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# User-Centered Feature Requirements in Wearable Digital Health to Support Self-Care Among Stroke Survivors

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## ABSTRACT

**Introduction:** Stroke is a major cause of death and disability in Indonesia, leaving many survivors with long-term self-care challenges. Wearable technologies using digital health technology offer potential support. However, the adoption of technology is hindered by usability, accessibility, and cultural barriers. This study explores user-driven feature requirements to inform inclusive and effective digital self-care solutions for stroke survivors

**Methods:** This explorative qualitative study with a phenomenological approach involved in-depth interviews with 19 stroke survivors conducted between May and August 2024 in Yogyakarta and Bandung. Participants were selected using purposive and snowball sampling and analyzed using thematic analysis. Ethical approval was obtained from the Universitas Aisyiyah Yogyakarta Ethics Committee (No. 3832/KEP-UNISA/VII/2024), and all participants provided informed consent.

**Results:** A total of 19 stroke survivors (mostly male and aged 45–60) participated in this study, with the majority having lived with stroke for over five years. Two overarching themes emerged. The first, Managing Health and Daily Life, reflected the need for features that assist stroke survivor to navigate their self-care practices. The second, Navigating Technology with Limitations, highlighted emotional and socio-cultural barriers that hinder technology adoption and sustained use among stroke survivors. These findings suggest that effective wearable solutions must integrate practical health management functions with user-centered design, addressing cognitive, emotional, and contextual barriers to long-term use, with implications for inclusive design guidelines and grassroots-based technology policies.

**Conclusion:** This study gives an understanding of user-centered perspectives in digital health technology by highlighting the practical and emotional aspects of technology use. Future research should incorporate caregiver and healthcare provider perspectives and evaluate prototypes in real-world settings to strengthen inclusive innovation and sustainable adoption.

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# INTRODUCTION

Stroke is a severe non-communicable disease (NCD) that significantly disrupts individuals' physical functioning, social relationships, and occupational capacities (1). Globally, stroke remains the second leading cause of death and constitutes a major public health concern (World Health Organization, 2019). The Global Burden of Disease (GBD) 2019 Stroke Collaborators reported a 32% increase in stroke incidence, prevalence, mortality, and years of healthy life lost over the past three decades, with the highest growth occurring in low- and middle-income countries (2). In Indonesia, stroke has become the primary cause of death, with prevalence rising from 7% in 2013 to around 11% in 2018, affecting approximately two million individuals (3). Furthermore, stroke represents one of the top three costliest diseases, with healthcare expenditures reaching 3.23 trillion rupiah in 2022 (4).

Beyond the clinical effects, stroke has far-reaching socioeconomic consequences, imposing severe burdens on both survivors and caregivers. Stroke often leads to long-term disability, resulting in dependency, economic hardship, and profound lifestyle disruptions for caregivers (5). The transition from hospital-based care to home rehabilitation is a particularly vulnerable period, during which families frequently feel ill-prepared and unsupported (6,7). Although advances in acute stroke treatment have improved survival, gaps remain in addressing long-term care and support. One of the most persistent challenges is ensuring continuity of care through effective self-management strategies (8).

Self-care is the capacity of individuals, families, and communities to maintain well-being, promote health, prevent disease, and manage illness and disability, whether or not they receive assistance from healthcare professionals (9). In stroke recovery, self-care involves medication management, physical therapy exercises, dietary adjustments, and monitoring vital signs (10). Despite recognition of its importance, many stroke survivors and caregivers encounter barriers to effective self-care due to limited resources, inadequate education, and the lack of tailored support systems (11,12). This study focuses on a critical gap in post-stroke care: the absence of sustainable and accessible systems to support long-term self-care, particularly those leveraging digital health technologies. This study adopts the Unified Theory of Acceptance and Use of Technology (UTAUT) to identify performance expectancy, effort expectancy, social influence, and facilitating conditions as determinants of technology adoption and continued use (13). Moreover, the Technology Acceptance Model (TAM) emphasizes perceived usefulness and perceived ease of use as central predictors of technology acceptance (14). Applying these approaches enables systematic examination of how stroke survivors and caregivers perceive, adopt, and sustain the use of digital self-care tools.

Although international guidelines recommend incorporating self-care education into stroke rehabilitation (15), implementation often falls short, especially in community-based settings. Without consistent follow-up and digital support, survivors may face declining health outcomes and diminished quality of life (11).

Emerging digital technologies offer promising solutions to enhance chronic disease management. Wearable devices such as smartwatches can monitor vital signs such as heart rate, blood pressure, and physical activity continuously and provide real-time data (16,17). These technologies have the potential to enhance clinical monitoring and personalize recovery when combined with mHealth platforms (18,19). Some studies have demonstrated the utility of wearable-based systems in enhancing stroke self-management, particularly in physical and psychosocial dimensions (20). There is currently an absence of research on their efficacy in user experience, daily activity support, and cognitive support (21). However, their adoption remains limited in low-resource contexts due to several barriers: complex interfaces, high costs, inadequate internet access, and socio-cultural challenges in technology acceptance (22). Against this backdrop, this study makes a distinct contribution by generating grounded, user-derived insights into the specific features and design priorities most valued by stroke survivors in Indonesia—an empirically underexplored domain where user perspectives are critical for shaping inclusive and sustainable digital health solutions.

A Qualitative study suggests high demand among caregivers for mobile-based applications to support home-based stroke care, especially for accessing information, facilitating physiotherapy, enhancing well-being, and improving healthcare service engagement (23). Nevertheless, the systematic design of digital technologies often overlooks user adoption, usability, and cultural relevance (24,25). There is a clear lack of empirical studies examining the contextual needs, user expectations, and perceived feature utility of wearable self-care technologies in the Indonesian context. Hence, this study explores wearable monitoring features needed to support self-care among stroke survivors.

# METHOD

## Research Type

This study employs a qualitative phenomenological approach to explore stroke survivors' lived experiences, focusing on their efforts to manage self-care and achieve autonomy. The phenomenological method is selected to delve deeply into personal narratives and perceptions (26), providing a rich, detailed understanding of how stroke affects daily life, long-term health management, and their perspectives on future technology. The incorporation of phenomenology into digital health enhances comprehension of user experiences, allowing for the creation of more adaptive and ethical digital health solutions, and provides a means to connect technology innovation with human-centered healthcare (27).

This approach aims to comprehend the personal experience by considering the aspects of time, place, physicality, and social relationships (26). This study aims to enhance our understanding of the features and needs of stroke survivors in adopting wearable technology for self-care. It emphasizes the significance of personal experiences and social interactions in the management of chronic diseases, including the use of wearables. By capturing the essence of their experiences, we aim to provide profound and practical insights, highlighting the real-world implications of stroke on long-term health and wellness.

## Data Collection

Data were collected through structured, in-depth interviews with 19 stroke survivors, which were conducted from May to August 2024 in the Special Region of Yogyakarta and Bandung, West Java, with interview sections ranging between 30 and 90 minutes. Both of these cities were chosen due to the accessibility of established networks of stroke survivors and community-based health workers among other cities in Indonesia. Hence, it facilitates participant recruitment and engagement more easily. This research uses the snowball sampling method to ensure a diverse representation of age, gender, and severity of stroke.

The interviews were conducted at their own house or at the stroke survivors' community gathering using the Indonesian and Javanese languages. All interview sections were audio-recorded with the informants' informed consent on paper and verbally. Then, the recordings were transcribed verbatim and analyzed thematically. Several most relevant quotes were translated into English for the article writing. In this research, all informants' identities were kept anonymous.

The core questions asked in this interview focused on stroke survivors' personal experiences in carrying out self-care, their feelings about the changes experienced post-stroke, and how these changes affect their ability to manage their health independently. In addition, the interviews also highlighted the use of technology to support self-care, including the devices currently used and their views on new technologies, such as apps and wearable devices. Informants were interviewed about their hopes for technology systems that could help improve their quality of life through real-time health monitoring, medication reminders, and more comprehensive rehabilitation support.

## Data Analysis

A total of 19 interviews were done, and the final three sessions revealed no new data, indicating that the data were adequate (28). This study employed a six-phase thematic analysis methodology, as delineated by (29): (i) immersing oneself in the data, (ii) producing preliminary codes, (iii) identifying themes, (iv) refining themes, (v) defining and categorizing themes, and (vi) composing the report. An inductive approach was used, allowing themes to emerge directly from the data. This process ensured that the analysis remained grounded in participants' narratives. The coding and theme development were carried out manually and collaboratively, with iterative discussions among the research team to enhance analytical rigor and reflexivity. Although no statistical measure of intercoder reliability was used, trustworthiness was enhanced through collaborative coding and consensus-building discussions to resolve any discrepancies.

To ensure the trustworthiness of this qualitative research, this study uses the triangulation method to ensure trustworthiness by gathering data from multiple perspectives, including survivors and caregivers. Moreover, this study also uses prolonged engagement to foster rapport, while member checking confirms the accuracy of findings. An audit trail documents each research step, also conducted to enhance the transparency and credibility. A thick description of the study setting and context is also provided to inform transferability.

### Ethical Approval

This study "adhered to the ethical standards of Universitas Aisyiyah Yogyakarta No. 3832/KEP-UNISA/VII/2024, which ensures that all research procedures comply with the principles of research ethics, including confidentiality, participant consent, and protection of participants' personal data.

## RESULTS

As shown in Table 1, there were 19 informants in this study. Most of the participants in this study were male (78.95%) and were in the productive age range of 45–60 years (42.11%). The majority had a high level of education, with more than half of them being bachelor's graduates (52.63%), and most were married (84.21%). In terms of employment status, only about a quarter were still working (26.32%), while the rest were unemployed (42.11%) or were outside the workforce, such as housewives and retirees (31.57%). More than two-thirds of the participants had been living with post-stroke conditions for more than five years.

**Table 1**. Demographic Characteristics of Stroke Survivor Participants

| Category | | Frequency | Percentage |
|---|---|---|---|
| **Sex** | Male | 15 | 79 |
| | Female | 4 | 21 |
| **Age** | < 45 | 4 | 21 |
| | 45 - 60 | 8 | 42 |
| | > 60 | 7 | 37 |
| | *Mean ± SD* | 54.2 ± 11.3 | - |
| **Education** | Junior High School | 2 | 11 |
| | High School | 4 | 21 |
| | Diploma | 1 | 5 |
| | Bachelor | 10 | 53 |
| | Master | 2 | 11 |
| **Marital Status** | Married | 16 | 84 |
| | Divorced | 2 | 11 |
| | Single | 1 | 5 |
| **Employment Status** | Employed | 5 | 26 |
| | Unemployed/Not Working | 8 | 42 |
| | Not in Labor Force (e.g., retired, homemaker) | 6 | 32 |
| **Stroke Duration** | ≤1 year | 1 | 5 |
| | >1 year to 5 years | 4 | 21 |
| | >5 years to 10 years | 6 | 32 |
| | >10 years | 8 | 42 |
| | Mean ± SD | 8.1 ± 5.7 years | - |
| **Stroker Location** | Yogyakarta | 12 | 63 |
| | Bandung | 7 | 37 |

This qualitative research has identified two main themes regarding desired features (see Figure 1): (1) Managing Health and Daily Life, which concerns what is expected in technology to help them in self-care; and (2) Navigating Technology with Limitations, which includes aspects that need to be considered in developing digital innovations for stroke survivors so that the technology developed is more inclusive.

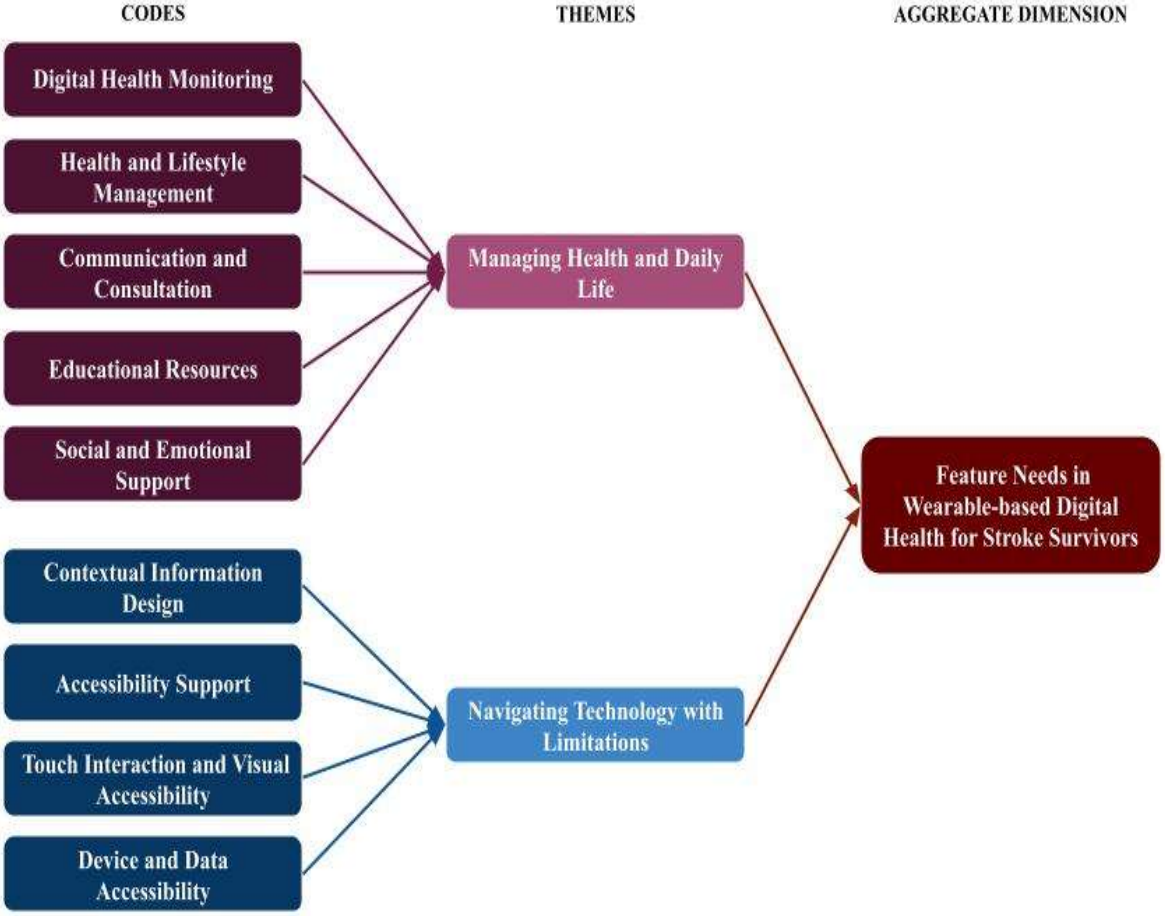

**Figure 1.** Main Findings of Qualitative Research

## Managing Health and Daily Life

### Digital Health Monitoring

The unpredictability of physiological variations increases the need for constant, real-time monitoring for stroke survivors. Participants noted these changes not just as clinical abnormalities but also as causes of worry, often overlooked without technical help. In this regard, the smartwatch is positioned not only as a health tool but also as an emotional buffer that helps people to regain control. As informants state:

> *"Because it's important to track the fluctuations in blood pressure, which can change unexpectedly. It's frustrating when it rises without us noticing" (I1).*
>
> *"A smartwatch and app system is necessary because I find it more useful. It eases my burden since I need to check my blood pressure when I wake up; if something happens, I can simply take a photo" (I12).*

Adoption of digital monitoring is strongly affected by behavioural compatibility and technological simplicity rather than being motivated only by clinical need. Informants compared their inactivity with conventional tools with their ready-to-use nature, should such functions be app-integrated and automated.

> *"It's helpful for monitoring since I rarely check, even though I have the equipment at home, but I'm too lazy. Maybe I'd use it if there were an app" (I13).*

These encounters expose a contextual type of digital health in which the ability of technology to lower behavioural friction determines its value. From this perspective, the wristwatch is a pragmatic infrastructure for self-regulation and autonomy rather than only a data-collecting tool.

> *“There's no need to go anywhere; we can use the application at home. Isn't that the purpose of the app? It could be more beneficial this way" (I3).*

Information access, especially in early phases of personal care, was another issue for participants. Users underlined how physical immobility worsened their ignorance of the resources that were at hand. Thus, digital technologies providing unambiguous, location-independent information can help to close important early awareness gaps.

> *"What was needed initially was the information, like this and that. If we had to travel far, I wouldn't be able to go as I have no one to take me. There used to be an app for checking blood and blood pressure, but I wasn't aware of it" (I14).*

Most importantly, participants stated a need for individualised, practical feedback in addition to raw measurements. Only when health statistics guide daily decisions, encourage introspection, and support good behaviour will they be relevant.

*"By monitoring my blood pressure, I can assess and better myself. I need to exercise regularly" (I6).*

The desire for a complete monitoring system exposes consumers' view of technology as a quasi-diagnostic partner. This covers early warning systems, smart alarms, and technologies able to promote anticipatory action and health literacy.

> *"What I’m hoping for is the ability to monitor blood, including heart rate, pulse, and rhythm. It would be great if that could be achieved" (I8).*
>
> *"Notes are very helpful in tracking fluctuations and progress. We need to monitor the changes because blood pressure is variable; it can increase on its own without us being aware of it" (I1).*
>
> *"Having a warning, alarm, or something to detect yourself is important [...] But if there is a personal electronic detection system, it could help prevent it, like 'oh, I need to do this'" (I19).*

### Health and Lifestyle Management

Medication adherence was found to be more facilitated by including automated reminders in digital health systems. Participants underlined that such capability is essential for the development of controlled drug schedules. This emphasizes a more general realization: the success of digital interventions depends on their ability to reduce the load of regular decision-making and cognitive work, not on novelty.

> *"I think it’s more helpful; it at least serves as a reminder for medication times" (I11).*
>
> *"Having an app to manage medication would be useful. It could remind me to take my medicine, as I currently rely on self-reminders" (I10).*

This visible usefulness contrasts with the flaws of many current health apps, especially concerning the legitimacy and clarity of dietary recommendations. Participants expressed annoyance at the general availability of contradicting, anecdotal, or ambiguous guidance. This reflects a greater need for evidence-based design in health technology, in which individualized, research-backed advice replaces subjective interpretations.

> *"Currently, I need an app that provides clear information on which foods are allowed and which aren't. I haven’t found one that fits this need; the best I’ve come across is advice that isn’t based on research but on personal opinions. For instance, some say apples and grapes are off-limits, while berries like strawberries and blueberries are fine. Then, a doctor might say you can have a little, but 'a little' is unclear. People don't know if it means one piece or a whole kilogram" (I15).*

Though the dietary recommendations are unclear, participants showed a pragmatic knowledge of moderation, especially of sweet foods and beverages. This suggests that users are active agents negotiating their health with adaptive judgment, not just passive direction receivers.

> *"You can have sweet foods and drinks too, but it depends on the quantity" (I11).*

Regarding physical exercise, simplicity, and concrete feedback were greatly prized. Wearable technology that gave clear, actionable measurements, such as step counts positive responses from the participants. Fascinatingly, the motivating aspect of these characteristics was more about preserving personal rhythm and responsibility than competing goals, implying that self-tracking can function as a psychological foundation for behavioral reinforcement.

> *"My goal is just to have a watch that counts steps. If I can press and see the number, that's enough. As long as I go to bed, I've reached 3,000 (steps), and I'm already happy. If I'm still at 500, why is it still so few? I feel guilty. So, in my opinion, the more I move, the better" (I9).*

Another tool that participants connected with the prospect of self-regulation and improved energy management was sleep monitoring. The focus was on knowing the outside factors affecting sleep quality, not only on hours slept. This shows that participants seek a system of reflecting knowledge that allows adaptability, not only diagnosis.

> *"Sleep patterns and the overall condition of sleep are important. It's useful to understand the quality of sleep and how energy from electronics affects it. This can be observed and measured" (I8).*
>
> *"Improving sleep quality would be helpful for me. I've had trouble sleeping well since I was young and face difficulties every day" (I7).*

Particularly for those vulnerable to cognitive overload and emotional dysregulation, stress management became clear as a need not satisfied. This points to a flaw in the present architecture of health apps, whereby mental and emotional health care still comes second. The information indicates a demand for integrated mental health elements, combining stress-reducing therapies with real-time feedback.

> *"Maybe for someone like me, when there is stress, it's very high. It's like I keep thinking about various things" (I2).*

The importance of anthropometric data, such as weight, was not lost on participants. Their remarks reflected an intuitive grasp of the clinical significance of biometric data for medication dosing and health assessments. However, long-term engagement with tracking these metrics remained challenging, particularly when progress appeared stagnant.

> *"Yes, weight is also a factor; there's some ideal formula for it. As far as I know, when doctors prescribe medication, they consider the patient's height because it helps determine the appropriate dosage" (I13).*
>
> *"I used to record everything, but when I noticed that progress was slow and stayed the same, I stopped. I might still have the notes on my phone. Back then, I tracked my weight, what I ate, and the calories in the food" (I1).*

**Communication and Consultation**

Particularly for stroke survivors with limited mobility or persisting chronic diseases, digital technologies have expanded the terrain of patient-provider communication. Study participants underlined the importance of teleconsultation, which enables more flexible and quicker communication with medical experts. As one source stated, these instruments were considered bridges, lowering geographical and physical boundaries and facilitating medical treatment.

> *"I'm open to it. My doctor advised me to call if I needed anything and to get in touch. For a tooth extraction, I was instructed to use a video call" (I10).*

Apart from physical treatment, psychological counseling was also often regarded as a neglected yet essential part of rehabilitation. Citing stigma and concern of being misinterpreted, several individuals were reluctant to interact personally with mental health specialists. Considered a safer substitute was remote access via digital channels.

> *"When I was hospitalized, a psychologist suggested a visit, but I was reluctant because I feared it might make things worse. An app to connect with a psychologist is needed" (I10).*

Participants also underlined the need for community support but pointed out that distance, apathy, or lack of reminders prevent people from engaging in peer-based stroke networks. The poor attendance in physical meetings points to the possibility of digital nudging, alerts, and hybrid models of involvement helping to increase participation. As one source pointed out:

> *"Pak Iskandar, who manages the stroke community, has over 200 members listed, but only about 60 attend […] A device could be helpful for automatic reminders, as people with stroke can be quite passive" (I7).*

## Educational Resources

Instructional videos were mentioned as vital resources to help stroke survivors in implementing appropriate rehabilitation strategies and preserving self-care practices. Particularly, a participant also underlined that the first year following a stroke is a "golden period" for recovery, in which suitable exercise and behavioral modification can greatly affect long-term autonomy.

> *"For stroke survivors, it's crucial to use the proper methods to enhance health and recovery" (I11).*
>
> *"It would be beneficial if there were videos demonstrating exercises or other self-care activities" (I15).*
>
> *"It makes sense to have educational information available, and it should emphasize that the first year is the golden period […] if there's no progress after three years, adjusting the mindset, adapting, and continuing activities as much as possible is important. This is the basic principle" (I1).*

Apart from general rehabilitation advice, participants also demanded instructional materials on speech therapy to treat post-stroke aphasia, a common disorder affecting verbal communication. Such material is needed because of uneven therapeutic experiences and a dearth of easily available advice on managing speech loss or regression.

> *"After the scan, I couldn't walk, so I called the therapist. After a couple of therapy sessions, I could still walk, but then I had another therapy session. The last time I had therapy, it suddenly got worse. And well, the speech isn't clear, right?" (I2).*

The importance of balance and motor coordination training ran across the interviews as a recurring subject. Unresolved coordination problems caused survivors to show anxiety or uneasiness even as they went about their daily duties. Effective tools for restoring proprioception and confidence were shown as videos and home therapy aids.

> *"Coordination and integration are also important […] I'm afraid my shoulder might bump into something. This became clear during my last therapy session. A friend of mine […] recorded that my shoulder was leaning until it eventually improved. It turns out that our motor skills still weren't good." (I9)*
>
> *"Sometimes I feel like my balance is still lacking [...] Nordic walking really helped me because my legs are still a bit stiff. Since (it) provides pressure, it improves blood circulation" (I8).*

Participants also underlined the need for regular home exercises and consistency in physiotherapy since lack of movement might prevent recovery or cause regression. These realizations show the need to develop low-barrier, habit-forming routines supplemented with instructional reinforcement.

> *"Usually, the hands become stiff if they lack enough exercise" (I11).*
>
> *"So, the right side of my foot remains like this […] I was therefore advised to perform more exercises at home during physiotherapy" (I6).*

Some participants related how early on in their recovery, they were confused and lacked direction, which inhibited quick reaction and knowledge of stroke symptoms. This emphasizes the importance of pre-loaded, easy-to-learn instructional materials to help survivors from the start of their path.

> *"The first effect I noticed was difficulty swallowing […] I initially did not understand it was a stroke" (I5).*
>
> *"I didn't know where to go. Over the first three years, I truly felt that way. I had no idea about recovery. I doubted if I could bounce back or not" (I1).*

Beyond content, adaptable training settings and assistance tools were essential to rehabilitation. Those who had access to items like exercise cycles, parallel bars, or customized homes said these helped them to be more independent and to build psychological resilience.

> *"Just make left and right side posts [...] I work out there every morning and evening" (I11).*
>
> *"I ride a stationary bike essentially. I also incorporate dumbbells to get my hands working" (I15).*

Customized mobility devices like modified tricycles help some people overcome physical restrictions and maintain social, religious, or occupational roles. These changes demonstrate how beneficial mobility technology and mechanical instruction can be, surpassing exercise guides.

> *"I use a motorcycle for religious activities and getting around the house […] I consulted with a mechanic to move the accelerator to the right side […] and modified so that both the front and rear brakes would function" (I11).*

Digital literacy also surfaced as a minor but important issue, especially regarding false or overly ambitious health claims. While demonstrating interest in easily available and reasonably priced knowledge, given it remained reliable, participants voiced doubt about miracle treatments sometimes found on social networking sites.

> *"I'm skeptical of claims that something can provide a 100 percent permanent cure… fake therapists often make exaggerated claims" (I1).*
>
> *"For me, if I come across affordable information on TikTok, I'll give it a try. However, if it seems too extravagant, I won't pay attention to it" (I3).*

At last, participants showed a forward-looking curiosity in instructional materials aimed at preventing, not just for survivors but also for the whole public. One proactive approach suggested to lower the incidence by early awareness is to include stroke prevention information in mobile apps.

> *"Preventive measures are also important […] The app could eventually include features on stroke prevention" (I8).*
>
> *"The cause of the second stroke was exhaustion. The doctor advised me not to overwork myself or stress out" (I6).*

### Social and Emotional Support

Although health data is usually presented as clinical information, participants regarded remote health monitoring systems as a means of emotional comfort and family connection. Particularly when users are vulnerable or alone, digital surveillance was seen as a tool for allowing distant care rather than as invasive. One source clarified:

> *"An automatic feature that can be monitored from a distance is exactly what we're looking for [...] It will provide peace of mind knowing that loved ones can be observed from anywhere" (I1).*

One of the most important things mentioned was the capacity to let family members access health data. This helps carers monitor and build cooperation and trust. In this regard, keeping an eye on things becomes a group obligation.

> *"Can I access it? If so, it would be convenient because my father could also monitor it remotely" (I12).*

Participants underlined that wearable equipment and monitoring tools provided clinical support and psychological security and were quite important during emergencies. These remarks indicate a communal logic of care in which technology offers peace of mind to the larger caregiving ecosystem and determines its value and relevance to individual results.

> *"These devices remain crucial in emergencies, like during the pandemic, allowing for the monitoring of many people, not just those directly using them. So, the overall benefits are increased" (I8).*

### Navigating Technology with Limitations

### Contextual Information Design

For stroke survivors, effective digital health systems have to give top priority to consistent information architecture. One described as a non-negotiable need is the capacity to obtain necessary data on a single screen or interface. Participants underlined that juggling several screens or hidden fields typically results in confusion or disengagement, particularly for users with cognitive or physical restrictions.

> *"If there's any hidden information, it should be made visible, such as the address. Everything should be presented in one place, so there's no need to switch screens" (I8).*

Participants also underlined the need to create programs depending on known platforms. Because of its simplicity and availability, WhatsApp became a main digital tool. Many stroke survivors depend just on WhatsApp for communication, emphasizing the need to include health communication or educational tools into this ecosystem instead of creating a whole new system from scratch.

> *"Yes, communication with stroke survivors, I just use WA (on the phone)" (I5),*
>
> *"Yes, it's just limited to playing around (using WA/WhatsApp). I also create (WhatsApp statuses)" (I8).*

Furthermore, the design of information systems has to consider personal adaptation mechanisms and the variety of stroke situations. While some survivors have recovered a sense of autonomy and fit a "new normal," others need ongoing observation and situationally appropriate treatments. This variance calls for a flexible, context-sensitive system that can react dynamically to independent and high-risk users.

> *"I appear normal, so I enjoy my new normal now. We can indeed function, but it's still dangerous, right? We know our limits" (I9).*

A participant also underlined that customizable monitoring features were crucial. The system should allow selected vigilance informed by individual risk profiles and contextual triggers instead of constant data collection for every user. This highlights the requirement for smart triaging and adaptive data reporting systems that mix clinical value and user-friendliness.

> *"I completely agree (that the watch is worn continuously), but that's situational [...] it can be used, so we differentiate between general and specific situations. Yes, (only for certain stroke cases) because not all conditions require continuous monitoring. For example, at home, my blood pressure keeps rising. So how is this reported? That's where it's important. It will help the doctor" (I8).*

### Accessibility Support

Particularly for consumers unfamiliar with digital technology, including contextual and basic guidance inside a health application, is absolutely necessary. Many stroke survivors, especially older people, need precise, detailed directions right at first use. Without this help, technical instruments run the danger of being underused or misconstrued, therefore lowering their capacity to support self-care and rehabilitation.

> *"If someone provides initial guidance, that would be helpful. We're unfamiliar with how the application works or how it connects to the phone yet" (I5).*

People with stroke often have problems with motor coordination, reducing engagement with mobile devices. Anxiety over dropping or harming devices can deter use, even in cases when survivors still have cognitive and visual abilities. This points to the need for lightweight hardware, flexible interface design, or accessories enhancing safety, comfort, and grip.

> *"Yes, if there's a call, I can (use the phone, can't I?). But now, when I hold it, I'm afraid it'll fall" (I3).*

### Touch Interaction and Visual Accessibility

Creating easily accessible user interfaces for stroke survivors means reducing difficult interactions like returning to previous displays or making fine motor corrections. Although simple navigation, such as vertical scrolling, is usually adequate, cognitive strain and motor limits become clear when users have to act with more accuracy or memory recall. These challenges draw attention to the need for simplified, straight travel paths with few decision points.

> *"Scrolling up and down is fine. But if it requires returning or making adjustments, that's difficult" (I8).*

Double-tapping, a gesture that may be challenging for users with poor dexterity or rigidity—both prevalent post-stroke symptoms—was one ongoing issue. Replacing double-tap functions with single-touch commands can improve usability by matching motor capabilities and lowering mistakes brought on by inadvertent interactions.

> *"Hopefully, there won't be any double-tapping, as that will be troublesome, especially for those with limited mobility or stiff movements. They may struggle with double-tapping. But single touches are safe" (I8).*

Applications, especially to differentiate between single and double-touch gestures, must include visual indicators and sensitivity training to guarantee an inclusive interface. Ambiguous touch interactions could annoy users or make one feel technologically inadequate without clear direction. Different physical capabilities can enable users to interact more boldly using clear feedback and calibratable touch sensitivity levels.

> *"Training is necessary because it can be sensitive to touch" (I8).*

One other important factor underlined was visual accessibility. Citing better contrast and readability, participants favored dark mode with bright writing. Already common on messaging apps like WhatsApp, this visual arrangement was seen as helping recognition and easing strain, especially for people with light sensitivity or partial vision problems.

> *"The text should ideally be bright on a dark background. I use dark mode on WhatsApp because it makes the text clearer for me. Dark mode is easier to read because the text is white, while a bright background can make it difficult to see" (I15).*

Participants also underlined the crucial need for clear, visible, unambiguous text. Cognitive and memory problems linked to strokes can make processing either dense or small-format material more difficult. Thus, the textual design should prioritize clarity over aesthetic minimalism so that every element stays accessible regardless of the cognitive or perceptual state of the user.

> *"Text should be large, easily accessible, and clear. Stroke survivors often have impairments and memory issues, which can make it difficult for them to process information like others because their brain function is affected" (I5).*
>
> *"Yes, having large text is essential. Small text is challenging for stroke survivors due to memory and vision problems, which can make them hesitant. The content needs to be designed in a way they find helpful; otherwise, it can be problematic" (I8).*

### Device and Data Accessibility

Designing health-related mobile apps for stroke survivors has to include digital infrastructure inequities, including device constraints resulting from socioeconomic circumstances. Most informants from low-income backgrounds said they used simple cell phones with little RAM and memory. This greatly affects their capacity to download and run data-intensive apps, emphasizing the need for lightweight, efficient software that carries out necessary tasks without using too many system resources.

> *"Random access memory (RAM) limits prevent downloading another application" (I14).*

Participants voiced worries about mobile data usage, besides storage limitations, suggesting a very mindful and conservative attitude to digital material consumption. Not out of lack of interest but rather out of a pragmatic need to control internet quotas and retain device performance, large video files, automatic downloads, and data-heavy functions are commonly skipped or uninstalled.

> *"Sometimes people send videos that are large in size. Because I often don't open them, I check how many megabytes they are first" (I14).*

### Feature Requirements Mapped to Design Priorities

To consolidate the empirical insights from both themes, we synthesized participants' expressed needs into a design-oriented matrix (Table 2). This table outlines how specific challenges experienced by stroke survivors can inform practical design strategies for wearable digital health tools. Moreover, each need is aligned with key constructs from established technology adoption frameworks such as TAM and UTAUT. This synthesis provides a bridge between grounded user data and theory-informed recommendations, serving as a reference for developers aiming to create more inclusive and contextually responsive health technologies.

**Table 2.** Design-Oriented Synthesis of Stroke Survivors' Needs and Theoretical Mapping

| User Need / Insight | Design Implication | Theoretical Link |
|---|---|---|
| Difficulty navigating interfaces due to cognitive limitations | Use simplified layout, large icons, audio guidance, and minimal navigation steps | Perceived Ease of Use (TAM) (14) |
| Dependency on caregivers for using digital tools | Enable caregiver access, shared monitoring dashboards, or remote assistance features | Social Influence (UTAUT) (13) |
| Need for daily health tracking and medication reminders | Provide automatic symptom logging and customizable notification systems | Performance Expectancy (UTAUT) (13) |
| Anxiety and fear of making mistakes with new technology | Include step-by-step onboarding, trial modes, and reassuring feedback mechanisms | Technology Anxiety (30) |
| Limited access to stable internet and tech support | Ensure offline functionality and integration with existing non-digital routines | Facilitating Conditions (UTAUT) (13) |

# DISCUSSION

## Main Findings and Interpretation

This study highlighted essential qualities for developing user-centric monitoring systems utilizing wearable devices to enhance self-care for stroke survivors. A significant finding of this study was that it thoroughly examined data on feature requirements derived from grassroots information provided by stroke survivors. This research can be used in future systems with a user-centered approach in the design of mHealth applications with prioritizing acceptability and usability (31). The integration of user-centric design is crucial in the development of these technologies. Incorporating end-users into the design process enables developers to create solutions more likely to be accepted and frequently used (32).

The development of more inclusive and efficient health technology is made possible by giving priority to features that address the particular requirements of stroke survivors, such as accessible design and easy navigation. While these findings align with previous studies emphasizing the importance of personalized feedback and accessibility in digital health technologies (33), they contrast with findings from a U.S.-based national survey where users tend to value consistent use and real-time data analytics over simplicity of interface (34). This discrepancy suggests that local contexts influence user expectations on technology adoption (35). Furthermore, some expressed needs may reflect adaptation to systemic limitations, rather than intrinsic preferences, which underscores the importance of considering structural factors in technology design.

This study identified essential components for effective health management, including health monitoring, lifestyle management, communication, and education. These findings align with prior research that elucidated that the predominant functionality for stroke rehabilitation management was educational information; the second was rehabilitation guidance, and the third was communication with healthcare professionals and others (36). This indicates that, in addition to self-care, stroke survivors require the support of others in managing their condition. This aligns with research findings indicating that stroke survivors desire empowered caregivers to assist with their needs, including adaptation to new roles and relationships, engagement in care, and self-care, utilizing various functionalities such as informational resources, risk assessment, remote monitoring, data sharing, and reminders (31). A study notes that most applications are designed specifically for stroke survivors and caregivers, primarily addressing language and communication challenges (37).

The utilization of mobile applications in stroke management can reduce healthcare expenses, improve the rehabilitation process, promote patient involvement in decision-making, and enable continuous health monitoring (23). Real-time health monitoring enables the ongoing observation of these parameters to ensure timely intervention and care (16,18). It also allows people to control their health, hence potentially decreasing the strain on healthcare systems by lowering the necessity for frequent hospital visits (19). As a result, it can enhance health outcomes in low- and middle-income countries by offering effective self-care tools (22).

## Design Implications

The study also emphasizes the crucial significance of user interface design for stroke survivors due to their frequent encounters with cognitive deficits and physical constraints. Based on the synthesis of stroke survivors' experiences with wearable technologies, we propose a set of user interface (UI) design heuristics to inform the development of more inclusive mHealth applications. These heuristics reflect the cognitive, emotional, and contextual needs observed in this study and translate them into practical design principles tailored for stroke-related digital health tools. Table 3 outlines six key heuristics and corresponding guidelines that mHealth developers can adopt to enhance usability, reduce anxiety, and promote sustained engagement. Characteristics such as legible and sizable text and simple touch-based interactions correspond to the requirement for user-friendly interfaces in healthcare technologies (11). Moreover, medication reminders and communication tools are essential for compliance with treatment programs and permitting prompt consultations with healthcare specialists (38). An advancement in smartphone technology is required to enable uninterrupted health monitoring around the clock, using a form that adheres closely to the skin while preserving essential phone functionalities (39). While increasing the size of screens enhances user engagement, it can diminish sensing capabilities, affecting health monitoring accuracy (39). Smartphones have the potential to develop into advanced wearable technology that can gather and provide real-time health data by integrating sensors and leveraging the Internet of Things' (IoT) capabilities (40).

**Table 3.** User Interface Design Heuristics for Stroke-Oriented Digital Health Applications

| Heuristic Principle | Design Guideline |
|---|---|
| **Simplicity and Cognitive Ease** | Use a clean layout with minimal text, large buttons, and uncluttered visuals to reduce mental load. |
| **Step-by-Step Navigation** | Provide guided task flows with progress indicators and optional voice or visual prompts. |
| **Error Tolerance** | Design forgiving interactions (e.g., confirmation dialogs, undo functions) to reduce fear of mistakes. |
| **Emotional Support** | Incorporate positive reinforcement, friendly tone, and calming color schemes to ease user anxiety. |
| **Accessibility and Adaptability** | Enable customization (e.g., font size, contrast), offline access, and support for caregiver integration. |
| **Familiar Interaction Patterns** | Maintain a consistent layout and use commonly recognized icons and gestures to support intuitive use. |

## Policy Implications

The findings of this study show that adoption of wearable-based self-care technologies for stroke survivors is shaped not only by technical performance, but also by accessibility, cultural relevance, social support, and infrastructure readiness. This finding is in line with previous research that emphasizes the importance of combining socio-cultural and technological aspects to realize inclusive and sustainable digital technology-based health innovations (41,42). We propose setting accessibility standards—such as larger text, high-contrast display modes, and simple navigation—to meet the needs of users with cognitive or motor impairments, and introducing caregiver integration policies that allow secure shared monitoring to improve adherence and continuity of care. In low-resource areas, limited connectivity and device capacity point to the importance of offline functionality and lightweight applications (43). Previous research has shown that the level of cultural adaptation in the development of digital interventions is greatly influenced by culturally appropriate and accessible interface design, as well as appropriate translation, which in the context of the findings of this study prove to be important factors for building trust and increasing the use of health applications (44). Addressing low digital literacy and technology anxiety remains critical in for the sustainability of digital innovation. Several studies highlight that enhancing health literacy and e-health literacy can open opportunities to adapt healthcare services and better support patients with low e-health literacy (45), positioning digital literacies as key policy drivers for social innovation (46). Finally, ensuring interoperability with widely used, low-barrier platforms may help maintain engagement, particularly in settings where such tools dominate daily communication (47).

Building on these insights, Table 4 outlines specific policy recommendations derived from this grassroots study, linking each key finding to the relevant regulatory or governance domain.

**Table 4.** Technology Policy Implications for Wearable Self-Care in Stroke Recovery

| Study Finding | Technology Policy Implication | Policy Domain |
|---|---|---|
| Stroke survivors need adjustable, easy-to-use interfaces (large text, dark mode, single-tap) | Set accessibility rules for health wearables and apps based on inclusive design | Digital Health Regulation/ Accessibility Standards |
| Caregiver involvement is important for self-care | Create policies for secure caregiver access and shared monitoring | Data Governance / Privacy Policy |
| Limited internet and device capacity in some areas | Provide support for offline mode and lightweight apps | ICT Infrastructure Policy / Digital Inclusion |
| Need for relevant education, rehab guidance, and teleconsultation | Require localized, clear, and evidence-based content in health apps | Health Content Regulation / Patient Education Policy |
| Low digital literacy and technology anxiety | Fund community-based digital health training for patients and caregivers | Public Health Education Policy |
| Local culture and social norms affect adoption | Require participatory design with end-user input in tech projects | Innovation Governance / Public Participation |
| Preference for offline use and familiar platforms (e.g., WhatsApp) | Allow interoperability with widely used, low-barrier platforms | Interoperability Standards / Consumer Tech Policy |

## Interpretation through Theoretical Frameworks

These adoption barriers are a reflection of larger structural and contextual issues in addition to personal limitations. The findings can be viewed from the perspective of the TAM and the UTAUT. Perceived usefulness and ease of use in TAM are correlated with participants' concerns about usefulness and lack of confidence when using wearable technology (14). Likewise, the influence of family, health workers, and infrastructure aligns with UTAUT constructs such as social influence and facilitating conditions (13). Recent empirical studies extend these models to digital health contexts showed strong effects of self-efficacy and privacy concerns on mHealth adoption (48), and a study, which highlighted the role of technology anxiety in shaping adoption decisions among older patients with chronic conditions (30). These theoretical perspectives suggest that successful wearable systems must enhance perceived utility and usability, build trust, minimize anxiety, and ensure robust support in the user environment.

## Limitations

This study has several limitations to disclose. This study was only conducted in two urban areas, namely Yogyakarta and Bandung, so the findings may not fully represent the needs of stroke survivors in rural or remote areas with limited access to technology and health services. Urban participants typically have higher digital literacy, better infrastructure, and more exposure to recent digital innovations (49), which may shape more optimistic expectations toward wearable technologies. In contrast, rural users may prioritize simplicity, offline functionality, or integration with local health workers due to infrastructural and socio-economic constraints (50). This urban bias may limit the transferability of our findings to under-resourced settings. This study also only focuses on the perspective of stroke survivors without involving the views of caregivers, health workers, or technology developers, so it does not reflect the overall needs and challenges in developing a wearable-based self-care system.

## Future Research Directions

Future research should directly test prototypes or wearable applications based on the features identified in this study to evaluate their effectiveness, usability, and impact on stroke survivors' quality of life. In addition, quantitative or mixed approaches could be used to measure the extent to which specific features contribute to increased adherence to self-care and identify associations between individual characteristics and preferences for the technology needed.

## CONCLUSION

Findings in this study suggest that stroke survivors require not only clinical health monitoring but also other features such as medication reminders, lifestyle guidance, emotional support, and accessible communication. This study also found that users' engagement with health technologies is influenced beyond physical and cognitive limitations, but also by socio-cultural conditions. In order to support stroke survivors' self-care, these findings emphasize the value of adaptive and user-centered digital health design and recommend that future interventions include accessible and personalized features. These findings have implications for developing design guidelines and grassroots-based technology policies to ensure that digital health is context-sensitive and responsive to the lived realities of stroke survivors.

While this study provides valuable insights, some limitations need to be noted, such as the study area being limited to an urban area of Yogyakarta and Bandung, and the research focusing only on stroke survivors without caregiver and healthcare worker perspectives. Further research needs to test prototype solutions in more diverse communities and involve a wider range of stakeholders to deepen understanding of inclusive digital health technology design and strengthen practices, policies, and theoretical frameworks in stroke rehabilitation.

## AUTHOR'S CONTRIBUTION STATEMENT

M Arini: study design, funding acquisition, writing—review and editing. MZ Islami: conceptualization, study design, coding and analysis, original draft, writing—review and editing, data collection. AH Fathiya: coding and analysis, original draft, data collection. MA Puspitosari: critical engagement, funding acquisition, writing—review and editing. Nurchayati: critical engagement, funding acquisition, writing—review and editing. F Pribadi: critical engagement, funding acquisition, study design. W Setyonugroho: conceptualization, writing—review and editing, funding acquisition.

## CONFLICTS OF INTEREST

There are no conflicts of interest to declare.

## DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this manuscript, the authors used generative AI tools, including ChatGPT 4.0 (OpenAI) and Grammarly, to assist with language editing, clarity improvement, and structure refinement. ChatGPT was also used for translating segments of interview quotations from Indonesian to English to enhance contextual accuracy and readability. Additionally, these tools were employed for grammar checking and plagiarism screening. All AI-assisted outputs were critically reviewed and edited by the authors to ensure accuracy, integrity, and adherence to academic standards.

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