

Primary caregivers' perspectives on metaverse-based care training for home-based stroke care: a qualitative study

Haonan Qin

Naval Medical University

Jiale Xu

Naval Medical University

Yijia Li

Naval Medical University

Xuan Zhou

Naval Medical University

lanshu Zhou

zhoulanshu@hotmail.com

Naval Medical University

Qiuyi Wang

Naval Medical University

Research Article

Keywords: Stroke, Primary caregivers, Care training, Metaverse, Qualitative research

Posted Date: October 14th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10924758/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

Additional Declarations: No competing interests reported.

Abstract

Background

Inadequate caregiving competence among primary home caregivers is a critical bottleneck limiting the effectiveness of home-based stroke rehabilitation. Metaverse technology offers a novel approach to care training with its immersive, repeatable, and low-risk features; however, systematic empirical research on the real acceptance and underlying needs of this population remains scarce.

Objective

To explore the caregiving challenges and training needs of primary home caregivers of stroke patients, as well as their functional expectations and practical concerns regarding metaverse-based care training, to provide demand-side empirical evidence for the development and implementation of such programs.

Methods

A descriptive qualitative study was conducted. Twelve primary home caregivers of stroke patients were recruited from a rehabilitation hospital in Shanghai by purposive sampling between January and February 2026. Prior to interviews, a standardized contextual introduction to metaverse technology was provided via videos, images, and oral explanations. Semi-structured in-depth interviews were conducted, and data were analyzed using thematic analysis. The study was designed and reported in accordance with the COREQ guidelines.

Results

Four core themes were identified: (1) systemic deficit in emergency decision-making and response capacity in high-risk scenarios; (2) fragmented daily care knowledge with a lack of standardized guidelines and immediate feedback; (3) multi-dimensional psychological burden with differentiated peer support needs; (4) general recognition of the value of immersive metaverse training, alongside three major practical concerns: physiological tolerance to devices, economic costs, and the virtual–real gap in skill transfer.

Conclusion

Primary home caregivers of stroke patients hold a generally positive attitude toward metaverse-based care training, but its widespread implementation is constrained by multiple practical factors. Future research and product development should focus on immersive training modules for high-risk scenarios and take into account caregivers' real usage contexts and constraints to improve the contextual relevance and accessibility of training.

1 Introduction

Stroke is the leading cause of death and disability among adults in China [1]. According to the China Stroke Prevention and Treatment Report (2024) [2], the current number of stroke patients in China stands at 26.34 million, with 4.09 million new cases diagnosed annually; approximately 75% of survivors experience varying degrees of functional impairment. Influenced by China's traditional family care model, stroke patients in the stable phase often choose to return home to complete their rehabilitation process. Primary home caregivers, defined as family members who provide the longest daily care and assume core caregiving responsibilities, are a key factor influencing patients' rehabilitation outcomes, quality of life, and risk of readmission [3].

However, the population of primary caregivers for stroke patients in China has generally not received systematic professional care training, resulting in a significant gap between their caregiving capabilities and the rehabilitation needs of the patients.

Extant empirical research has confirmed that stroke family caregivers generally suffer from multi-dimensional deficiencies in information and skills in terms of disease-related knowledge reserve, acute emergency management, rehabilitation skills, and psychological support capability [4–6]; therefore, there is an urgent need for external support to address these gaps. For example, Yan Lu et al. [4] conducted a qualitative meta-integration study and found that the caregiving needs of family caregivers for stroke patients can be summarized into core dimensions, including information-seeking needs and caregiver role support needs; Zhang Tianyue et al. [5] developed a Professional Caregiving Needs Questionnaire for Caregivers, which enables the quantitative assessment of caregivers' specific demands across dimensions such as disease knowledge, rehabilitation skills, and psychological support.

To enhance the quality and accessibility of information- and skills-based support services, researchers both domestically and internationally have developed and implemented various digital support solutions—including health management applications, remote guidance videos, and electronic health education manuals [7, 8]. These approaches overcome the temporal and spatial limitations of traditional centralized training programs and, to some extent, alleviate the information access challenges faced by caregivers providing home-based care [7]. However, notable limitations still exist in the phases of skill application training and feedback: caregivers can only observe operational procedures via static media materials and cannot participate in closed-loop practical experiences covering the full cycle of "operation–feedback–error correction–re-operation". This leads to a knowing-doing gap: although caregivers have mastered knowledge of related procedures, they lack the ability to implement these procedures correctly, making it challenging to effectively transform training content into actual home-based care practices.

In recent years, the rapid advancement of Metaverse technology has offered a novel approach to overcoming the aforementioned limitations. Built upon immersive interaction technologies—including Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR)—the Metaverse enables the creation of three-dimensional virtual spaces characterized by high immersion, interactivity, and repeatability [9, 10]. In the context of care training, such a system would allow caregivers to practice procedures repeatedly within simulated home environments and receive real-time corrective feedback, thereby establishing a complete closed-loop training mechanism [11]. This aligns with the core pedagogical requirement of skill acquisition: practice with immediate feedback.

In medical education, Metaverse-related technologies have already been applied to surgical simulation, emergency care training, and clinical communication skills development, demonstrating distinctive strengths in low-risk experiential learning and immersive engagement [12, 13]. Extending this logic to the stroke caregiving context, emerging evidence indicates that VR-based training can enhance caregivers' preparedness and improve patient outcomes, with documented benefits in disease awareness, operational confidence, and alleviation of care-related psychological distress [14–16].

However, these existing VR applications remain largely single-function educational or demonstration tools; a comprehensive, system-level Metaverse-based care training platform has yet to be developed [17, 18]. Moreover, current research has predominantly emphasized technical feasibility and intervention efficacy, with product design guided primarily by clinical expertise rather than informed by systematic needs assessment from caregivers themselves [17, 18]. This gap is particularly consequential given that caregivers vary considerably in age, digital literacy, and caregiving status [19]; consequently, their content needs, preferred training modalities, and technology acceptance may differ, yet these heterogeneous needs have received limited attention in existing research.

The effectiveness of metaverse-based training initiatives is highly dependent on a precise understanding of the target users' usage scenarios, capability profiles, and core needs. If product development is undertaken without first conducting thorough user needs exploration, it is highly likely to lead to misalignments between functional design and actual user requirements, or between interaction patterns and users' capabilities. This basic proposition is supported by three interrelated research fields: user-centered design theory, which emphasizes that design should be anchored in users' needs, capabilities, and contexts [20]; human factors engineering further cautions that designs developed in isolation from users' actual usage characteristics often result in poor usability or safety risks [21]; and health information systems research underscores upfront needs assessment as a prerequisite for effective implementation [22].

Therefore, this study aims to systematically explore primary caregivers' caregiving challenges, training needs, and their acceptance of metaverse-based training, in order to identify the key user dimensions and constraints that should inform the

future development of a caregiver training system aligned with real-world needs.

2 Methods

This study was reported in accordance with the Consolidated Criteria for Reporting Qualitative Research (COREQ) guidelines.

2.1 Study participants

Using purposeful sampling, primary caregivers of stroke patients receiving home-based care were recruited from the discharge follow-up list of the Rehabilitation Department at Shanghai First Rehabilitation Hospital between January and February 2026.

Inclusion criteria: (1) Age ≥ 18 years; (2) Being the primary family caregiver for a stroke patient—i.e. the individual providing the longest duration of daily care and bearing the core caregiving responsibility; (3) Ability to communicate effectively in Mandarin; (4) Providing informed consent and voluntarily participating in the study.

Exclusion criteria: (1) Participants unable to complete the full-length interview; (2) Participants with severe cognitive or psychiatric disorders who could not cooperate during the interview.

The sample size is determined based on the principle of information saturation [23]; that is, saturation is considered to have been reached when two consecutive respondents fail to provide any new substantive information.

2.2 Design

This study employs a descriptive qualitative research methodology. This approach aims to closely align with the participants' original accounts, providing a systematic description and synthesis of their experiences, perceptions, viewpoints, and needs; it is strongly practice-oriented [24] and is well-suited for uncovering the challenges faced by caregivers of stroke patients in real-world caregiving contexts, the limitations inherent in their existing knowledge acquisition experiences, as well as their level of acceptance and potential concerns regarding the metaverse as a specific technological solution.

Given that the metaverse is an emerging abstract concept and that caregivers providing home-based stroke care often lack a solid cognitive foundation in this area, conventional open-ended interviews may hinder respondents from developing effective embodied cognition due to the absence of concrete reference points; as a result, their expressions and concerns tend to remain at the level of vague imagination about the unknown, failing to capture the core needs arising from real-world usage scenarios. To address this, this study incorporates a standardized contextual introduction phase into its interview design, drawing upon the core principle of the Contextual Inquiry method—namely, "using visual materials to help respondents develop a concrete understanding of abstract technological concepts." By employing videos, images, and physical demonstrations, the study creates tangible, contextual reference points for the respondents, transforming the abstract notion of "metaverse-based care training" into perceptible and describable product forms. This approach guides respondents to articulate their views and needs based on real, tangible usage scenarios, thereby enhancing the authenticity and relevance of the interview data.

2.3 Research instruments

- **General information questionnaire**

The survey was independently designed by the researchers and comprised two sections: the first section contains the respondents' basic information—such as gender, age, educational background, relationship to the person receiving care, care status, and total duration of care; the second section contains information related to the patient's medical condition—including the primary diagnosis, primary functional impairment, and current disease stage.

- **Semi-structured interview guide**

Based on the core research objectives and the findings from the literature review, an initial outline framework was drafted. This framework was then reviewed and revised by two nursing experts (one specializing in stroke nursing and one specializing in nursing education), and finally finalized after its comprehensibility was verified through pre-interviews conducted with two participants. The outline comprises questions centered around four core dimensions, complemented by open-ended follow-up

prompts; these prompts can be flexibly adapted during the interview based on the respondents' responses. For detailed content, please refer to Table 1.

Table 1
Semi-structured interview guide

Dimension	Core Interview Questions	Follow-up Example
Dilemmas and challenges in care practice	During your care of patients, what situations have you encountered that have caused you difficulty or anxiety?	"What exactly happened at the time? How did you respond? And how did you feel after dealing with it?"
Training Needs and Learning Preferences	During your caregiving experience, which pieces of knowledge or skills do you feel you particularly need but still don't quite yet know how to apply?	"How did you previously learn these skills? How effective was that approach? What kind of learning method do you think is most suitable for you?"
Psychological Support Experience and Stress Relief Strategies	"How have you been feeling mentally since you started taking care of your patients?"	"When you're under a lot of stress, how do you usually relieve it?"
Expectations and practical concerns regarding metaverse training models	What would you think if there were a metaverse-based training tool that allowed you to practice these caregiving skills within a virtual environment?	"Do you think it could be helpful to you? What features would you like it to offer? What concerns you? Compared to the training methods you've used before, what do you notice as being different?"

2.4 Data collection

Data collection for this study was conducted between January and February 2026. Researchers screened caregivers who met the inclusion criteria using a discharge follow-up list from the Department of Rehabilitation Medicine at Shanghai First Rehabilitation Hospital; they then explained the purpose, content, and participation procedure of the study by telephone and, upon obtaining preliminary consent, scheduled an interview time. The interview was preferably conducted in a quiet, undisturbed room at the participant's home, with the interview conducted in a one-on-one setting without the presence of any third party, thereby ensuring the privacy of the interview environment and the participant's comfort during the interview. The interviews were conducted by the first author of this study, who is a Master of Nursing student who has received systematic training in qualitative research methods and interview techniques, as well as specialized simulation training in the situational interview method; prior to the interviews, the first author had no prior relationship or conflict of interest with any of the participants.

Before the interview begins, the researcher provides the participant with a detailed explanation of the study's purpose, the content of the interview, the intended use of the collected data, and the confidentiality principles. Upon confirming that the participant fully understands these details, the researcher asks the participant to sign a written informed consent form, followed by instructing the participant to complete a general demographic questionnaire. Prior to the formal interview, a contextual introduction phase is conducted: the researcher presents the participant with standardized visual materials—including an approximately 2-minute demonstration video of a metaverse-based care training scenario, screenshots of the virtual training interface, and physical images of the VR equipment—and explains, in plain language, the basic structure and core functions of this training approach. This phase lasts approximately 5–8 minutes; once it is confirmed that the participant has understood these details, the formal interview proceeds.

The formal interviews were conducted using a semi-structured framework as guidance, with questions posed in an ascending order of complexity. During the interviews, the researcher maintained a neutral stance—neither guiding nor judging the interviewees' views—while encouraging them to express their genuine experiences and thoughts freely. The researcher dynamically adjusted the sequence of questions and the direction of follow-up inquiries based on the interviewees' speaking pace and key points, promptly clarifying or delving deeper into ambiguous statements or pivotal events to ensure the richness and authenticity of the data collected. With the consent of the interviewees, all interviews were audio-recorded; simultaneously, the researcher documented the interviewees' tone of voice, facial expressions, body language, and other non-verbal cues to supplement and enhance the written records. Each interview was conducted over a duration of 25–35 minutes; upon completion, a small gift was given to the interviewee as a token of appreciation. All interview recordings were transcribed verbatim within 48

hours of the interview's conclusion; during this transcription process, non-verbal cues and notes regarding the interview context were annotated in real time to create a comprehensive interview transcript.

2.5 Data analysis

This study employed content analysis to analyze and synthesize the interview data [24]. Content analysis is the most commonly used analytical approach in descriptive qualitative research; it aims to systematically code, classify, and extract themes directly from the raw data, emphasizing a direct description of participants' experiences rather than in-depth interpretation. The analysis was conducted jointly by three researchers who had received systematic training in qualitative research. The analysis procedure was as follows: (1) Data familiarization: All researchers carefully read through all interview transcripts repeatedly to gain an overall understanding of the interviewees' statements and core viewpoints, thereby forming a preliminary perception of the data; (2) Initial coding: The three researchers independently performed sentence-by-sentence coding of the transcripts, extracting meaning units relevant to the research themes and assigning initial codes; (3) Coding verification and theme aggregation: The three researchers collectively reviewed and discussed the initial codes; for codes that were interpreted differently, consensus was reached through collective deliberation; subsequently, similar codes were aggregated into subthemes, which were then further summarized and refined into core themes; (4) Theme confirmation: The initially identified themes were carefully refined and validated against the raw data to ensure that they accurately reflected the interviewees' true experiences and concerns. The data management and coding processes were supported by the NVivo 12 software.

2.6 Quality Control

To ensure the reliability and validity of the study, the following quality control measures were implemented: (1) Prior to interviews: The interviewers received systematic training and simulated practice sessions on qualitative research methods, interview techniques, and the contextual interview approach; the interview outline was reviewed and revised by two nursing experts, and its clarity was confirmed through testing with two pre-interview participants before finalization; the contextual introduction materials underwent expert content review and pre-testing by caregivers to ensure that the language was accessible and did not pose any cognitive barriers. (2) During interviews: The principle of neutrality was strictly observed, and leading questions were avoided; the interview pace and follow-up questions were flexibly adjusted based on the respondents' responses to ensure the depth and authenticity of the data collected; non-verbal cues were recorded simultaneously to supplement the textual transcribed data. (3) Post-interview: Dual independent coding was employed, and coding consistency was verified; the final coding inter-rater agreement rate exceeded 90%, and any discrepancies were resolved through collective discussion among three researchers; after identifying the core themes, member verification was conducted by sharing the thematic summaries and representative original statements with all respondents to confirm the alignment of the findings with their personal experiences; only minor adjustments were made to individual statements without altering the core meaning of the themes; all interview recordings, transcribed texts, and coding records were securely encrypted and archived to ensure full traceability of the research process.

2.7 Ethical review

This study was conducted in accordance with the Declaration of Helsinki and relevant Chinese ethical guidelines for nursing research, and was approved by the Ethics Committee of Shanghai First Rehabilitation Hospital (Approval No.: YK-2025-03-011). Prior to participating in the interviews, all respondents were thoroughly informed of the study's purpose, content, and confidentiality principles, and voluntarily signed a written informed consent form. Participants have the right to withdraw from the study at any time without affecting the medical care they receive. Interview data are anonymized (real names are replaced with coded identifiers); all information is used solely for the purposes of this study, and the raw data are encrypted and stored by the research team in strict confidentiality.

3 Results

3.1 General characteristics of the study subjects

This study ultimately enrolled 12 home-based stroke caregivers who met the inclusion criteria; the respondents were numbered P1–P12. Among them, there were 5 males and 7 females; their ages ranged from 35 to 62 years, with a mean age of 50.1 ± 7.2 years; their educational backgrounds ranged from junior high school to undergraduate level, with a majority having completed

secondary vocational or college education; their relationships with the patients included 4 spouses and 8 children; 7 caregivers provided full-time care, while 5 provided part-time care; the duration of care ranged from 1 to 6 months, with a mean of 2.9 ± 1.7 months; the types of patient conditions included cerebral infarction in 10 cases and cerebral hemorrhage in 2 cases; the types of functional impairments were predominantly hemiplegia/limb movement disorders, but also encompassed various other conditions such as dysphagia, speech and cognitive impairment, and visual field defects; the disease stages covered the acute phase, recovery phase, and post-stroke phase, with the recovery phase being the most common. The general demographic characteristics of the respondents are presented in Table 2.

Table 2
General characteristics of respondents (n = 12)

number	sex	age	Educational Background	Relationship with the person being cared for	Care Status	Patient's primary diagnosis	Patient's primary functional impairment	Patient's current disease stage	Total care duration (months)
P1	man	55	junior college	adult child	full-time	cerebral infarction	Right-sided hemiplegia	recovery phase	2
P2	woman	51	secondary vocational school	adult child	full-time	cerebral infarction	Left-sided hemiplegia	acute stage	1
P3	woman	52	secondary vocational school	spouse	full-time	cerebral infarction	Right-sided hemiplegia	acute stage	1
P4	man	48	junior college	adult child	Part-time	cerebral infarction	Left-sided hemiplegia + bladder dysfunction	recovery phase	2
P5	woman	46	undergraduate course	spouse	Part-time	cerebral infarction	visual field defect	recovery phase	2
P6	woman	58	senior middle school	spouse	full-time	cerebral hemorrhage	Speech disorder + right-sided hemiplegia	recovery phase	3
P7	man	62	junior middle school	spouse	full-time	cerebral infarction	Weakness in both lower extremities	recovery phase	4
P8	woman	42	undergraduate course	adult child	Part-time	cerebral infarction	Cognitive impairment + Left-sided hemiplegia	sequelae stage	6
P9	woman	53	junior college	adult child	full-time	cerebral infarction	Dysphagia + right-sided hemiplegia	sequelae stage	6
P10	man	50	secondary vocational school	adult child	full-time	cerebral hemorrhage	Right-sided hemiplegia	recovery phase	3
P11	woman	35	junior college	adult child	Part-time	cerebral infarction	Right-sided hemiplegia	recovery phase	2
P12	man	39	junior college	adult child	Part-time	cerebral infarction	Left-sided hemiplegia + mild cognitive impairment	recovery phase	3

Table note: "Full-time" refers to caregivers who do not have fixed employment and whose caregiving activities span the majority of the daytime; "Part-time" refers to caregivers who have other fixed employment or caregiving duties, with these activities primarily concentrated during certain time periods. The "patient's current disease stage" is classified based on the descriptions of the patient's onset time and rehabilitation progress provided in the interview records: "Acute phase" refers to the period within one month after the onset of the disease; "Recovery phase" refers to the stage where the patient's condition is stable, has been discharged from the hospital, and is undergoing functional rehabilitation training; "sequelae stage" refers to the stage lasting more than six months after the onset of the disease, when functional recovery has entered a plateau phase.

3.2 Content analysis

Thematic analysis of the interview data identified four core themes and corresponding sub-dimensions. The overall thematic framework is shown in Fig. 1.

Figure 1 Thematic framework of caregiving challenges and metaverse training needs among primary home caregivers of stroke patients.

Theme 1: Systemic deficit of emergency response capacity in high-risk scenarios

All respondents reported obvious fear and helplessness when facing acute stroke emergencies. The core dilemmas were concentrated in three interlinked dimensions: risk identification, on-site response, and procedural standards.

First, caregivers generally lacked the ability to identify dangerous conditions and judge the timing of medical consultation. Most families had no prior care experience and were completely unfamiliar with early manifestations of stroke. P1 recalled, "We certainly had no such knowledge. When he suddenly lost strength in his hand and couldn't hold things, we didn't understand what was happening at first, because no one in our family had ever had this disease." Some caregivers with online information-seeking habits had basic recognition of typical symptoms such as limb weakness and facial asymmetry, but still could not clearly distinguish between normal recovery reactions and danger signs requiring urgent medical attention. P11 stated, "I roughly know that stroke causes numb limbs and a crooked mouth, but I still can't tell exactly when to rush to the hospital and when it's just normal recovery."

Second, falls and acute choking were the most common and feared high-risk events in home care. Without systematic emergency training, caregivers often fell into instinctive panic when events occurred, not daring to intervene casually yet unable to take effective measures quickly. P3 described the choking scenario, "He easily chokes when drinking water. At first, he couldn't sit up, and we were so scared when he was lying down that we didn't dare feed him for fear of choking." P4 also expressed worry about falls: "He can go to the bathroom by himself now and sometimes walks alone. I'm very worried he'll fall, but I can't watch him 24 hours a day."

Third, the absence of standardized response procedures was widely recognized as the core cause of helplessness. The lack of step-by-step procedural knowledge directly led to decision confusion in emergency situations. P10 noted, "When he suddenly fainted during an episode, I didn't know whether to help him up or call 120 — my mind went completely blank."

Theme 2: Systemic gaps in daily care knowledge and skills

None of the respondents had received systematic professional training in home-based stroke care. Common problems included insufficient knowledge reserves and non-standard operations, with demand characteristics reflected in three aspects: acquisition channels, content dimensions, and practical standards.

In terms of access channels, knowledge acquisition was generally single and fragmented. Ten respondents (83.3%) reported that their core care knowledge came only from fragmented explanations and demonstrations by medical staff during hospitalization. After discharge, there was a lack of continuous formal information supply, and they could only search for information sporadically online, but were unable to verify accuracy or form a systematic knowledge system. P1 described, "During hospitalization, the rehabilitation therapist taught me some operations, and I practiced them at home when I had time. But what he explained was not comprehensive, and I only remembered the general idea." P2 added, "The doctors and nurses gave a few instructions at discharge, but I couldn't remember them all and forgot after going home. I wasn't sure if what I found online was correct, so I didn't dare to try it on the patient."

In terms of content, care needs covered the entire rehabilitation cycle, including limb function training, swallowing care, speech rehabilitation, and complication prevention, and the focus dynamically adjusted with the patient's disease stage. P7 said, "His leg can't move. I do passive joint movement for him every day, but I have no idea what angle or force is appropriate." P9 expressed an urgent need for swallowing care skills: "He has difficulty swallowing. Every time I feed him, my palms sweat with nervousness, afraid he'll choke. I really want to learn how to help him practice swallowing and how to feed him safely, but no one can teach me."

Across all participants, there was a strong and consistent demand for standardized operating procedures. Caregivers were worried that non-standard operations would cause secondary injury and expected clear, unified step-by-step guidelines to ensure safety and effectiveness. P4 pointed out, "I'm always afraid my technique is wrong or my movements are not standard, and I'll hurt him instead. It would be much more reassuring to have step-by-step standard operating procedures to follow."

Theme 3: Multi-source psychological stress with differentiated peer support needs

Most caregivers experienced varying degrees of psychological burden during long-term home care, with negative emotions accumulating and lacking effective outlets. The stress stemmed from multiple overlapping factors, and peer support needs showed obvious group differences.

The psychological burden was formed by the superposition of multiple dimensions. Long-term uninterrupted care led to disordered routines, sleep deprivation, and physical exhaustion, which further aggravated emotional depletion. Uncertainty about disease prognosis and recurrence risk kept caregivers in a state of persistent anxiety. Caregivers also often faced decision dilemmas in rehabilitation options and timing of medical consultation, and experienced internal conflicts from multiple role shifts. P1 stated, "I have to be on guard all day, and I can't sleep through the night. My body is tired, and my mind is even more drained. Sometimes I feel like I can't hold on anymore." P8 added, "I don't know if it will get worse or if there will be another stroke. I have no peace of mind, always on edge every day."

Compared with traditional psychological counseling, caregivers preferred to communicate with peers in similar situations for emotional resonance and practical experience, but their needs varied in focus. Some caregivers prioritized emotional support, seeking understanding and companionship from people with the same experience. P2 said, "It would be great if we could communicate with other caregivers to relieve some psychological pressure. We're all in the same boat. Chatting and encouraging each other is better than going through it alone." Others expected both emotional release and practical resources, hoping to obtain transferable care skills and rehabilitation information through peer exchange.

Theme 4: Positive acceptance of metaverse training with coexisting expectations and concerns

After establishing a concrete perception through contextual introduction, caregivers showed high overall acceptance of metaverse-based care training, recognizing the value of immersive operation training. Meanwhile, they put forward specific functional expectations and practical concerns combined with their actual home care situations.

Caregivers generally agreed that compared with traditional video teaching, three-dimensional demonstration under metaverse technology was clearer and more intuitive, providing immersive hands-on practice opportunities that made up for the shortage of "watch-only" learning. P3 noted, "VR is more three-dimensional than video. You can view it from multiple angles. A 3D demonstration is definitely clearer—for example, the angle and position of turning the patient can be seen more clearly. The action passes quickly in a video, but with a 3D model you can rotate it to look."

The expected core functions focused on intelligent interaction and immediate feedback. Caregivers expected the training to break through the limitations of traditional one-way information transmission and realize a learning effect of "learning while practicing, correcting when wrong." P1 said, "It would be great if an AI assistant or teacher could answer questions at any time, instead of waiting for a doctor to be available. The key is to tell me how to correct mistakes."

Low operational threshold and flexible learning time were universal rigid demands. Caregivers generally require simple interfaces and easy operation, rejecting complex equipment debugging and operation procedures. They also generally rejected fixed-schedule live teaching and strongly supported asynchronous self-paced learning to adapt to the uncertainty of caregiving time.

P2 said, “I’ve never used this before. You’d have to teach me how. If wearing the glasses is too complicated, I probably wouldn’t bother. It’d be best if it’s like a phone — just turn it on and use it.”

Despite overall recognition of potential value, three major practical concerns constrained long-term adoption. First, more than half of the respondents worried about dizziness caused by head-mounted VR devices, or expressed health risks due to underlying conditions such as unstable blood pressure. Second, hardware purchase and training costs directly affected willingness to try; most families had already incurred large medical expenses and had low acceptance of additional paid training tools, generally hoping for free trial access. Third, caregivers generally worried about the gap between virtual training and real care scenarios, especially regarding complex interpersonal situations such as patient non-cooperation and emotional resistance, questioning the effectiveness of skill transfer. P8 questioned, “The virtual person definitely won’t cry in pain or move around, but my mother has a bad temper. When things don’t go her way, she hits my hand and pushes me away. Can virtual practice teach me how to deal with her resistance?”

4 Discussion

This study explored the caregiving challenges and training needs of primary home caregivers of stroke patients, as well as their acceptance and concerns regarding metaverse-based care training, through semi-structured in-depth interviews with 12 participants. The findings provide demand-side empirical evidence for the development of home-based care support systems and metaverse training curricula.

4.1 Emergency response capacity deficit in high-risk scenarios

All caregivers interviewed in this study reported varying degrees of helplessness when confronted with acute stroke emergencies, with their difficulties following a consistent pattern: difficulty recognizing warning signs, panic during emergency response, and a lack of standardized procedures. These findings align with those of multiple domestic studies on family caregiving challenges in stroke care [4, 7].

At the cognitive level, the inability to recognize early warning signs of stroke recurrence emerged as a pervasive challenge. While prior research has often attributed this to caregivers’ limited disease-specific knowledge [7], our findings reveal a more nuanced picture: some caregivers—predominantly those with no prior stroke care experience—demonstrated a complete lack of awareness of any early signs. Others, by contrast, had acquired basic factual knowledge of typical stroke symptoms (e.g. limb weakness or facial asymmetry) but struggled to differentiate between normal recovery-phase responses and warning signs of recurrence, leaving them uncertain about when to seek medical attention. This gradient in recognition capacity—from complete unfamiliarity to partial but insufficient understanding—has important implications for educational design. Previous research has similarly identified symptom recognition deficits as a key barrier to caregivers’ engagement in discharge planning [25], and unmet information needs have been shown to heighten uncertainty during acute situations [26]. Together, these findings suggest that stroke emergency education for home caregivers should be tiered, with content calibrated to caregivers’ varying levels of baseline recognition capacity.

From an implementation perspective, the core deficit in emergency response lies not in the absence of relevant operational knowledge, but rather in the failure to activate procedural knowledge under stress. The experience described by Participant P10 —“when he suddenly collapsed, I didn’t know whether to help him up or call 120—my mind was completely blank”—exemplifies this dilemma. Most caregivers in our study possessed declarative knowledge of emergency procedures (e.g., knowing to call emergency services), yet under time pressure and emotional duress, they were unable to execute the complete response sequence of symptom assessment, decision-making, and intervention. This finding elucidates why traditional knowledge-based training approaches often fall short in improving home-based emergency preparedness: the mere transmission of static information does little to address the breakdown of decision-making under stress.

4.2 Systematic gaps in daily care knowledge and skills

This study identifies gaps in caregivers’ daily care competence across three dimensions: information acquisition channels, content scope, and skill types. Fragmentation and lack of feedback emerged as common challenges, though their specific

manifestations varied across subgroups.

The fragmentation of knowledge acquisition was universal among participants, yet its mechanisms differed. While prior research has shown that family caregivers of stroke patients in China predominantly receive fragmented guidance from healthcare professionals, with limited systematic information provision [5], our findings further differentiate this pattern: caregivers who relied solely on in-hospital instruction experienced passive, episodic information delivery, whereas those who consulted multiple sources—including online platforms—also struggled to form a coherent knowledge base, due to the inconsistency and variable quality of information encountered [27]. Both pathways ultimately resulted in fragmented care knowledge and a lack of unified operational standards.

Caregivers' knowledge needs spanned the entire rehabilitation trajectory, with varying scope across individuals. The majority prioritized basic operational skills—such as turning, back patting, and feeding—aiming to “get daily care tasks done.” A subset of caregivers, however, extended their concerns to management-oriented competencies, including phased rehabilitation goal-setting, medication management, and early complication recognition, reflecting a greater emphasis on care planning and efficiency. This variation suggests that caregiver training content should adopt a tiered structure, accommodating both the diverse care stages and the varying baseline competencies of caregivers.

The need for standardized operating procedures was universal across all age groups. All caregivers expressed concern about the risk of secondary injury from non-standardized practices and desired clear, hospital-level procedural guidance—a finding consistent with the systematic review by Meng et al. [7]. Caregivers prefer step-by-step, demonstrative content presented in a structured and easily followed format.

4.3 Multi-source psychological stress and differentiated peer support needs

This study found that caregivers' psychological burden stemmed from multiple interconnected sources—physical exhaustion, prognostic uncertainty, care-related decision dilemmas, and role conflicts—consistent with the international findings reported by Pindus et al. [28].

In terms of stress sources, physical fatigue from sustained caregiving, uncertainty about disease trajectory, and dilemmas in care decision-making emerged as universal core stressors. For some caregivers—for instance, those who were caring for both their stroke-affected parent and their own children—additional strain arose from balancing multiple caregiving demands. Compared with physical fatigue alone, the cumulative effect of these multidimensional stressors is more likely to precipitate burnout and mental health problems—a dimension that deserves close attention in home-based caregiver support. This aligns with evidence that the prevalence of anxiety and depression among stroke caregivers exceeds that among patients themselves, with the multidimensional caregiving burden serving as a primary driver [29].

With respect to peer support, participants consistently preferred connecting with others in similar situations. Some caregivers primarily sought emotional support—understanding and companionship rooted in a sense of ‘sharing the same plight’. Other caregivers report dual demands for both emotional comfort and practical help, such as operable caregiving strategies and access to rehabilitation resources. This categorization deepens the existing academic understanding of peer support needs among caregivers and indicates that such support demands do not conform to a single homogeneous pattern [30]. Metaverse platforms can enable the construction of social scenarios featuring virtual avatar-based interaction; theoretically, these platforms are able to provide caregivers with a group-based communication scenario that delivers a certain degree of “presence” even across long distances[31], thus creating technological feasibility for caregivers to build peer support networks that break through geographical restrictions.

4.4 Acceptance and constraints of metaverse-based care training

4.4.1 Perceived benefits of immersive visualization and real-time feedback

Participants consistently identified two specific features of metaverse-based training as particularly valuable: three-dimensional visual demonstrations and immediate performance feedback. These perceived benefits directly address the limitations of traditional self-directed learning identified in this study.

On one hand, three-dimensional spatial visualization breaks through the perspective constraints of conventional planar videos, allowing for explicit presentation of operational details, including turning angles and patient posture adjustment. This directly resolves the problem inherent in traditional video learning, namely that "movements are transient and key details are difficult to capture." The research conducted by Thompson-Butel et al. [14] also verifies that stroke primary caregivers show a high level of acceptance for VR technology, and its robust visualization capability and support for repeated practice are the core driving factors for this outcome. On the other hand, in terms of the feedback function, participants reported a clear demand for real-time error correction, which is specifically expressed as the expectation to "clarify how to adjust incorrect operations". This expectation is exactly matched with the capability gap identified in daily home care, where caregivers often lack effective channels to verify whether their operations are standardized.

Furthermore, participants' expectations regarding interactive features—such as intelligent Q&A systems and rapid search capabilities—reflect a deeper unmet need: the absence of immediate professional support in home care settings. Unlike the hospital environment where professional consultation is readily available, home caregivers often have limited access to timely guidance when questions arise during daily care. This expectation for immediate professional responses is consistent with the earlier-identified challenges of fragmented knowledge acquisition and lack of feedback during care delivery.

4.4.2 Three-dimensional real-world factors constraining the long-term adoption and implementation of technology

Despite the perceived value of metaverse-based training, participants raised three practical concerns related to the constraints of home-based care—barriers that collectively hinder its long-term adoption.

First, physiological tolerance constraint. Some participants reported dizziness and physical discomfort from previous VR use experiences, while others raised concerns over potential health risks stemming from their pre-existing medical conditions (e.g., unstable blood pressure). These findings are consistent with the conclusions reported by Huygelier et al.[32], who identified dizziness and operational complexity as core determinants that reduce the acceptance of VR technology among older adult populations. In the present study, both prior negative VR experience and anticipated health risks directly reduced participants' willingness to attempt the technology.

Second, economic cost constraints. Costs associated with hardware procurement and supporting training constitute a prominent practical barrier to technology adoption. Participants generally consider VR devices as a substantial additional expenditure, and this concern is not rooted in subjective cost sensitivity per se, but derived from the heavy financial burden that the patient's ongoing medical care has already placed on the household. Existing studies have similarly reached consistent conclusions that high hardware cost is one of the primary obstacles for the adoption of VR/AR technologies in home care scenarios [4]. For most families receiving routine home care services, the high cost of specialized equipment directly elevates the entry threshold for technology application and reduces the accessibility of corresponding training services.

Thirdly, the "virtual-real disconnection" effect and skill transfer risks. The gap between virtual training and real-world care contexts emerged as a particularly significant concern, not only because of its practical implications for training design but also because of its theoretical relevance. Participants questioned whether training with virtual patients—who do not resist or express pain—could adequately prepare them for real patients who may exhibit emotional fluctuations or resistance to care. This concern directly challenges the validity of skill transfer from training to practice. As Participant P8 stated: "The virtual person certainly won't cry out in pain or move around randomly, but my mother has a strong temper; whenever things don't go her way, she hits me or pushes me away. Can virtual practice teach me how to deal with her resistance?" Situated Cognition Theory [33] posits that knowledge and skills cannot be acquired independently of the contexts in which they are applied; when virtual training strips away the social and emotional contingencies of real caregiving, the skills acquired risk becoming "inert knowledge" that is unlikely to be activated in actual situations. This finding suggests that metaverse-based curriculum design should extend beyond visual and

operational fidelity to better approximate the unpredictability of real patient behavior—for instance, by incorporating graded behavioral responses and unexpected events within virtual scenarios to bridge the fidelity gap between training and reality.

4.5 Implications for future research

Building on this study's findings—which reveal caregivers' competence gaps, the structural characteristics of their training needs, and their concerns regarding technology application in home-based stroke care—future development of metaverse-based training programs could be systematically optimized across three dimensions: content design, learning approach, and equipment selection.

4.5.1 Content design: Prioritizing high-risk scenarios and enhancing contextual fidelity

The core value of metaverse-based training lies in addressing the limitations of traditional in-person training, rather than simply virtualizing and replicating all caregiving scenarios; therefore, content selection should adhere to the principle of "preferring real-world scenarios over purely virtual ones." On one hand, priority should be given to identifying low-frequency, high-risk operational skills—such as fall emergency response, choking emergency first aid, and stroke recurrence recognition—that are difficult to practice repeatedly in real-world settings as the core training content. This approach addresses the gaps in caregivers' capabilities when managing acute events and provides them with a safe, repeatable practice environment. On the other hand, to mitigate the risk of "disconnection between virtual and real-world skills" during skill transfer, the response pattern design for virtual patients should be optimized: moving beyond the "fully cooperative" standardized model by incorporating varying degrees of non-cooperative behavior, emotional fluctuations, and random emergent situations, along with a tiered difficulty gradient. This ensures that the training scenarios gradually approximate the complexity and unpredictability of patient behavior in actual caregiving settings, thereby narrowing the "faithfulness gap" between training and real-world scenarios and enhancing the transferability of acquired skills.

4.5.2 Learning approach: Strengthening interactive feedback and expanding peer support

To overcome the limitations of traditional self-directed learning—characterized by unidirectional information delivery and insufficient feedback—metaverse-based training should fully leverage the technological affordances of digital interaction. At the skill acquisition level, real-time feedback mechanisms should be strengthened to identify caregivers' operational deviations and provide immediate corrective guidance and standardized demonstrations, addressing their core demand of "knowing how to correct mistakes." Intelligent Q&A functions should also be integrated to provide timely responses to questions arising during care, compensating for the lack of professional support in home settings. At the social support level, virtual spaces can be designed to facilitate peer support scenarios and establish communities for caregivers, serving both as platforms for emotional resonance and as hubs for experience sharing. This approach offers caregivers with diverse needs a range of customizable support channels, helping to alleviate isolation and psychological stress associated with home-based caregiving.

4.5.3 Equipment Selection: Implement a multi-device compatibility strategy to lower the entry barrier for device adoption.

To address caregivers' multiple concerns regarding device cost, operational complexity, and physiological tolerance, future training programs should adopt a multi-device adaptation strategy featuring "low-barrier entry and tiered user experience." Priority should be given to developing universal mobile device versions, e.g.(smartphones and tablets) that are "ready-to-use and easy to operate," aligning with caregivers' demand for low entry barriers while eliminating additional hardware procurement costs and meeting the usage needs of most households; on this foundation, an immersive augmented reality version compatible with VR headsets could be offered, providing a more realistic operational training experience for caregivers who have the means and desire to use it. This dual-track approach—combining a "mobile device version for general accessibility" with a "VR device-enhanced version"—balances accessibility with immersive experience, thereby maximizing coverage across caregiver groups with varying levels of digital literacy and diverse economic circumstances.

4.6 Research Limitations

This study has three limitations: (1) limitations regarding sample representativeness. All respondents in this study were primary caregivers of stroke patients discharged from medical institutions in Shanghai; as Shanghai is a first-tier city, its healthcare resource accessibility, residents' economic status, and health literacy all exceed the national average. Therefore, the generalizability of the study's findings to rural and economically underdeveloped regions requires further validation. (2) A relatively narrow data source dimension. All data in this study were derived solely from the caregivers' self-reports; consequently, the findings are susceptible to social desirability bias and recall bias, making it difficult to fully and objectively reflect the caregivers' actual operational competence or true psychological state. Future research could employ triangulation methods—such as caregiver diary recording or participatory observation—to diversify data sources and enhance the robustness of the study's conclusions. (3) A discrepancy between cognitive perceptions and actual user experiences. The respondents' perceptions and evaluations of metaverse-based training in this study were shaped by contextual introductions involving verbal explanations and visual demonstrations; only a small minority of caregivers had prior experience using VR devices, which represents a fundamental difference from the immersive, physical experience of actually wearing a VR headset and undergoing comprehensive operational training. Future studies could conduct small-scale home-based pilot trials after the development of the course prototype is completed to gather feedback and evaluations based on real-world usage scenarios.

5 Conclusions

This descriptive qualitative study explored the caregiving challenges, training needs, and acceptance of metaverse-based training among 12 primary caregivers of home-based stroke patients. Four core themes were identified: systemic deficits in high-risk scenario response, gaps in daily care knowledge and skills, multi-source psychological stress combined with differentiated peer support needs, and coexisting expectations and concerns regarding metaverse-based training.

The findings reveal that caregivers face systemic deficiencies across three domains—emergency response, daily care competence, and psychosocial support. While immersive visualization and immediate feedback are seen as valuable, real-world adoption is constrained by physiological tolerance, economic costs, and concerns about skill transfer from virtual to real-world settings.

This study delineates the core concerns and optimization directions for metaverse-based care training from the user demand-side perspective, providing an empirical foundation for the subsequent content design, model refinement, and product implementation of metaverse-based care curricula, as well as serving as a reference for establishing a home-based stroke care support system.

Declarations

Ethical Approval and Informed Consent

This study has obtained ethical approval from the Ethics Committee of Shanghai First Rehabilitation Hospital (Approval No.: YK-2025-03-011). All participants were fully informed of the research purpose, implementation procedures, and potential risks of this study, and voluntarily signed the written informed consent form.

Consent for publication

All respondents provided consent for the use of their anonymized interview data in academic publications.

Availability of data and materials

The de-identified interview transcripts and coding datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

All authors declare that they have no competing interests.

Funding

This study was funded by the Shanghai Municipal Health Commission's Smart Healthcare Special Research Project titled "Development and Application of a Metaverse-Based Smart Training Platform for Elderly Home Care" (Project No.: 2025ZHY023); there is no conflict of interest.

Authors' contributions

HQ and JX contributed equally to this work. HQ and JX were responsible for the study conception, design, data collection, and data analysis. YL and XZ participated in data collection and interview transcription. LZ and QW supervised the study, contributed to the study design, and critically revised the manuscript for important intellectual content. All authors read and approved the final manuscript.

Acknowledgments

The authors would like to acknowledge the support provided by the Department of Rehabilitation Medicine at Shanghai First Rehabilitation Hospital in participant sample recruitment, and thank all home care providers who participated in this study.

References

1. Committee NPFS. China Stroke Prevention and Control Report 2024: An executive summary. *BRAIN CIRC*. 2025;11(4):251–60.
2. Expert Committee on the National Health Commission's Initiative to Strengthen Stroke Prevention and Treatment. Reduce Millions of New Cases of Disability, Ji XM. Summary of the 2024 China Stroke Prevention and Treatment Report. *J Cap Med Univ*. 2025;46(6):947–60.
3. Zhong M, Zhou Y, Jia Y, Yao Y, Cheng Y, Li D, Zhang Y, Lei Y, Zhao Q, Huang J, et al. Association between family support and 6-months functional recovery in acute ischemic stroke patients: a prospective cohort study. *FRONT MED-LAUSANNE*. 2025;12:1684785.
4. Yan L, Wang XY. Meta-integration of qualitative studies on home care needs of family caregivers of stroke patients. *Chin J Mod Nurs*. 2025;31(24):3307–12.
5. Zhang TY, Lin BL, Liu XH, Zhang ZX. Development and reliability and validity test of a professional care needs questionnaire for family caregivers of stroke patients. *Nurs Res*. 2020;34(10):1704–10.
6. Zhang J, Fang YM. Analysis of public health service needs and influencing factors of primary caregivers of stroke patients in community. *South China J Prev Med*. 2025;51(11):1270–4.
7. Meng LY, Jin Y, Zuo ZQ, Hou LL, Shen SY, Wang F, et al. A scoping review of care ability intervention programs for caregivers of stroke patients. *Gen Nurs*. 2024;22(13):2377–82.
8. Anwar Fazal Abu Bakar ANAR. mHealth Apps for Family Caregivers of Stroke Patients: A Systematic Review. *Iran J PUBLIC HEALTH*. 2025;54(10):2114–26.
9. Lee L, Braud T, Zhou PY, Wang L, Xu D, Lin Z, Kumar A, Bermejo C, Hui P. All One Needs to Know about Metaverse:: A Complete Survey on Technological Singularity, Virtual Ecosystem, and Research Agenda. *Found Trends Hum Comput Interact*. 2024;18(2):100–337.
10. Sandrone S. Medical education in the metaverse. *NAT MED*. 2022;28(12):2456–7.
11. Park M, Moon KJ. The Effects of Game-Based Virtual Reality in Nursing Education: A Scoping Review. *Korean J Adult Nurs*. 2025;37(4):384–400.
12. Li G, Chen JJ, Liu XY, Li Y, Li GH, Fan XQ. Research on the application and development of digital technology in medical institutions. *Chin J Eng Sci*. 2025;27(6):20–31.
13. Xue Li MEd RN, Ruth Wei PhD RN, Susan Slatyer PhD RN, PhD NAR. Extended reality for enhancing communication skills in nursing education: a scoping review. *TEACH LEARN NURS*. 2025;20(2):e587–95.

14. Thompson-Butel AG, Shiner CT, McGhee J, Bailey BJ, Bou-Haidar P, McCorriston M, Faux SG. The Role of Personalized Virtual Reality in Education for Patients Post Stroke-A Qualitative Case Series. *J STROKE CEREBROVASC*. 2019;28(2):450–7.
15. Sukron S, Romiko R, Putra H, Sari I, Agung M, Maulana M. The Effectiveness of Virtual Reality–Based Training for Family Caregivers in Supporting Post-Stroke Recovery: A Quasi-Experimental Study. *Media Publikasi Promosi Kesehatan Indonesia (MPPKI)*. 2026;9(3):524–32.
16. Lo S, Chau J, Choi KC, Butt L, Lau A, Lee V, Kwok E, Thompson DR. Stroke survivor and caregiver experiences of virtual reality gaming to promote social participation: A qualitative study. *PLoS ONE* 2024, 19(12).
17. Li X, Zhou Y, Xue M. NurseVerse: nursing in the metaverse era. *FRONT MED-LAUSANNE*. 2025;12:1577153.
18. Ibrahim NH, Norman H, Nasir MKM. Transforming nursing education towards metaverse as an innovative teaching tool: A systematic review. *Social Sci Humanit open*. 2026;13:102492.
19. Luo H, He J, Yang P, Wang Y. Health education needs of stroke patients and caregivers: A qualitative meta-synthesis. *Int J Nurs Stud Adv*. 2026;11:100585.
20. Angelina M, Jannik S. User or patient/human or person? Development of a practical framework for applying user-centered design to vulnerable populations for digital transformation in healthcare. *DIGIT HEALTH* 2025, 11.
21. Kushniruk A, Borycki E. Human factors in healthcare IT: Management considerations and trends. *Healthc Manage Forum*. 2022;36:72–8.
22. Awad S, Begg R, Loveday T, Baysari MT. Using human centred design and human factors to support a rapid health information technology patient safety response. *BMC HEALTH SERV RES*. 2025;25(1):1169.
23. Guest G, Bunce A, Johnson L. How Many Interviews Are Enough? An Experiment with Data Saturation and Variability. *FIELD METHOD*. 2006;18(1):59–82.
24. Sandelowski M. Whatever happened to qualitative description? *RES NURS HEALTH*. 2000;23(4):334–40.
25. Guan CX, Guo SL, Xiao MY, Chen H, Zheng CY. A qualitative study on the willingness to participate in discharge planning and its influencing factors among caregivers of elderly stroke patients. *Geriatr Med Res*. 2025;6(3):69–74.
26. Qin JY, Zhou KB, Wang QQ, Peng Y, Yan FX. Research progress on information needs of stroke caregivers. *Med Res Educ*. 2024;41(2):63–70.
27. Wang C, Wang YN, Song ZY, Yang YY, Li SL, Wang S. A qualitative study on online health information seeking among caregivers of stroke patients. *Gen Nurs*. 2024;22(24):4707–10.
28. Pindus DM, Mullis R, Lim L, Wellwood I, Rundell AV, Abd Aziz NA, Mant J. Stroke survivors' and informal caregivers' experiences of primary care and community healthcare services – A systematic review and meta-ethnography. *PLoS ONE*. 2018;13(2):e192533.
29. Xu L, Li M, Wang C, Liu SS, Jiang Y. A qualitative study on the experience of social isolation among caregivers of stroke patients. *Chin J Nurs*. 2025;60(12):1474–9.
30. Kanokwan Hounsri JZSK. Effectiveness of technology-based psychosocial interventions for improving health-related outcomes of family caregivers of stroke survivors: A systematic review and meta-analysis. *J CLIN NURS*. 2024;33(11):4207–26.
31. Li C, Dai Y, Chen G, Liu J, Li P, Ip HH. Avatar-mediated communication in collaborative virtual environments: A study on users' attention allocation and perception of social interactions. *COMPUT HUM BEHAV*. 2025;167:108598.
32. Huygelier H, Schraepen B, van Ee R, Vanden Abeele V, Gillebert CR. Acceptance of immersive head-mounted virtual reality in older adults. *SCI REP-UK*. 2019;9(1):4519.
33. Brown JS, Collins A, Duguid P. Situated Cognition and the Culture of Learning. *EDUC RESEARCHER*. 1989;18(1):32–42.

Figures

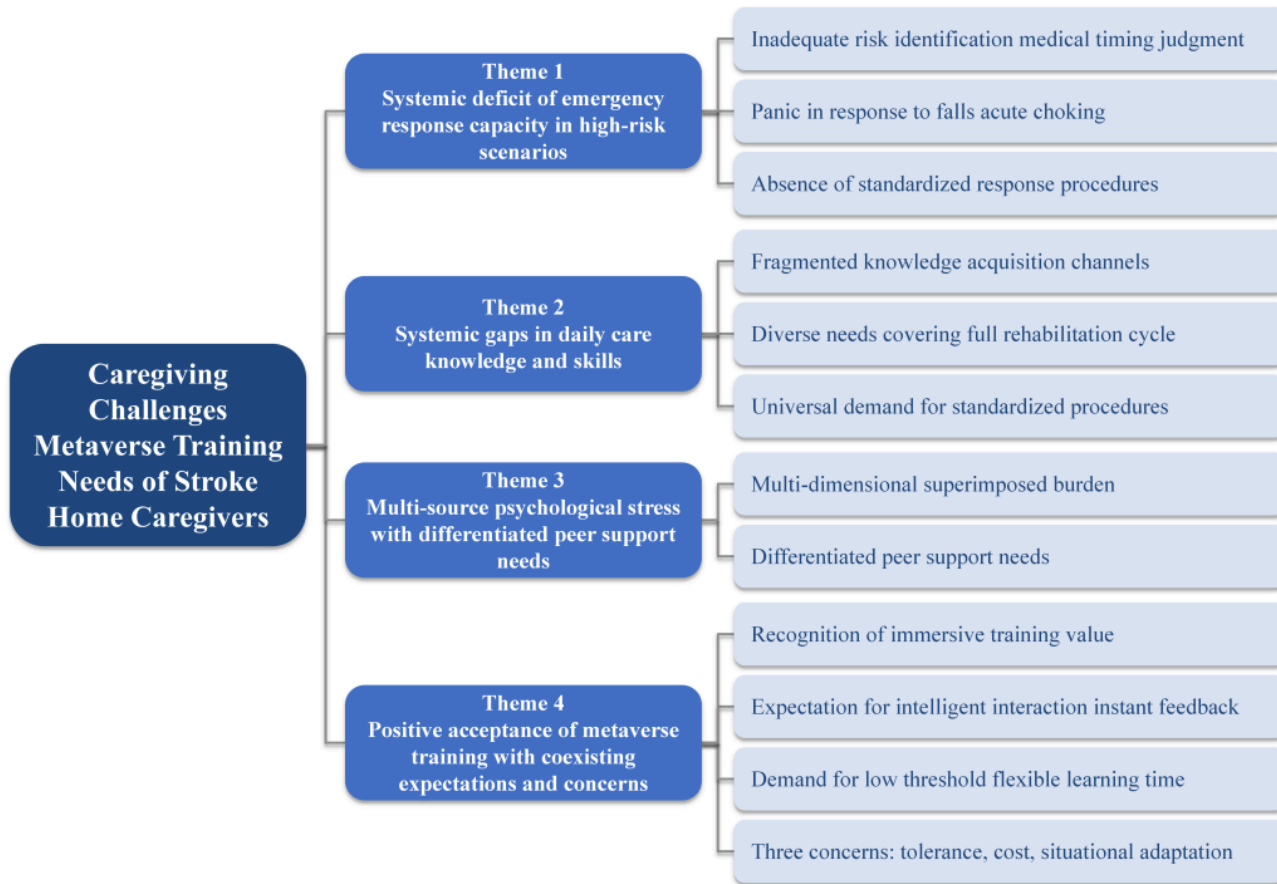


Figure 1

Thematic framework of caregiving challenges and metaverse training needs among primary home caregivers of stroke patients.