost any aspect of their life, such as physical activity, sleep patterns, and dietary habits. These technologies that facilitate collecting and reflecting personal information, according to Li et al., [24], are called Personal Informatics (PI), which has emerged as a dynamic and rapidly evolving field of research within HCI.

Since then, two models of PI have been proposed. Li et al. [24] introduced the stage-based model composed of preparation, collection, integration, reflection, and action. The model is designed to help researchers and designers better understand the barriers in every five stages. The model was later refined to specify two types of reflection: discovery and maintenance [25]. However, Epstein et al. [14] argued that the stage-based model is deeply rooted in

the behavior change goal and does not reflect real-life practice as people don't strictly follow the stages. People often sometimes switch tools for tracking, are not always goal-oriented, and regularly fail to keep tracking. Thus, to integrate self-tracking into everyday life, they emphasized and proposed a lived informatics model. Despite the differences, both models aim to guide researchers and designers to better design PI systems for self-improvement.

In addition to models, a plethora of research has studied various aspects of PI over the past decade. PI research spanned a wide range of domains such as food and diet [30], fertility [10], physical activity [26], chronic illness [3, 32], dreams [19], and more, with health and well-being being the most frequent domain of study [13]. Furthermore, to support better tracking, many approaches have been examined. For example, Choe et al. proposed a Semi-Automated tracking approach- 'any combination of manual and automated tracking', which aims to lower the capturing workload for users but also increase tracking awareness of people [9]. To support reflection, recent studies began to explore the shared reflection approach, emphasizing the importance of social learning [15, 17]. Additionally, other studies experimented with multiple mediums and strategies, from visual encoding [43], situated data visualizations [6], and structured storytelling [46] to ambient narrative-based interfaces [37] and personal customized data visuals [22].

Despite the variety of domains and approaches explored in PI, there are very limited or no studies that have explored how to design tracking systems to facilitate the need to use assistive technologies (ATs) such as wheelchairs in daily life. Motahar and Wiese [36] reviewed 50 publications and found a lack of research incorporating the needs of people with motor disabilities into PI. This lack of interest is also reflected when Sean and Vatavu reviewed research in wearable interactions for people with motor impairment [42]. A few attempts have been made. For instance, Carrington et al. [8] designed an activity-tracking app for wheelchair performance, but it is dedicated to wheelchair basketball players, not the usage in daily life. Malu and Findlater [34] found numerous benefits of sharing automatically tracked data from the perspectives of both wheelchair users and therapists. However, the interest is still predominately physical activity driven. Therefore, there is a lack of research interest in exploring the personal tracking needs of wheelchair users and a lack of diversity of interest among the existing research.

2.2 Tracking Technologies for Mobilities

Many studies have explored using different sensors to monitor wheelchair use and activity. From a rehabilitation perspective, H.V. van der Woude et al. [44] broke down wheelchair performance into three categories for people with spinal cord injury (SCI), including physical capacity, skill, and propulsion technique. They argued that evaluating how well one uses the wheelchair in daily life requires measuring the stress and strain of daily wheelchair use, the physical wheeling capacity of the user, wheelchair skills, environmental barriers, and the quality of wheelchair design and fitting. The technologies for measurements need to be tailored accordingly, for example, measuring heart rate to monitor cardiovascular strain of using a wheelchair, using accelerometer sensors to monitor activity level [11, 16], and measuring 3D force on the hand rim of the wheelchair to track the use of upper body musculoskeletal. This shows the great importance of tracking these types of information in daily life for wheelchair users.

To measure these, Routhier et al. conducted a scoping review synthesizing the literature specifically on the sensing technologies used in wheelchair research [39, 40]. They identified a list of sensors along with the intended outcome discussed in past studies. Accelerometers attached to the users are the most used, followed by odometers and accelerometers embedded in wheelchairs. This finding correlates to the interest in measuring the distance it

travels, speed, driving time, and mobility events. Meantime, sensors worn by the user are most often used to measure physiological responses, including heart rate, respiration, and body temperature, which can be used to detect users' stress and excitement levels. With the growing availability of commercial sensors, the prospects for developing a comprehensive system that can monitor various data points about wheelchair use are incredibly promising. Overall, the findings of this review underscore the need for further research in this area and highlight the potential benefits that such a system could bring to wheelchair users.

However, the challenge remains as commercial fitness tracking tools are usually not applicable for measuring physical activity with wheelchairs [7]. For example, Apple Watch⁴ and PushTracker E2⁵ allow manual wheelchair users to track the push count – 'the number of times a wheelchair user moves their chair by applying a force to the rim of the wheel' [21]. However, past research [7, 34] reported the inaccuracies of data tracked with the current activity trackers. Furthermore, there is a lack of research that has investigated how people make sense of such data (e.g., push counts), how they would use this data, or what other data regarding using wheelchairs people would be interested in. In addition, these current commercial products are expensive and inaccessible to people. Therefore, this study took the first step, starting with asking the question of what data about using wheelchairs users would like to know and track, and what their motivations and concerns would be.

3 SURVEY

Considering all tracking methods (i.e., manual, automated, and a blend of both), we created an anonymous short online survey with worldwide wheelchair users on Qualtrics to answer three main research questions:

1. What types of information do wheelchair users want to collect regarding using wheelchairs in everyday life?
2. What are their motivations for collecting or being aware of this information?
3. What general concerns do users have regarding tracking this information?

By answering these questions, the main objective is to explore what types of information users consider useful and important to track to support their daily use of wheelchairs and reveal insights into how tracking tools can be designed or improved to better meet the needs of wheelchair users.

3.1 Survey Design

The survey started with an information sheet and consent form, explaining the research purpose and recruitment criteria, followed by two main sections (9 questions in total), and ended with demographic information. The first main section aimed to gain an overview of what types of information users are currently gathering and what tools they use. These information categories were based on Epstein et al's overview of the PI literature [13]. Participants were also given the option to provide additional details under each category.

The second section investigated specifically users' interests and motivation in tracking information related to using wheelchairs and general concerns towards such collection. The majority of the survey consisted of multiple-choice questions that included an "Other" option allowing short answers. To capture users' interests, we provided 10 categories with examples for participants to choose among three options: (1) Yes, I track this information, (2) No, but I am interested in tracking this in the future and (3) No, and I am not interested. The categories were selected based on past studies in accessibility, tracking technologies with wheelchairs, and lived experience of wheelchair

⁴ <https://support.apple.com/en-us/HT204576>

⁵ <https://hub.pernobil.com/smartdrive-pushtracker-e2-wheelchair-power-assist>

users [29, 43, 45]. An open-ended question was included to report additional comments. We also asked the reasons why they are not currently tracking the categories in which they showed interest. The options for motivations and concerns were informed by prior work in PI [13] and health and fitness tracking for wheelchair users and athletes [29].

3.2 Participant Recruitment

To participate in our survey, the participants need to be over 18 years old and used to be or are currently a wheelchair user. A series of questions in the participant consent form detailing inclusion and exclusion criteria were designed for screening purposes. The participants were recruited through two main methods, (1) posting adverts on social media, including Reddit, Facebook Group, Twitter, LinkedIn, and Instagram, and (2) contacting professional and industry networks by e-mails. Participants were not compensated for the survey.

3.3 Participant Demographics

A total of 56 participants engaged in the survey, however, three responses were discarded due to consent issues. Of the remaining eligible 53 respondents, 55% identified as women, 40% identified as men, 2% were non-binary, and 3% preferred not to disclose. Participants' age ranges from 18 to over 75: 18-25(18.87%), 26-34(20.75%), 35-44(24.53%), 45-54(18.87%), 55-64 (5.66%), 65-74(9.73%) and 75-84(1.89%). The majority are from high-income countries (HICs) (69.8 %), mostly from the US and the UK, 7.55% from upper-middle-income countries and the rest are from four lower and middle-income countries. Notably, 49 % of the participants live in urban areas and at least 66% have a bachelor's degree.

Among the 53 participants, 91% were current wheelchair users, and 9% used to be a user. 85% (N=45) of users used manual wheelchairs while 26.67% (N=12) out of these users own one additional mobility aid including an electric/power wheelchair (N=5), mobility scooter (N=4), electric tricycle (N=1), walker (N=1) and scooter attachment (N=1). Participants' experience in using wheelchairs ranged from six months to 55 years (average: 16 years; median: 11 years).

3.4 Data Analysis

Our data analysis method combined quantitative and qualitative approaches. For quantitative data, we employed descriptive statistics to summarize responses to multiple-choice questions, and for qualitative data, we conducted a thematic analysis [5] using the bottom-up approach to code the responses to the open-ended questions. The goal was to identify deeper insights into the types of information wheelchair users track, their reasons, and concerns for tracking, thereby linking these aspects to the broader context of daily wheelchair use. We found most of them served as supplementary details for the predefined categories, for example, participants added "pushes a day" in "other categories" to express what they would like to track which aligns with the category of "physical activity". Some responses reconfirmed the answers to other questions, such as writing "Never considered" in answering questions for "Concerns", which matches with the option "It never occurred to me" in the question about "Why not tracking".

3.5 Survey Result

3.5.1 Overall tracking practice.

Out of our 53 participants, 75.5% (N=40) reported tracking some aspects of their lives. Of these participants, from 0 (minimal familiarity) to 10 (expert), the average self-rated tracking experience was 6.1 and the median was 7.

Meanwhile, the most used tracking tools among these 40 participants are smartphones (72.5%), followed by paper (47.5%), fitness trackers (40%), computers and laptops (30%), and lastly tablets (15%).

The most popular category participants reported tracking was physical activity (62.5%). Many participants commented on the need to track their exercise patterns but experienced inaccuracies with the existing tools which aligns with the past research findings [34]. One participant adopted a workaround strategy by putting Fitbark⁶ on their assistance dog to gauge distances traveled. The second most tracked category was physiological data (52.5%), with heart rate and blood pressure reported in the comments as the most monitored. These physiological metrics are closely linked to the third most popular category: managing chronic conditions (50%). Six participants elaborated on the need to manage pain and their energy levels, and four highlighted their chronic conditions such as asthma, Lyme disease, and hydrocephalus, as many mobility impairments are caused by chronic conditions.

Although social interaction was the least tracked category reported by only one-fifth of participants, a few users provided detailed examples. For instance, one emphasized the importance of being mindful of social interaction frequencies due to living alone and feeling isolated, while another participant reported feeling 'crabby' after social interactions with non-disabled persons led them to intentionally limit such interactions. These contrasting attitudes towards social encounters reflect wheelchair users' different coping mechanisms but also reveal a deep psychosocial need for relatedness.

3.5.2 Overall information needs to support wheelchair use in everyday life.

Currently, there are 69.8% of the total 53 participants tracking information participants considered to be specifically regarding using wheelchairs. Across all categories, it is evident that there are more people interested in tracking than those who are currently tracking or those who are uninterested. This is underscored when aggregating the number of participants who reported tracking now in each category with those who expressed an interest in tracking. We consider the combined total number as an indication of the "Need for tracking" as shown in [Figure 1](#). Seven out of a total of 10 categories of information were selected by more than 80% of the participants which projects a great need for tracking and a lack of access to these types of information.

Although physical activities are the most tracked category in overall practice, when it comes to wheelchair use, the most selected categories all belong to the domain of accessibility: outdoor environment (96.2%), travel plan (92.5%), and indoor accessibility (90.6%). This emphasized wheelchair users' fundamental need for accessibility information that facilitates their mobility and independence. The second most selected domain is fitness and health, including physiological data linked to wheelchair use (84.9%), such as heart rate or energy level when pushing or steering wheelchairs, physical injuries and pain (83%), and physical activity (81.1%).

This trend was similar to the overall tracking practice and also further demonstrated by participants' top motivations for tracking ([Figure 2](#): Left), which included managing trips when going outside (49%) and using wheelchair usage data to manage chronic conditions (40%). Notably, 81.1% of participants also required data to maintain their wheelchair conditions. This shows a high demand to consider incorporating sensors that provide information to support not only the health of wheelchair users but also that of their wheelchairs.

3.5.3 Challenges and concerns for tracking needed information.

There is a clear trend ([Figure 1](#)) that the number of participants interested in tracking exceeded the number of active trackers in most categories (e.g., physical injuries or pain, wheelchair maintenance, wheelchair skills, and

⁶ <https://www.fitbark.com/>

mental health). According to participants, the possible explanation for not tracking these activities, despite being highly interested, was a lack of access to tracking tools (63.6%) and a lack of awareness among users (30.2%). 43.2% of participants were uncertain about what information they could track, and 36.3% had never considered searching for such information.

Meanwhile, in the comments asking what else they would like to track, some participants emphatically raised their desire to record and track how others react towards them and the progress of their wheelchair skills considering that 35.9% of the participants were motivated by storytelling and be aware of own habits ([Figure 2: Left](#)).

Some participants noted that they worried tracking would be too time-consuming, effortful, and inaccurate, with the most common being “too much work” (52.8%), difficulties in tracking (43.4%), and inaccessibility (37.7%) ([Figure 2: Right](#)). 34% of the participants were also worried about the cost. Notably, when answering other concerns, many participants wondered how the uses of those tracked data would inform policies. Two participants particularly questioned the purpose of this survey as they thought tracking would not be truly helpful to them if there were no changes. This raises the question of how to measure the impact and ensure the accountability of the tracked data.

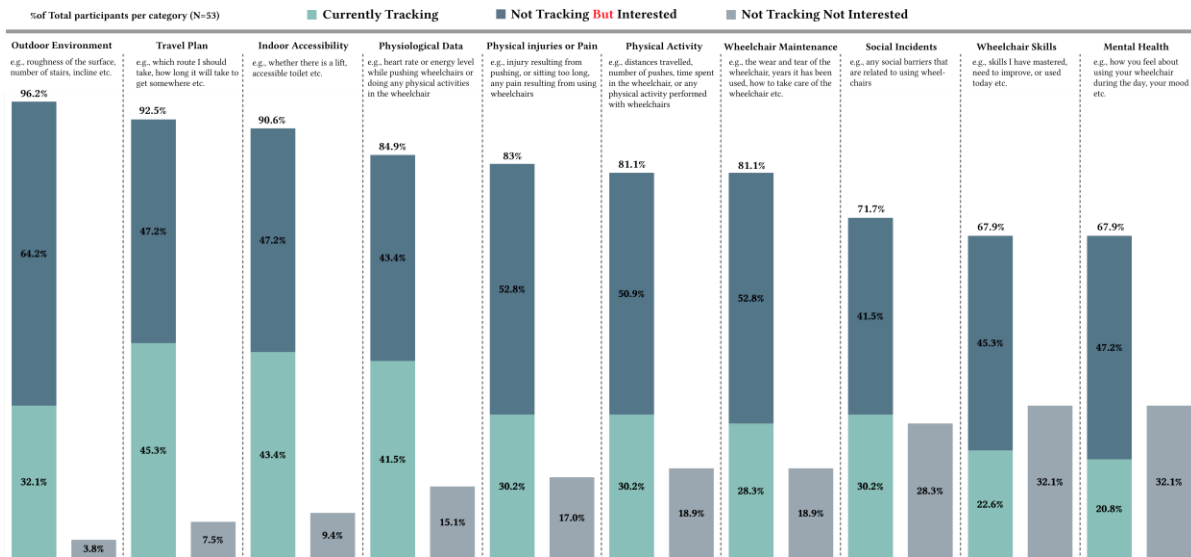


Figure 1: Current Practice and Future Interests in What to Track about Using Wheelchairs

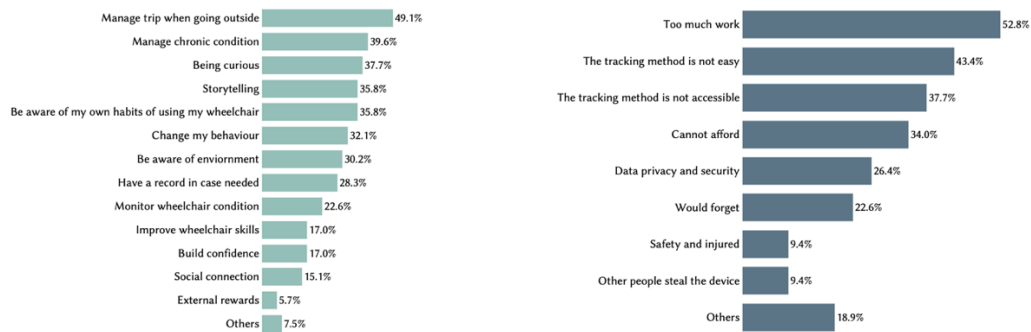


Figure 2: Motivations (Left) and Concerns (Right) for Tracking

4 DISCUSSIONS, LIMITATIONS, AND CONCLUSION

This study revealed that wheelchair users have clear and diverse information needs that extend beyond just physical health-related data, underscoring immense opportunities and directions for future HCI research and PI system design.

First, despite the extensive work in accessibility mapping [1, 2, 4, 12, 23, 35] and fitness and health tracking both academically [13] and commercially [47, 48], a significant gap remains in providing wheelchair users with tailored, accurate, and affordable tracking solutions and understanding how users make sense of such tracked data. Future research should continue enhancing tracking accuracy, such as by leveraging machine learning to recognize different mobility aids [33], predict user needs from their behavior, or incorporate manual feedback. To integrate tracking seamlessly into users' daily lives, designers could explore various modalities and form factors [33] such as

having simple gestures or voice commands or developing low-cost modular tracking kits that can fit with different mobility aids.

Secondly, research in PI should expand to other domains for instance, there is a pressing need to track wheelchair maintenance, currently mostly limited to monitoring battery status for power-driven wheelchairs. This calls for developing sensor-embedded smart systems for all wheelchair types. Such a tracking system (e.g., modular tracking kits) could provide notifications of issues (e.g., tire pressure, brake condition), offer insights into the use patterns which could suggest users adjust their habits accordingly, and thus prevent injuries and extend wheelchairs' lifespan.

This opens the door to researching how to create a tracking ecosystem, that combines environmental data, users' physiological metrics, and wheelchair wear and tear indicators. Imagine a PI tool that not only provides deep insights into users' energy exertion, health, and mobility [44] but also correlates them with the reported terrain traversed or ramp inclines. Together they can assess the impact on wheelchairs (e.g., areas with rough terrain leading to quicker wear and tear). When such data is shared collectively, it has the potential to reveal the accessibility issues of the areas, which could address participants' concerns regarding how to use self-tracked data to inform policy change. However, this entails not only technical and design challenges (e.g., tracking accuracy, information overload [20], self-reflection [25]), but also challenges in ethics such as understanding users' concerns in sharing self-tracked data (e.g., location, health) [34], safeguarding data anonymity and transparency, and more.

In addition, participants' requests to track how others react toward them and mood changes from social interactions highlighted the need to support mental well-being. To address this, designers can consider building self-tracking tools that foster community interaction [31] and social learning [15, 17]. Users' sharing of their wheelchair skill progress, how to navigate different environments, or maintain their wheelchairs can be useful teaching materials for the community, especially for people in resource-constraint settings. Also, tracking social encounters can become a storytelling platform and generate resources for disability advocacy. Such platforms can build a sense of belonging and collective knowledge-sharing among wheelchair users, contributing to enhanced confidence and improved mental health. Notably, sharing such personal data also raises data privacy and security issues [34], potentially mitigated through having faces blurred and voices altered for all multimedia materials or employing generative AI to create multimedia content by using aggregated user inputs as prompts [18, 28].

In conclusion, our survey revealed a pronounced demand among wheelchair users to track various types of information to support using wheelchairs. However, the study faces limitations, including a reliance on pre-curated options that may overlook crucial aspects of daily wheelchair use and a sample predominantly from high-income countries, limiting the understanding of diverse needs across different socioeconomic backgrounds. Therefore, future research should aim for a broader demographic reach and consider adopting other research methods such as interviews or focus groups to capture a more nuanced understanding of what information about wheelchairs is crucial for users to track in everyday lives and how tracking one aspect can illuminate others. In short, this study paved the way for a more informed and inclusive design of tracking technologies in HCI, revealing their potential to both enhance the lived experiences of wheelchair users and drive improvements in accessibility.

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