

“Within Their Spaces, Within Their Context”: Māori Therapists’ Perspectives of Robotic Technology in Upper Limb Stroke Rehabilitation

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ABSTRACT

Upper limb impairment following stroke is common, contributing to restrictions in functional capacity and reduced quality of life. Robotic devices are being developed to augment rehabilitation and support upper limb recovery. However, a lack of end-user input has resulted in devices that fail to fully meet therapist and patient needs. In Aotearoa New Zealand, involving Māori (Indigenous) rehabilitation therapists is essential for developing culturally responsive devices and interventions. This qualitative study utilised a Māori-centred approach underpinned by Kaupapa Māori (Indigenous research) principles to explore the requirements for effective upper limb robotic rehabilitation with Māori following stroke. Semi-structured interviews were conducted with six Māori stroke rehabilitation therapists to explore their perspectives. Five interconnected themes were interpreted through thematic analysis. Inequities imposed by *The system* (Theme 1) and burden from *The stroke* (Theme 2) profoundly impact Māori people’s experiences of rehabilitation and recovery, requiring devices that avoid perpetuating or exacerbating these challenges. *Hononga (Joining and connection)* (Theme 3) highlights how robotic devices could support connections to Te Ao Māori (Māori worldview), whānau (family and communities), and meaningful activities. *Whanaungatanga (Relationships)* (Theme 4), emphasised the importance of building trusting relationships between therapists, patients, and whānau. Therapists can uphold *Tino rangatiratanga (Self-determination)* (Theme 5) by supporting Māori patients and whānau to have control over their rehabilitation. The participants’ clinical and cultural expertise provided valuable insights for advancing robotic device design and implementation, emphasising the importance of inclusive approaches that address the diverse needs of Māori and promote culturally responsive rehabilitation technology.

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INTRODUCTION

Stroke is a leading cause of disability globally. In Aotearoa New Zealand, an estimated 9,000 people experience a stroke each year, and over 50,000 people live with disability due to stroke (Feigin et al., 2021; Ranta, 2018). Upper limb

motor impairment is one of the most prevalent disabilities, affecting approximately 80% of people with stroke acutely and leaving 65% of people with ongoing upper limb deficits at six months post stroke (Ingram et al., 2021; Langhorne et al., 2009). Upper limb impairment restricts the ability to perform functional activities and participate in life

roles, impacting individuals' wellbeing and quality of life (Langhorne et al., 2011). While some spontaneous recovery occurs, rehabilitation delivered by a multi-disciplinary team can maximise upper limb recovery (Cassidy et al., 2017).

A tailored approach to rehabilitation, incorporating a large volume of task-specific practice at an optimal challenge point, is key to promoting adaptive neuroplasticity (Lang et al., 2015; Ward et al., 2019). Current stroke clinical guidelines suggest people with stroke should receive at least three hours of daily input during inpatient rehabilitation (Stroke Foundation, 2024) with 400–600 repetitions of practice per session to effect change (Kimberley et al., 2010). However, limited resources and high therapist caseloads often result in inadequate levels of rehabilitation being provided (McLaren et al., 2020). Addressing the challenge of delivering optimal rehabilitation to support stroke recovery remains a healthcare priority in Aotearoa New Zealand (Thompson et al., 2020).

The age- and sex-adjusted prevalence of stroke is almost twice as high for Māori compared with non-Māori (Manatū Hauora – Ministry of Health, 2023) and the average age of stroke onset within Māori is 65 years, in contrast to over 80 years for New Zealand Europeans (Thompson et al., 2022). Māori stroke survivors face significant inequities when engaging with the healthcare system, which exacerbate the burden of stroke for Māori and their whānau (families and communities) (Ranta et al., 2023). Evidence shows that Māori face inequitable access to services, systemic bias and racism within the healthcare system, and inequities in health outcomes (Reid et al., 2019). Furthermore, Māori with stroke face additional challenges during rehabilitation; Māori are less likely to be offered the recommended minimum amount of rehabilitation or access to specialist services, which contributes to poorer outcomes in function and quality of life (Thompson et al., 2022). Furthermore, rehabilitation settings and processes that are not culturally congruent can impact on engagement and functional outcomes for Māori who have had a stroke (Palmer et al., 2019), a factor exacerbated by underrepresentation of Māori in the healthcare workforce (Reid et al., 2019).

The compounding health inequities faced by Māori highlight the importance of ensuring Māori perspectives and aspirations shape the development, implementation, and evaluation of potential solutions that aim to optimise stroke rehabilitation (Dawes et al., 2023). One promising solution that could enhance upper limb rehabilitation after stroke is rehabilitation robotics (Lee et al., 2023). Robotic rehabilitation devices facilitate upper limb movement, potentially enabling high volumes of repetitive, task-specific practice at graded challenge levels, which may promote functional recovery beyond the effects of conventional rehabilitation alone (Flynn et al., 2022). However, the uptake of robotic rehabilitation in clinical settings has been limited (Alt Murphy et al., 2024). This has been attributed to insufficient user input during development, resulting in devices that fail to address clinical, cultural, and individual needs (Goodman et al., 2023). Consequently, there is a lack of clarity regarding which robotic device features are preferred by therapists and patients, and the optimal methods for delivering upper limb robotic therapy within specific rehabilitation and cultural contexts.

To address these challenges and support more effective and equitable stroke rehabilitation, the design, implementation, and evaluation of robotic rehabilitation technologies must be informed by end users of these devices. Rehabilitation therapists are an important end user of technology as they play a critical role in selecting, adapting, and delivering rehabilitation interventions, and their decisions significantly influence how rehabilitation technologies are introduced and implemented with people with stroke (McGrath et al., 2017). Research has shown the importance of involving therapists in device design to facilitate the development of devices that best meet users' needs (van Ommeren et al., 2018). Thus, as key facilitators of technology use, capturing therapist insights into rehabilitation robotics is an important first step, yet these remain underexplored (Alt Murphy et al., 2024).

In Aotearoa New Zealand, the inclusion of Māori rehabilitation therapists is paramount to ensuring the development of culturally responsive devices and rehabilitation programmes. While Māori therapists do not speak on behalf of Māori, they frequently witness the complex journeys Māori and their whānau navigate after a stroke (Espiner et al., 2021). Through their clinical practice and cultural insight, they have a deep understanding of the significant challenges, systemic barriers, and areas of unmet need faced by Māori and whānau (Sheehy et al., 2025). Their involvement may support the incorporation of mātauranga Māori (Māori knowledge) and Māori perspectives into the future development and implementation of rehabilitation robotics, which could enhance effectiveness, improve health equity, and ensure inclusivity for all stroke patients in Aotearoa New Zealand (Te Morenga et al., 2018). This approach aligns with Te Tiriti o Waitangi (the Treaty of Waitangi) principles (Manatū Hauora – Ministry of Health, 2024). Therefore, this research aimed to explore Māori therapists' perspectives of the requirements for effective upper-limb robotic rehabilitation with Māori following stroke.

METHODS

Study design

This research utilised a Māori-centred methodology, adapting a qualitative descriptive approach using Kaupapa Māori research principles (Smith, 2012) to explore the perspectives of Māori therapists on robotic rehabilitation through a culturally responsive lens. Kaupapa Māori principles underpinning this research included centring Māori voices and perspectives, upholding and privileging mātauranga Māori, fostering whanaungatanga (relationships and connectedness) within the research team and research participants, and promoting manaakitanga (respect and care) throughout the research process (Smith, 2012). Ethical principles outlined in the Te Ara Tika framework informed and underpinned ethical decision making across all stages of the research (Hudson et al., 2010). Semi-structured interviews with Māori rehabilitation therapists ($n = 6$) were guided by tikanga Māori (customs and protocols), employing the Hui Process framework for participant engagement and incorporating elements of the Meihana Model (Pitama et al., 2014) to reflect Māori health and wellbeing concepts. Data collection was further enriched using image elicitation

techniques. Thematic analysis, informed by te ao Māori concepts, was employed to interpret the findings. The design of this study has been detailed in a prior publication (Boardsworth et al., 2024).

The research team included both Māori (BW, TW, RB) and tauīwi (non-Māori) researchers (KB, NS, SO, RS). Two researchers (BW, TW) had prior experience in Kaupapa Māori research methods. All members of the team had clinical backgrounds, including physiotherapists (BW, TW, NS, SO), an occupational therapist (KB), and two physiotherapy undergraduate students (RB, RS). While diverse perspectives shaped our individual positionality, our collective interests were focused on enhancing stroke rehabilitation approaches, with a commitment to equity and cultural responsiveness in rehabilitation technology development.

Participants, sampling, and recruitment

Informed by the concept of information power (Malterud et al., 2015), a sample of six Māori physiotherapists, occupational therapists, and rehabilitation assistants who were currently working, or had previously worked in stroke rehabilitation, were recruited through professional networks. Purposive sampling was employed with consideration given to gender, profession, geographical location, years of clinical experience, clinical setting, level of academic qualification, and the funding structure of the participant's organisation (Campbell et al., 2020), to ensure a breadth of perspectives.

Data collection

Informed verbal and written consent were obtained from each participant prior to the interview. Participants were offered the opportunity to meet with the researchers in a 'Zui' – a Hui (meeting) via Zoom, or a telephone conversation prior to the interview to engage in whakawhanaungatanga.

The interviews were undertaken jointly in English by a Māori (RB) and a tauīwi (KB) member of the research team. Data were collected between February 2021 and September 2022 either kanohi ki te kanohi (face to face) or online via

Zoom. Interviews were audio and video recorded to be later transcribed verbatim by a transcriber fluent in te reo Māori (Māori language). The interviews were 80–90 min in duration. The structure of the interview was guided by the Hui Process (Lacey et al., 2011), a framework that upholds tikanga Māori, and included opening with a karakia (prayer), an exchange of mihimihi and pepeha (Māori cultural forms of greeting and introductions), and whakawhanaungatanga (see Figure 1).

Interviews were semi-structured and based on an interview guide using open-ended questions (see Appendix A). The content of the interview questions was framed to address constructs of health and wellbeing after stroke from a te ao Māori perspective using the Meihana model (Pitama et al., 2014). As many rehabilitation therapists in Aotearoa New Zealand have had limited exposure to rehabilitation robotics, image elicitation was utilised during part of the interview to provoke thoughts and ideas from the participants (Pauwels, 2019). The participants were shown eight custom-designed images that depicted an array of robotic devices being used in various stroke rehabilitation contexts to prompt discussions about device features, programme requirements, and considerations for robotic rehabilitation implementation (Figure 2).

Data analysis

Data were analysed using a thematic analysis approach (Terry et al., 2017) guided by te ao Māori concepts to ensure a culturally grounded and responsive process (Boardsworth et al., 2024). Familiarisation with the data involved repeated engagement with interview recordings and transcripts. Two researchers (RB, KB) initially undertook inductive coding using NVivo 20 software. Coding was collaboratively reviewed to develop a coding framework and then refined with the wider research team. Coded data were then manually collated and grouped, and subthemes and themes were iteratively developed through a series of analysis team meetings. Themes were critically examined to ensure they reflected participant perspectives, demonstrated internal coherence,

Figure 1

Hui Process Applied to the Structure of Participant Interviews

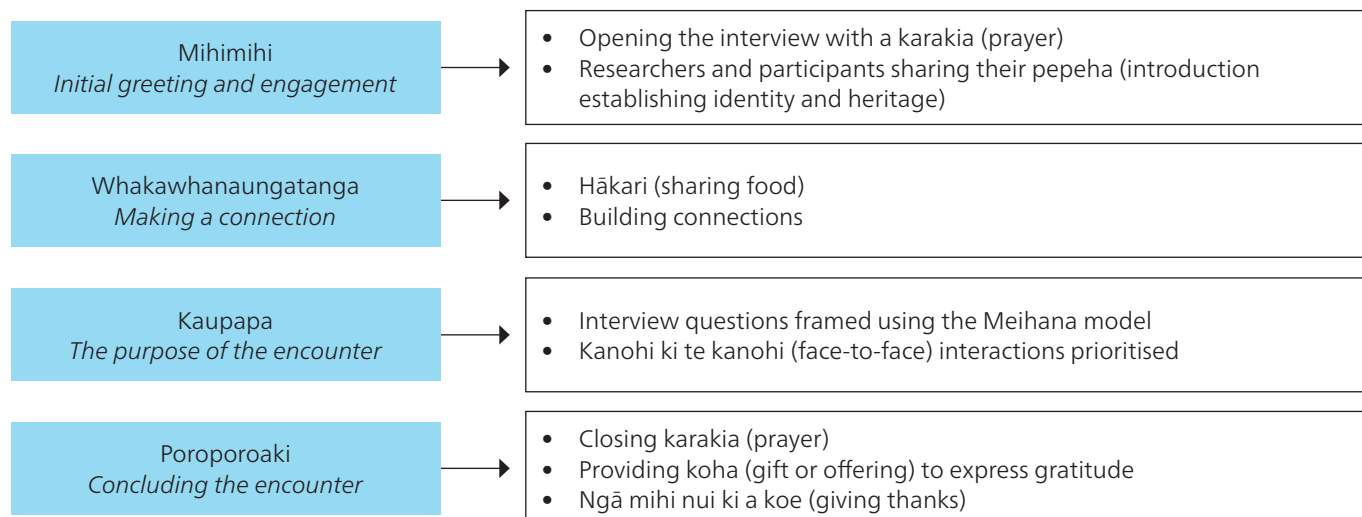




Figure 2
 Example of an Image Elicitation Prompt Depicting an Elbow Exoskeleton Device Worn in the Home Environment

and were robustly supported by the data. Reflexive memoing was employed throughout the analysis process to document critical reflections and analytical decisions, with both individual and team reflections integral to upholding analytical rigour and ensuring a robust application of a cultural lens (McGrath, 2021). To ensure the findings reflected the participants' views, the refined themes were shared with participants via email, along with an invitation to discuss the findings with the researchers. Participants' exemplar quotes were assigned a pseudonym in the interests of confidentiality. Three participants engaged in the member checking process and provided feedback on findings. This feedback was integrated into the final themes.

RESULTS

Participant characteristics

The participants who identified as Māori included four physiotherapists, one occupational therapist, and one rehabilitation assistant. Their clinical experience in stroke rehabilitation ranged from three to 13 years. Three participants were wāhine Māori (women), and three were tāne Māori (men). Participants worked in various practice settings, including publicly funded rehabilitation services, private practice, community organisations, and universities.

Themes

Five themes that could influence the implementation of effective upper-limb robotic rehabilitation with Māori following stroke were interpreted. These can be visualised in Figure 3.

The first two themes, *The system* and *The stroke* represented in the lower half of Figure 3, were factors that may negatively impact Māori patients and their whānau and hinder stroke recovery and rehabilitation. Such factors warrant consideration when implementing robotic stroke rehabilitation. The first theme, *The system*, recognises the Aotearoa New Zealand healthcare system as a predominant contextual factor influencing how Māori and their whānau

experience stroke and stroke recovery. In the second theme, participants described how *The stroke* often had devastating effects on Māori patients and their whānau, impacting identities, life roles, and ability to engage in daily activities. A further three themes (depicted in the upper half of Figure 3) were identified that could support the successful implementation of rehabilitation robotics with Māori people who have experienced stroke. Theme 3 – *Hononga* (Joining and connection) – highlights the ways robotic devices might enable connections to te ao Māori and what is meaningful for the person and whānau. Participants stressed the importance of *Whanaungatanga* (Relationships) (Theme 4), where trust and connection built between the therapist and patient, extending to whānau, enables engagement in rehabilitation and could promote trust in robotics. Theme 5 – *Tino rangatiratanga* (Self-determination) – emphasised the importance of supporting Māori patients and whānau to have control over their engagement in rehabilitation. These three interconnected themes were seen as having the potential to work together to uplift the patient and whānau in their stroke rehabilitation journey and present opportunities for robotic rehabilitation.

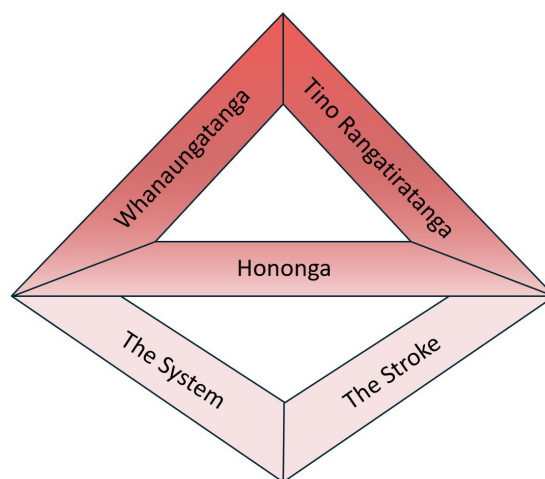


Figure 3
 Five Themes that Influence Implementation of Upper-limb Robotics with Whānau Māori Following Stroke from the Perspectives of Māori Rehabilitation Therapists

Theme 1: The system

In this theme participants emphasised the systemic challenges in Aotearoa New Zealand's healthcare system that may hinder effective upper-limb robotic rehabilitation with Māori following stroke. Participants highlighted significant constraints on current rehabilitation services including large caseloads, disconnections between services, and poor communication, which they felt limited the amount and quality of rehabilitation and compromised patient experiences and recovery. System pressures, such as the emphasis on rapid hospital discharge and limited time allocated for each patient, reduce opportunities for building the vital connections and relationships that are essential for effective rehabilitation. As a result, Māori patients often receive insufficient rehabilitation and are left unsupported in

the community: "They talk a big talk, but actions speak louder ... I don't think things are like, so patient-centred these days. It's all about money, unfortunately" (Aroha).

Participants highlighted that concepts of health, ageing, and healthcare differ between Māori and Western worldviews. These differences have often resulted in misalignment between the services offered and those valued by Māori with stroke and their whānau. One participant noted that, "It's, you go from sick to not sick anymore. The concept of rehabilitation doesn't fall in there. And it's, and it's like when they're sick ... I'll [whānau] take care of everything else 'cause they're sick" (Wiremu).

Participants shared accounts of bias and racism within healthcare, which they noted contributed to Māori having a lack of trust in the healthcare system. This distrust was compounded by intergenerational injustices experienced by Māori as a result of colonisation and the failures to uphold Te Tiriti o Waitangi. This is highlighted by Kiri, who stated, "And so, we have a system that is discriminative, it's racist. It's lack of funding, the disproportion of where funding is allocated to, is disproportionate to where the need is" (Kiri).

Participants described how whakawhanaungatanga, tikanga Māori, and culturally responsive practices were frequently overlooked in favour of expedience, and that Māori patients and whānau often remain silent in the face of such breaches.

It's just small things ... putting their food on the commode so they can shift all the blankets out the way. And ... that could be like a full plate of food, and they're [the patient] like, 'Nah, get that away from me'. Then they get turned into, oh, they get spoken about as the non-compliant patient ... It [tikanga] should take priority over timeliness. (Wiremu)

This can have a significant impact on how Māori and their whānau engage in rehabilitation and, in turn, how they are perceived by staff. While participants acknowledged that resource constraints pose challenges, they advocated strongly for more culturally responsive approaches to healthcare (as discussed in themes 3, 4, and 5). Participants highlighted that these systemic inadequacies in resourcing and cultural responsiveness have the potential to influence the implementation of novel interventions such as robotics.

Theme 2: The stroke

This theme emphasises the profound and multifaceted impact of the stroke on Māori patients and their whānau, encompassing not only physical impairments but also significant mental, emotional, and social challenges. These impacts are often compounded by other medical conditions, financial, and relational pressures, which can overshadow the priority of stroke rehabilitation and the potential value of robotic devices.

So, you know, that's [stroke rehabilitation] the least of their worries sometimes. You know, they've got kids on drugs and their daughter's getting or their son's getting bullied at school, so the last thing they're worried about is a device. (Manaia)

Participants described the loss of independence from stroke as particularly undermining, with Māori patients often experiencing discomfort with the attention drawn by visible disability and the act of participating in rehabilitation. In addition, the person with stroke can experience significant shifts in their roles within the whānau and community. These changes can result in a perceived loss of mana (spiritual power and prestige) and are frequently accompanied by a reluctance to accept help or rely on others, as outlined by Wiremu: "...especially in our kuia (female elder) and kaumātua (Māori elder and leader), so that age of where, you're either held in high esteem for the mahi you do or just the person you are...".

Participants highlighted that the use of robotic rehabilitation could exacerbate this loss of mana and that Māori patients could experience whakamā (shame or embarrassment) while using devices. This extended to a risk of spiritual disconnection with the body, which the participants had noted with the use of other devices and aids, such as prosthetics: "I feel this is making me disconnect to my body, because this is a machine. This is a, this is not my hand, this is a robot, or this is a technology" (Kiri).

Stroke also causes the demands on whānau to shift, with many finding themselves overwhelmed, balancing financial strains and other life responsibilities, while also supporting the person with stroke during rehabilitation. This challenge is compounded by the need for whānau to understand the implications of stroke and the rehabilitation process within a system that does not support Māori.

I think she said, 'Just let me rot here.' And that was really hard, because whānau also were trying to support her. But they also didn't have the capacity or the navigation in the health system to try to uplift this whānau member. Because they were all struggling. (Kiri)

Participants cautioned against assuming that whānau can be heavily involved in robotic rehabilitation.

You're gonna then put more pressure on whānau members to operate this at home or operate something like this. How might it be able to just be a bit more user friendly, because the caregivers or the whānau members, they're just gonna think, 'this is another job that we have to do and I'm not, I'm not qualified to do it'. Or they don't have the capacity to do it, 'cause they're already stretched as it is. (Kiri)

The participants stressed that given the burdens faced by Māori with stroke and their whānau, and the existing significant pressures within the healthcare system (Theme 1), the introduction of robotic devices should not contribute additional burden.

Theme 3: Hononga (Joining and connection)

This theme introduces the potential for robotic devices to connect Māori patients with their values, their whānau, and activities that are meaningful to them. To ensure devices resonate with Māori patients and whānau, participants advocated that the design of devices should integrate te ao Māori principles and support personal rehabilitation goals.

Connection with te ao Māori was identified as supporting both physical and spiritual wellbeing and described in relation to connection to whenua (land), language, traditional cultural practices, and relationships with whānau and hapu (subtribe). Participants emphasised the importance of designing robotic devices for use in culturally significant places, environments and activities, and alongside traditional Māori health practices like rongoā (Māori medicine) and mirimiri (massage): “If it was to support them in doing something related to the whenua (land), you know, that was of meaning to them. You know, like if it was, say, going to their urupā (burial grounds), for instance” (Kaea).

Devices were described as having potential to foster social connections with whānau and hapū, such as through the use of interactive games, as highlighted by Kaea: “It’s like, ‘Oh we’re gonna help Nanny do her thing’ ... I could imagine whānau being able to, you know, like children wanting to have a turn. And be playing a game, like involved in ... something fun”.

However, there was concern that some patients may perceive robotics as poorly aligned with Māori cultural values when compared to rehabilitation delivered by a person.

Have you ever had a massage from a massage chair? ... Yeah, I think that’s probably the best way I can compare it to in terms of what I think our patients are talking about. I feel like those chairs are nowhere near as good as the input of getting a massage from a person ... So, I feel like that’s one way that I could envisage our patients, especially our Māori patients, are behaving, or are seeing robotic therapy. (Wiremu)

The participants emphasised that Māori patients and whānau were likely to be receptive to using robotic devices if they could discern a clear purpose aligned with cultural values and linked to meaningful rehabilitative goals.

They simply just want to be able to make dinner for their kids, for their wives, for their family members. You know, like as simple as that sounds, if I said to them ... ‘If I was able to give you something to help you do that, to simply make dinner for your family’, they would jump at it. (Nīkau)

Participants noted that, as therapists, they would be more likely to implement devices if they could see clear benefits for the patient, and if devices could be used in ways that were personally meaningful and relevant to their daily life.

I would have to be feeling that I could see the connection between it being meaningful for them as well as opposed to actually, ‘There’s this device and it’s going to be great’ ... but actually is that, for what? So, I think it would be more just being able to see the utilisation or usability of it within their spaces, within their context. (Kaea)

In line with this concept, participants identified that devices should have the capacity to promote functional movements and should offer versatility to enable integration into everyday activities and routines. This adaptability would enhance the use of devices and patient enjoyment, while also promoting higher doses of rehabilitation. This approach

will ensure patients and whānau can see meaning in robotic rehabilitation and will enhance engagement.

Theme 4: Whanaungatanga (Relationships)

Participants emphasised the importance of therapists building genuine, trusting relationships with Māori patients and their whānau. They noted that deeper trust enhances engagement in rehabilitation and openness to interventions like robotics. Relationship building was considered more critical than the delivery of the intervention itself and should be developed through mihimihi (with links to whenua and whakapapa), whakawhanaungatanga, and use of te reo Māori during therapeutic interactions.

The participants noted that Māori therapists and Māori patients are often able to readily develop strong therapeutic relationships. A shared worldview, values, and experiences strengthen these connections, and participants emphasised the importance of having Māori therapists providing services. Without the foundation of a strong therapeutic relationship, patients may feel uncomfortable and hesitant to engage in rehabilitation.

That’s why they [Māori patients] don’t engage with those, because there’s no, they don’t trust the person that they’re talking to. And the reason they don’t trust the person they talk to, ‘cause the person they’re talking to doesn’t know them and doesn’t even take the time to know them or understand them. This is gonna be good for you. You know, this is what the doctor says, ‘This is gonna be good for you.’ And then they’re looking at you to say, ‘Well you don’t know what’s good for me.’ (Manaia)

Participants emphasised the need for therapists to understand the patient within the context of their social environment, and the importance of developing strong relationships with the patient’s support network. Recognising the whānau as a healing unit was seen as key to supporting engagement in rehabilitation and as having potential to counter the challenges experienced by Māori and their whānau after stroke, described in Theme 2.

Strong therapeutic relationships were seen as foundational to engagement with robotic rehabilitation.

You could have all the devices under the sun, but if you haven’t got that trust or that, you know, they’re just there because they were sent there ... if you just walk in here, waving around machines and saying, ‘Well, put this on, this will help you.’ (Manaia)

While participants emphasised that trust in devices primarily stems from trust in the therapist, they also explored the potential for designing and implementing devices that may in and of themselves elicit trust. Design elements such as aesthetics, size, use of natural-looking materials, and the sense of safety and control were identified as factors influencing the trustworthiness of robotic devices.

Theme 5: Tino rangatiratanga (Self-determination)

Participants emphasised the need to respect the tino rangatiratanga of Māori patients by enabling them to lead their healthcare and rehabilitation decisions in line with their

customs and values. In rehabilitation settings, this means that therapists supporting Māori patients have control over how they engage in rehabilitation and the direction of their recovery journey, reflecting a collaborative approach to rehabilitation. Therapists should support approaches that align with the person's values and those of their whānau (as described in Theme 3), and this extends from rehabilitative interventions such as robotics to the inclusion of traditional health and spiritual practices. Kaea noted, "Those assumptions ... 'I'm the therapist, and I know what's good for you.' As opposed to, 'Oh, you know, these are some options, you know, these are some tools'" (Kaea).

Participants emphasised that therapists need to deliver information and options in a way that fosters shared understanding, enabling patients and whānau to make informed choices.

Asking Māori who are looking, who are caregivers of people with stroke and saying, 'What support systems do you need?' You know, 'What does that look like for you, how might we be able to support you?' Because we're always, to some degree, we are coming, trying to come up with the answers for them. When actually it would be good for them to say, 'This is what I need'. (Kiri)

The participants highlighted that tino rangatiratanga in the context of using devices involves patients actively choosing to engage with the devices and maintaining control over how they are implemented. This is highlighted by Kaea, who stated that, "The ones where people feel in, you know, um, that they have control over it themselves. That they can do things more independently with um, and that um they can determine when and where, you know, it was used" (Kaea).

Thus, the implementation of robotic devices should not be something that is "done" by the therapist but instead undertaken in collaboration with Māori patients and whānau, empowering them to make decisions and have control over their rehabilitation journey. Furthermore, robotic devices should be designed with consideration for features that enhance tino rangatiratanga.

The interconnection between *Hononga* (Theme 3), *Whanaungatanga* (Theme 4), and *Tino rangatiratanga* (Theme 5) underpins the participants' call for culturally safe rehabilitation practices, particularly in the design and implementation of innovative approaches such as robotic rehabilitation. Participants emphasised that the success of meaningful robotic device design and implementation (Theme 3) relies on Māori patients and their whānau being able to establish trust in both the therapist and the device (Theme 4) while feeling empowered to actively lead their own rehabilitation journey (Theme 5). By embedding cultural safety within rehabilitation approaches, including robotic rehabilitation, there is significant potential to address systemic inequities (Theme 1) and mitigate the complex burdens of stroke (Theme 2) faced by Māori people who have experienced stroke. Additional participant quotes to illustrate these themes are presented in Table 1.

DISCUSSION

This research has provided an account, from the perspectives of Māori stroke rehabilitation therapists, of the requirements for effective upper-limb robotic rehabilitation with Māori following stroke. As the first study in the field to explicitly explore cultural considerations for inclusive technology design, it offers critical insights into how rehabilitation technologies can better support Māori, particularly if embedded "within their spaces, within their context". Participants expressed a generally positive outlook on the potential of robotic devices to enhance rehabilitation experiences and outcomes by incorporating the principles of *Hononga*, *Whanaungatanga*, and *Tino rangatiratanga*. Their cultural and clinical expertise highlights how these technologies could transcend conventional Western approaches if designed and implemented with cultural safety, while also addressing systemic barriers (*The system*) and the multifaceted challenges of stroke (*The stroke*). The findings have broader implications for health technology implementation in Aotearoa New Zealand, underscoring the need for systems, therapists, and devices to align with Māori values and practices to achieve more effective outcomes for Māori following stroke.

Risks and opportunities

The findings highlight both risks and opportunities associated with the development and implementation of rehabilitation robotics in Aotearoa New Zealand, which likely extend to other health technologies (Dawes et al., 2023). Participants emphasised the critical influence the healthcare *system* (Theme 1) plays in shaping experiences of, and outcomes from, stroke, noting that current rehabilitation practices often perpetuate inequities for Māori people who have experienced stroke. The development and implementation of health technologies, such as rehabilitation robotics, must actively address the risk of reinforcing existing biases and disparity, while leveraging the opportunity to promote equitable resource allocation and access to rehabilitation (Bitomsky et al., 2024). The participants consistently advocated for embedding the principles of Te Tiriti o Waitangi in device design and implementation as a mechanism for supporting the decolonisation of Aotearoa New Zealand's healthcare system (Came et al., 2020). This included developing robotic devices that support equitable resource allocation and access to rehabilitation, uphold te ao Māori values, integrate mātauranga Māori (Te Morenga et al., 2018), and foster culturally responsive rehabilitation practices that uphold tikanga and prioritise whānau-centred care (Graham et al., 2020).

Culturally responsive rehabilitation

The findings highlighted the importance of therapists prioritising culturally responsive care by building trust and connection with whānau through *Whanaungatanga* (Theme 4). This approach is essential for the success of stroke rehabilitation, including robotic and other health technologies (Boland et al., 2020; Wilson et al., 2022). Alongside relationship building, therapists can uphold *Tino rangatiratanga* (Theme 5) by providing Māori and

Table 1*Supplementary Exemplar Quotes from Participants*

Theme	Representative quotes
The system	<p>"...cause a lot of Māori don't trust the health system, and it still carries on. And to be honest I don't trust the health system either. (laughter), but yeah, but it's probably through my life growing up, 'cause my parents never trusted it and it's just followed on through those lines. It's quite a big thing." (Aroha)</p> <p>"Once you get rural ... in comparison to what the gold standard is in the urban centres. You know, the resources are short in the main cities, it's gonna be even smaller when you get further out." (Wiremu)</p> <p>"Technically you should be doing certain cultural competency learning or upskilling every single year, but that's not, you know, that's not monitored at all. And I think that's, you know, we monitor skills, we monitor documentation and those are all, those are all sweet..." (Wiremu)</p> <p>"So there's massive, big gaps between the hospital discharge and then community following up for Māori. They seemed to just get discharged ... The things that they needed to have in place weren't actually set up." (Kiri)</p>
The stroke	<p>"They don't like being dependent on others and they feel a burden. Um a sense of um losing control of who they are as a person. This is like um debilitating. You know, they talk about feeling disconnected with their family, 'cause no one seems to understand how they feel, 'cause they still think them, of what they used to be." (Kiri)</p> <p>"Their lack of independence to just be able to clothe themselves or wash themselves or make dinner for their loved ones. Um it's very frustrating for them not to be able to work and provide for their families." (Nikau)</p> <p>"You know, like and then they had to put this thing on, which is like, 'I just don't even, it doesn't make me feel very good at all and it's just really, you know, um, you know, takahi te mana. You know, stamping on their mana." (Kaea)</p> <p>"Cause you can't put it on to whānau, because they just, they just don't have the capacity. And they probably won't be able to sustain what you're trying to achieve ... I mean whānau will help support them and stuff, but they can't be the ones who have to feel like they've gotta put another hour into this, 'cause they're working two jobs or they've got the kids still. They've got dinner to get sorted..." (Kiri)</p>
Hononga	<p>"If you have um some form of impairment, which is something that is damaging your wairua [spirit] or your hinengaro [mind], tinana [body] ... whatever that may be. When you're out of balance, it has an impact on all of those facets. It's not just the one. So, if you had something to assist you in that area of your taha wairua [spiritual side] or anything like that, then maybe things like this can help you access that world." (Nikau)</p> <p>"Or visiting something and they could actually do something that, that they once did. Or even gardening, for instance ... it all comes back to how they connect with it." (Kaea)</p> <p>"Imagine you had something that helped you with your ... upper limb or lower limb ... to help you be able to go and walk in the bush or go down to the beach ... where they can immerse themselves back into their environments." (Nikau)</p> <p>"What had been working towards was ... how far he could walk ... but actually what he really wanted to do was take his mokopuna [grandchildren] swimming again. And so once, you know, like that, someone had finally tapped into that, then all of a sudden it was like, 'Well let's go and do all these things so that he could actually take, go swimming, you know, with his whānau.' And that became very different rather than, 'Oh I'm going to have to walk this far.' You know, because it was like actually 'this is meaningful for me'. So, you know ... all of the technologies ... if that had've enabled him to do that he, I'm sure he would've been open to that. You know, and it's like how does that fit within their purpose?" (Kaea)</p> <p>"But they don't care if their hand opens or closes, they just wanna be able to pick up their cuppa tea or cuddle their mokopuna or do whatever. But that's not a clinical type outcome measure." (Kiri)</p>

Theme	Representative quotes
Whanaungatanga	<p>"That's why when you do your mihi [introductions], you talk about your mountain, your river ... Then after that it might be, you know, um oh school or work ... then it might be about your kids, where they played rugby and in, and in New Zealand because it's such a small place, it's not hard to get a connection." (Manaia)</p> <p>"So that whole approach, it's really important. I think people underestimate the importance of that first initial meeting. That can make and break the whole treatment." (Manaia)</p> <p>"And when I say in context of whānau, it's like look, understanding or taking time to understand, relationships that already exist within the whānau network or what that person, what significance they hold within their whānau space." (Kaea)</p> <p>"It is in alignment with person-centred care; however, it extends it to being whānau-centred. So, it's not just the individual but actually, you know, that that is still important but it's the individual in context of whānau." (Kaea)</p> <p>"You'd have to have a lot of trust built up within the relationship ... You know, like if someone's not in control of what that arm is going to be doing ... It's like a third element ... I [as a patient] would feel quite vulnerable." (Kaea)</p>
Tino rangatiratanga	<p>"What is it that you need? What can we do right now? How might that look for you?' And I know they probably think, 'Oh man, I've had millions of people ask me that.' But I think, give control back ... 'Well what support systems do you need, is there enough for you, what, how else can we provide...' whatever that is that they need." (Kiri)</p> <p>"Yeah, and if there's not a relationship that's been built, you know, it becomes, becomes very much one sided like it's a delivery of, or a dumping of information. And then they're just like, 'Well what does that mean?' You know, but they haven't had an opportunity to, or don't, might not feel comfortable to ask questions, because it's delivered in a manner that's like, 'Well you should know'." (Kaea)</p> <p>"You know, who's ever involved, 'cause what, they can either either help them or it could either hinder them ... If they're not involved and they don't understand, they could look at it and say, 'Oh what are you up to now?' You know, 'What are you trying to do, what's all that carry on?' But if they're encouraged and they understand what it's all for, then it, the whole mindset could change and say, 'Have you put your thing on yet' or 'where's your, where's your device, you should be using that'." (Manaia)</p> <p>"...would've been useful to have some sort of device or some sort of support where they are in their rehab plan ... I think any opportunities to empower patients and empower stroke patients that can give them that sense of belonging, that sense of connection, that sense of in control of their life..." (Kiri)</p>

their whānau with comprehensive information about stroke recovery and enabling them to choose rehabilitation interventions and technologies that align with their needs, goals, and values. This would enable Māori and their whānau to make informed decisions about the use of rehabilitation technologies, including determining the timing, frequency, and contexts in which these technologies will be used. This approach aligns with research that has shown beneficial outcomes when self-directed rehabilitation strategies have been promoted with Māori patients with stroke and their whānau (Harwood et al., 2012). Finally, fostering *Hononga* (Theme 3), or a connection between the patient and their cultural and personal values and goals. Goal setting is a well-established part of stroke rehabilitation (Sugavanam et al., 2013); however, Western-centric approaches often prioritise physical recovery and independence, with goals typically being individualistic and task-specific (Bright et al., 2024; Ranta et al., 2023). Our findings highlight the importance of engaging in collaborative goal setting with Māori patients and their whānau that prioritises cultural values, fosters

connection with culturally significant places and activities, and addresses hauora (health and wellbeing) (Harwood et al., 2022). This culturally responsive approach has wide applicability but is particularly relevant to rehabilitation technologies that facilitate patients' participation in meaningful life roles, activities, and environments that hold significance for Māori (Boland et al., 2020).

Culturally informed device design

The findings indicate that design and functionality are pivotal in facilitating effective and culturally responsive robotic rehabilitation for Māori following stroke, offering clear guidance on design requirements applicable to a range of rehabilitation technologies. Participants expressed concern that Māori with stroke may experience whakamā when using equipment that draws attention to physical impairments (Dyall et al., 2008). Whakamā undermines the person's mana and may lead to feelings of disconnection, vulnerability, social isolation, and a decline in hauora (Kidd et al., 2013). Designing rehabilitation devices with a discrete and subtle aesthetic could

minimise such attention. Beyond appearance and aesthetics, participants highlighted the importance of the materials used to construct devices, recommending natural-looking materials. While this concept remains underexplored in technology design, recent research by August (2024) explored the potential of clay, wood, or plant-based filaments in 3D-printed prosthetics for Māori amputees. This research demonstrated the potential for such materials to enhance both functionality and cultural alignment by fostering a deeper connection between the material's physical properties and origin, and the device's purpose. Furthermore, using sustainable or recyclable materials aligns with values of *kaitiakitanga* (environmental guardianship), as reducing waste and enhancing biodegradability could improve user acceptance and engagement with devices (King-Hudson et al., 2023).

To support Māori in exercising *Tino rangatiratanga* (Theme 5) over their rehabilitation journey and use of technology, it is crucial for devices to be user-friendly, safe, and support independent use. Mechanisms enabling devices to be donned and doffed independently, having minimal set-up time, and incorporating safety features such as emergency stop buttons and ability to calibrate a safe range of motion could enable independent use (Arntz et al., 2023; Bessler et al., 2021). Participants emphasised that while devices should be designed to minimise reliance on whānau for setup, devices also present opportunities to foster *Whanaungatanga* (Theme 4). Encouraging relationships through features like multiplayer games could promote whānau involvement in a supportive and engaging context (Wilson et al., 2022) and have also been shown to both enhance motivation and engagement (Lohse et al., 2013) and increase motor and cognitive performance (Pereira et al., 2021). In discussing *Hononga* (Theme 3) and connection to meaningful goals, participants emphasised that devices require the functionality and robustness to enable performance of functional activities, and to be adaptable for use in meaningful environments beyond conventional rehabilitation settings, such as outdoors, visiting marae (meeting grounds) or urupā, or during activities related to whenua (Marques et al., 2021). Lastly, devices could support connections to language and culture by incorporating auditory and visual feedback, instructions, and other features in te reo Māori. This could be particularly significant for Māori patients with aphasia, who may lose the ability to communicate and feel disconnected from their language (McLellan et al., 2014).

Strengths and limitations

A key strength of this study lies in the use of a Māori-centred approach, which shaped both the research process and findings. By prioritising *whanaungatanga*, meaningful connections were fostered within the research team, and with participants, creating an environment of trust that enabled participants to share more nuanced perspectives (Boardsworth, 2024). The comprehensive member-checking process upheld the project's core values and supported active participant involvement. For example, in response to feedback, the original kupu (word) for Theme 5, was revised from 'Rangatiratanga,' to 'Tino rangatiratanga,' exemplifying the participants' own rangatiratanga in shaping

the research. Use of a Māori-centred approach also generated insights that may not have emerged using Western-centric methodologies. For instance, incorporating inquiry into the concept of *taiao* (natural environment), as depicted in the Meihana model (Pitama et al., 2014), led to data that emphasised the importance of using robotic rehabilitation devices in meaningful environments and spaces, particularly those connected to whenua and identity. These insights challenge conventional practices of restricting device use to traditional clinical settings, offering a deeper understanding of the cultural and contextual factors that could enhance the relevance and effectiveness of rehabilitation technologies. However, several limitations should be acknowledged. While insights from Māori rehabilitation therapists provide valuable, culturally grounded insights, they cannot substitute for the lived experiences of Māori stroke survivors and their whānau (Ingham et al., 2022). To ensure health technologies are not only clinically effective but also culturally safe and mana-enhancing, it is essential to prioritise the voices of Māori and their whānau in future research. Directly engaging with those with lived experience of stroke is critical to addressing inequities meaningfully and advancing the development of culturally responsive rehabilitation technologies. As per qualitative research, the results are not intended to be representative. Instead, we offer nuances that draw upon the richness of participants' lived experience (Vasileiou et al., 2018). The COVID-19 pandemic meant three interviews were conducted online rather than in person; however, the researchers ensured Zoom interviews included dedicated time for *whanaungatanga* to facilitate the deep, connection-based discussions central to relationship building and *tikanga*. Finally, the visual prompts used were originally developed for non-Māori therapists and did not explicitly reflect te ao Māori concepts or contexts; culturally tailored prompts may have elicited richer insights. These limitations underscore the need for future research that includes a broader range of Māori voices and prioritises culturally informed rehabilitation technology design.

CONCLUSION

This study advances understanding of cultural perspectives on robotic devices for upper-limb stroke rehabilitation, drawing on the invaluable insights of Māori rehabilitation therapists. Embedding principles of *Hononga*, *Whanaungatanga*, and *Tino rangatiratanga* into the development and implementation of rehabilitation technologies could lead to solutions that are not only clinically effective but also culturally meaningful for Māori people who have had a stroke. These findings offer guidance for designers, engineers, and therapists aiming to create equitable, user-centred rehabilitation technologies that reflect Māori values and aspirations. Without change, current practices risk reinforcing existing healthcare inequities. Collaborative efforts among healthcare systems, therapists, and technology developers are essential to ensure innovations support inclusive, equitable, and effective rehabilitation for all stroke survivors. This study underscores the transformative potential of engaging diverse perspectives in rehabilitation technology development to challenge conventional approaches and reduce the risk

of perpetuating health disparities, while shaping a future in which rehabilitation technology is grounded in cultural responsiveness and equity.

KEY POINTS

1. Māori stroke rehabilitation therapists emphasised the significant challenges Māori and their whānau encounter within the healthcare system during stroke recovery.
2. Integrating *Hononga*, *Whanaungatanga*, and *Tino Rangatiratanga* creates opportunities to implement robotic rehabilitation in a meaningful and mana-enhancing way.
3. Stroke rehabilitation therapists should consider their role in providing culturally safe practice while adapting to future innovations through the use of culturally responsive technology.

GLOSSARY

Aotearoa	Land of the long white cloud; New Zealand
Hākari	Provision of food or a feast to demonstrate hospitality and mana
Hapū	Subtribe/cluster of extended families
Hauora	Holistic health and wellbeing
Hinengaro	Psychological and emotional wellbeing
Hononga	Connection/union/bond/link
Hui	Gathering/meeting/assembly, central ritual of encounter
Hui process	Framework to guide clinical interactions and engagement with Māori
Kaitiakitanga	Guardianship and protection of the environment
Kanohi ki te kanohi	Face to face
Karakia	Ritual chant/incantation/prayer
Kaumātua	Respected tribal elder and leader
Kaupapa	Topic/purpose/matter for discussion/agenda/project/initiative
Kaupapa Māori	Māori approach/ideology/topic/customary practice
Koha	Gift/present/offering/donation/contribution
Kuia	Elderly woman/grandmother/female elder
Kupu	Word/vocabulary/terminology
Mana	Power/status/prestige/inherent dignity
Manaakitanga	Respect and care/generosity
Māori	Indigenous people of Aotearoa New Zealand (a heterogenous group with distinct understandings of language, culture, and customs dependant to hapū or iwi)
Māori-centred	Research approach informed by Kaupapa Māori principles and Māori people and experience, may incorporate both Māori and non-Māori research methods
Marae	Ancestral grounds, sacred space of communal or social gathering
Mātauranga Māori	Knowledge systems/wisdom
Meihana model	Clinical framework and assessment tool for Māori that considers the individual, support networks, environment, and wider societal issues
Mihimihi	Official speech of greeting/acknowledgement
Mirimiri	Spiritual and physical healing technique
Mokopuna	Descendant/grandchild
Ngā mihi nui ki a koe	Giving thanks
Pepeha	Formulaic expression/tribal saying (specific way of introduction reflecting ancestral connections, whakapapa, people, and places of significance)
Poroporoaki	Concluding an encounter/to take leave/farewell
Rongoā Māori	Traditional Māori healing system
Taiao	Physical environment
Tāne	Man/male
Tauīwi	Non-Māori people of Aotearoa New Zealand
Te ao Māori	Māori worldview
Te reo Māori	Māori language
Tikanga	Correct procedure(s)/cultural practices (expression of Māori values and practices informed by traditional Māori knowledge)

Tinana	Physical health and functioning of the person
Tino rangatiratanga	Absolute sovereignty/autonomy/self-determination/control
Urupā	Cemetery or burial site
Wahine	Woman/female
Wairua	Spirit/soul/essence/feel/mood/atmosphere
Whakamā	Shame or embarrassment
Whakawhanaungatanga	Process of establishing relationships
Whānau	Extended family and community
Whenua	Land

DISCLOSURES

The study costs were funded by a summer studentship scholarship provided by the Auckland University of Technology. There were no conflicts of interest that may be perceived to interfere with or bias this study.

PERMISSIONS

Ethical approval for this study was obtained from the Auckland University of Technology Ethics Committee (AUTC), reference number 18/384. Ongoing, informed consent was obtained from all participants. No other permissions were required.

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CONTRIBUTIONS OF AUTHORS

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Appendix A

INTERVIEW GUIDE AND QUESTION LIST

Topic	Interview questions/guideline
Exploring participants' experiences	<p>Can you tell us about your experience providing stroke rehabilitation in New Zealand? What about with Māori patients? How do you tailor rehabilitation to meet their needs? Can you tell us about a positive experience/interaction you have had with a Māori patient? What made it successful/positive?</p> <p>Can you tell us about your experience of being a Māori therapist working in New Zealand? What are some of the challenges? What are the positives of being a Māori therapist?</p> <p>What is your experience of using technology in your practice? Can you tell us about how you use or don't use technology in your practice?</p> <p>What is your experience of using robotics in your practice? Are you familiar with rehabilitation robotics? What have you seen/heard/read about?</p>
Responding to image elicitation prompts	<p>Can you describe what you see in this picture? What makes you think/feel/say that?</p> <p>What would be the value or limitations of this device in your practice? How would you improve this device? Can you think of a situation/patient groups/one of your patients this device might be helpful for?</p>
Questions framed by the Meihana model	<p>Can you think of a Māori patient who you have treated who may have benefitted from using a device such as the above? Tell me more about why/why not?</p> <p>What would a device need to be, look like, or do in order for it to be beneficial for Māori patients? What kind of support do you think Māori patients would need in order to use a device? What about their whānau?</p> <p>What kind of places can you see devices being used? Does the setting determine what type of device is used, or its purpose?</p> <p>How can a device strengthen someone's wairua, or spiritual connection to other people (whānau), or to a place (whenua)?</p> <p>What would need to happen for someone to develop a connection to an object such as a device? How can a device strengthen social connectedness?</p> <p>What level of function (mental/cognitive, physical) would a patient need to have in order to benefit from using a device?</p> <p>What would a device need to do/be/look like for you to consider using it in your practice? What would your ideal device look like? What does it do?</p> <p>What support would you as a therapist need to implement devices?</p>