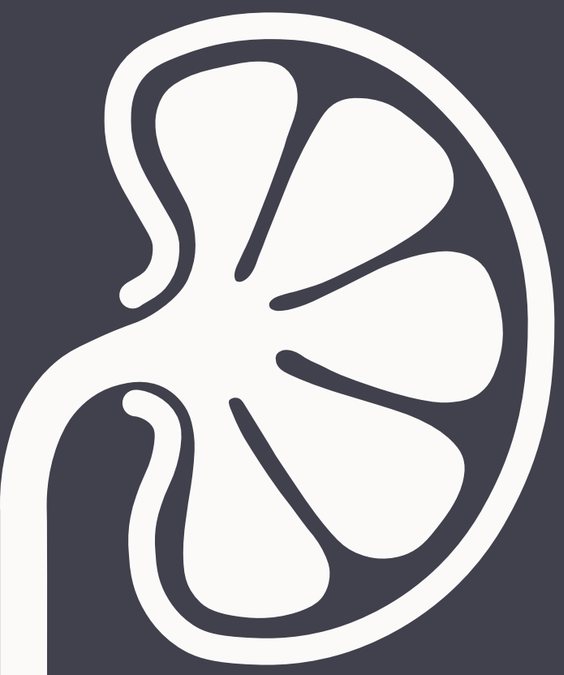
Beyond the Clinic

Industrial Design and its role in improving patient and caregiver confidence in home dialysis administration.

Tadhg Cullinane



Executive Summary

Healthcare is experiencing a rapid shift from the hospital to the home, offering patients with chronic conditions greater autonomy, whilst introducing a new set of complex challenges. Dialysis is an essential treatment for those with End Stage Kidney Disease and exemplifies this shift in treatment modalities, illustrating both the potential and the barriers in transition. While home dialysis reduces strain on the healthcare system and improves quality of life, uptake remains low due to technical difficulties, physical demands, and emotional burdens of treatment. This project aims to address these barriers by improving patient and caregiver confidence and comfort, supported by a learning model that empowers users with knowledge and reassurance. This research draws on both clinician insights and patient experiences to identify opportunities for design-led interventions that make home dialysis safer, simpler, and more supportive of everyday life.

Word Count - 4,150

Authenticity Statement

This is to certify that to the best of my knowledge, the content of this report is my own work. This report has not been submitted for any subject or for other purposes. I certify that the intellectual content of this report is the product of my own work and that all the assistance received in preparing this report and sources have been acknowledged.

Your name: Tadhg Cullinane
Date: 06/09/25

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Your name: Tadhg Cullinane
Date: 06/09/25

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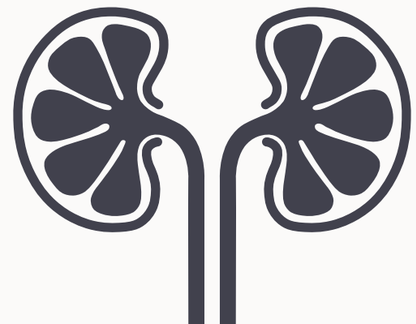

01.

Introduction

Background

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Glossary of Terms

CKD	Chronic Kidney Disease
ESKD	End Stage Kidney Disease
KRT	Kidney Replacement Therapy
HD	Haemodialysis
PD	Peritoneal Dialysis
AVF	Arteriovenous Fistula
AVG	Arteriovenous Graft
CVC	Central Venous Catheter
VA	Vascular Access
Bacteraemia	Bacteria found in the bloodstream
Peritonitis	Peritoneal membrane infection

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Introduction

As vital organs, the kidneys filter blood, removing toxins and waste products which are then excreted from the body as urine (Ausmed, 2025). Chronic Kidney Disease (CKD) is a long-term progressive loss of these vital functions, which, if left unmedicated, can progress rapidly to End Stage Kidney Disease (ESKD) (AIHW, 2024). At this stage, the kidneys can no longer sustain life, meaning intervention via Kidney Replacement Therapy (KRT) becomes essential for survival (AIHW, 2024). When pre-emptive transplants are not viable, dialysis is the most common form of treatment for ESKD. In Australia, as of 2024, 1,800 people were waitlisted for a kidney transplant, with a further 14,000 relying on dialysis (Donate Life, 2024) (Australian Government Department of Health, Disability and Ageing, 2025).

Because of its nature, CKD within Australia is both highly prevalent and underdiagnosed. Characteristically, CKD causes few to no symptoms until 90% of kidney function has already been lost (Better Health Channel, 2018). As a result, many only encounter the disease at its most advanced stage (ESKD), when KRT (dialysis) or transplantation is the only option. Dialysis, therefore, represents a worthwhile area for innovation to address systemic burdens and overall patient experience. The research conducted is uniquely positioned to view complex health-related challenges through a design lens, to improve dialysis administration within the home environment. A key component of this research involves patient, caregiver, and clinician perspectives to better align design outcomes with those directly affected.

Background

Prevalence

CKD is widespread, underreported, and often only recognised at late stages, making dialysis a critical system that is worth improving. Within Australia in 2022, 83% of people receiving dialysis underwent Haemodialysis (HD), whilst 17% received Peritoneal Dialysis (PD) (AIHW, 2024). In a broader context, haemodialysis accounts for 90% of all dialysis treatments worldwide (Charmaine et al., 2025) and is favoured over PD in most cases, due to increased infection risks associated with PD. Furthermore, the potential for peritoneal membrane failure may necessitate a switch back to HD (Ito et al., 2024), which, from a clinical standpoint, involves patient re-education and additional physical and emotional burden.

Access

As reflected in the literature, haemodialysis is confronting from both a physical and psychological standpoint. Themes continue to emerge that highlight patient anxiety and fear in relation to early phases of the treatment. Haemodialysis itself relies heavily on vascular access commonly in the form of an Arteriovenous Fistula (AVF), Arteriovenous Graft (AVG), or Central Venous Catheter (CVC) (Stegmayr et al., 2020). This Vascular Access (VA) is the source of many publications pertaining to increased infection risks, a decrease in patient confidence, and fears related to managing treatment independently.

Themes and Emotional Barriers

Associated pain with vascular access is a severe and common symptom in patients receiving HD. A primary study involving 1,343 dialysis patients aged 18 and over identified six key themes when it came to treatment-related pain (Zhang et al., 2020). These included ‘all-consuming agony, suffering in silence, provoking fear of treatment, preventing life participation, coping aided by connection with others, and developing awareness, assertiveness, and self-reliance’ (Zhang et al., 2020). As revealed in the literature, further studies have been conducted which point to consistent themes identifying few variations in results (see figure 01).

Comparison Table: Demonstrates theme similarities across seperate studies

All consuming agony	Draining cognitive capacity, exacerbating other symptoms	Bodily intrusion, fear of cannulation, threat of complications and failure, unpreparedness, and dependence on a lifeline	**Heightened vulnerability**
Suffering in silence	Surrendering to the inevitable, ignored or dismissed, hiding symptoms to protect others	Imminence of dialysis therapy and existential thoughts	**Confronting decisions and consequences**
Provoking fear of treatment	Resistance to cannulation, avoiding dialysis, anxious from witnessing other patients in pain	Bonded to a machine, internal abnormality, and constant maintenance	**Mechanisation of the body**
Preventing life participation	Preventing fulfilment of valued roles, depleting the will to live	Preserving normal appearance, visual reminder of disease, and avoiding stigma	**Disfigurement**
Coping aided by connection with others	Shared understanding among patients, comforted and supported by others	Physical incapacitation, instigating family tension, wasting time, and added expense	**Impinging on way of life**
Developing awareness, assertiveness, and self-reliance	Procedural vigilance, finding strategies to minimize pain, bodily understanding and knowing thresholds, positive thinking	Task-focused control, advocating for protection, and acceptance	**Self-preservation and ownership**

FIGURE 01

Infection

Access-related infection for PD and HD remains a significant risk across each modality. Access sites act as portals of entry for bacteraemia and peritonitis, with studies suggesting that for every 100 patients, approximately 42 infections occur in PD, and 30 in HD (C. Lam et al., 2024).

“Infection is the leading cause of hospital admission and the second most common cause of death in patients receiving dialysis.”

(C. Lam et al., 2024).

While different risks exist across both modalities, the literature shows consistency. HD generally offers longer treatment durability and fewer complications in clinical settings compared to PD. Furthermore, studies continue to emerge that highlight the significant advantages of home-based dialysis, identifying that home HD is associated with lower mortality, hospitalisation, and technique failure (Todorov et al., 2025) (D. Weinhandl et al., 2015). The timely emergence of this literature reflects the consistent push for home care, necessitating innovation to reduce adverse risks and strengthen patient and caregiver confidence.

Benchmarking

Overview

Understanding the current landscape of products that support dialysis administration in a home and clinical setting is vital in identifying gaps and opportunities for innovation. Due to the complexity of the system at hand and the wide array of products currently addressing various elements within the system, the project solution must sit within existing frameworks. Given the strict standards and contextual limitations of designing within health, benchmarking was completed to identify a scope for innovation appropriate to these constraints.

Innovation vs Improvement

It is important to note that while ‘new’ innovation in this context falls outside the scope of the project, industrial design-led improvements to existing and emerging technologies represent a clear opportunity. A human-centered focus on interface clarity, physical interaction, portability, and aesthetic integration will be vital to improve usability, emotional experience, training, and home integration. By benchmarking existing and emerging products, gaps in the criteria outlined will provide areas for meaningful improvement. Innovations in dialysis can be broken down into three key categories. These are, Wearable Artificial Kidneys (WAK), existing and emerging home haemodialysis machines, and home peritoneal dialysis machines.

Wearable Artificial Kidneys

The WAK is a disruptive and emerging technology that aims to provide continuous, low-volume dialysis in a truly portable format. Major improvements have already been made within this space, with the emergence of the WAK 3.0, which is currently a clinical prototype undergoing early-stage trials (National Kidney Foundation, 2018) (Today’s Medical Developments, 2021).

While the WAK 3.0 is currently pre-commercial, it promises future paradigm shifts and a solid area for future innovation.

Existing and Emerging Home Haemodialysis Systems

Innovations within home haemodialysis have largely emerged in the US and Europe, with companies such as Quanta, Outset, Next Kidney, and Fresenius leading the way (See Figure 02). With prices for their respective systems ranging from 15,000 to 25,000 USD, each company has prioritised compact design, simplified operations, and improved patient autonomy. Although systems are at different stages of commercialisation, they represent a confident push towards more suitable

Home Peritoneal Dialysis Systems

While Australia’s progress in the haemodialysis market has been slow on a global scale, within the PD space, there have been significant breakthroughs compared to HD. With a focus on low-cost, water-efficient PD systems for rural and remote settings like the EM-POC, developed by Ellen Medical Devices (Talbot et al., 2025). Other companies, such as Vantive, are advancing home Automated PD systems (APDs) to increase autonomy in a home setting by administering treatment overnight (Vantive Commercial, 2025). These innovations suggest that PD systems are moving towards accessible and sustainable design, enhancing patient comfort and autonomy, whereas home HD remains constrained by complexity, size, and cost (See Figure 03).

Thus, reimagining home HD technologies within an Australian context uniquely positions Industrial Design to have a high impact within this space.

Home Dialysis Systems

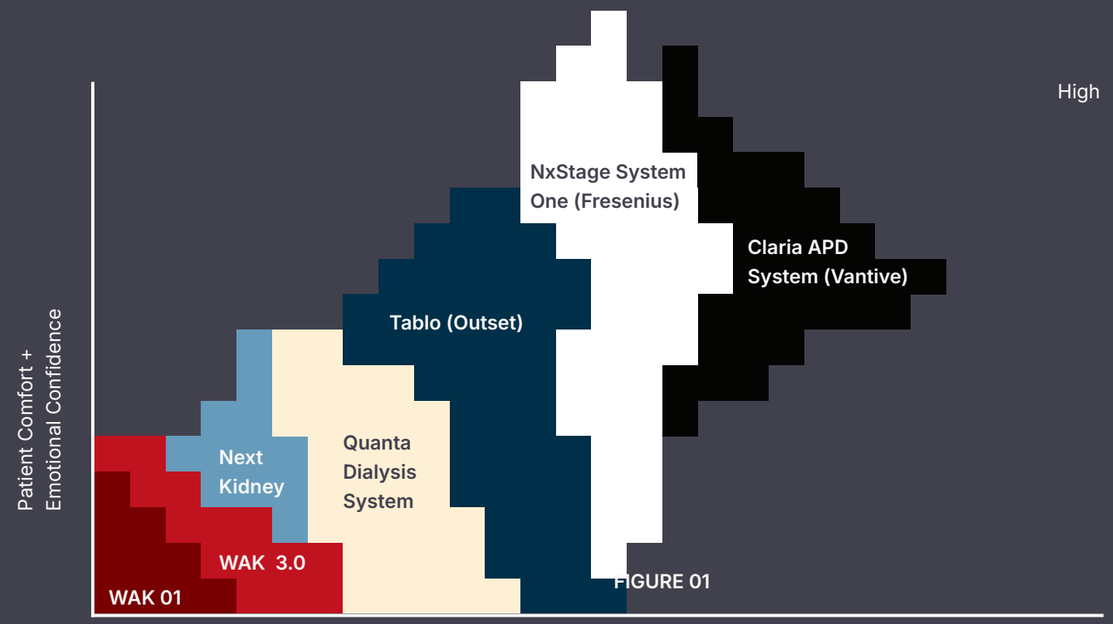


FIGURE 01

FIGURE 02

Matrices

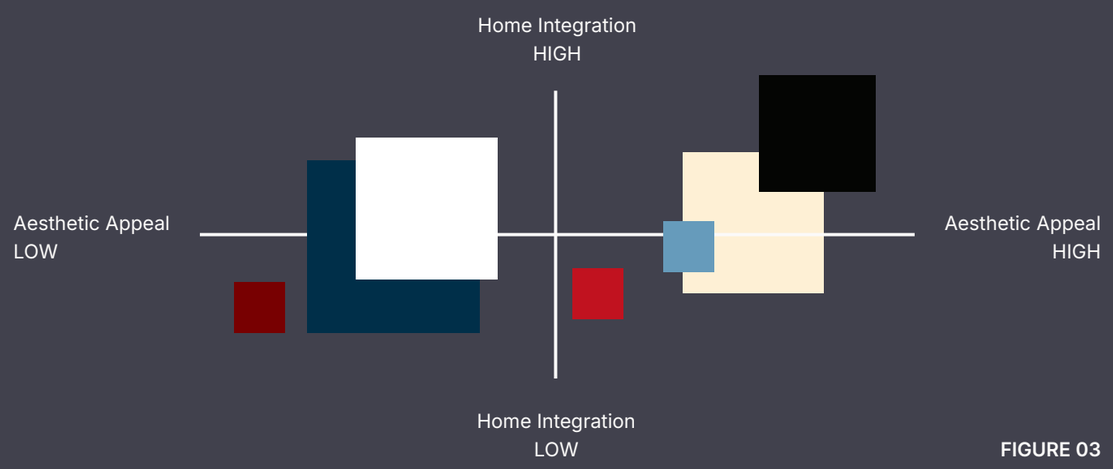


FIGURE 03

Refer to appendix for interpretation

Australian Market Context

In an Australian context, there is a gradual strategic shift from clinical to home-based HD. With strong institutional support and government subsidy frameworks, federal and state programs are offering up to 30,000 AUD per patient per annum to cover home utility expenses and encourage uptake (IMARC Group, 2024). However, the local market, as it stands, remains relatively small compared to the EU and the US, exemplifying current adoption strategies over local innovation due to affordability.

However, with increasing CKD and ESKD cases within Australia, the IMARC group (leaders in global market research) (IMARC Group, n.d.-a), expects the haemodialysis market to reach USD 2,609.93 Million by 2033, growing at 3.70% from 2024 (IMARC Group, 2024). This highlights both a gap and an opportunity with international systems offering proven models to follow, which, given market contexts, Australia is well positioned for.

Benchmarking Table | The best on the market

US EU

Product	Description	Expected Cost	Usability and training needs	Innovation Potential
WAK 01	Portable, battery operated dialysis device under development	Not yet commercial	High training needs, due to wearable format	Very high
WAK 3.0	Next-gen WAK model with automated fluid balancing on a smaller scale	Not yet commercial	High training needs	Very high
Quanta Dialysis	Compact home HD machine with a simplified interface for patients	15,000 - 20,000 USD	Moderate training with a simplified workflow	High - a focus on accessibility
Tablo (Outset)	All-in-one HD systems for home and clinical use	Approx 20,000 USD	Low to moderate training, simpler workflow	High - FDA cleared and widely adopted
NeoKidney (NextKidney)	Portable HD system in devlopment	Not yet commercial	Moderate training expected	High - early stage innovation
NxStage System One (Fresenius)	Widely used home HD system within the US	15,000 - 20,000 USD	Moderate training, but widely supported	Medium - existing market leader (US)
Claria APD System (Vantive)	Automated PD system for home use	8,000 - 12,000	Low training needs with a user-friendly interface	Low - already well established

The table above demonstrates market saturation in the US. While the EU is close behind, Australia lags significantly in dialysis machine innovation, despite its predicted readiness. This highlights a key area for innovation, with solid international models to follow.

Refer to appendix for market trajectory

02.

Methods and Methodology

Analyses and Findings

Methods and Methodology

Overview

Given the dynamic and complex nature of this topic, qualitative research was conducted to gauge patient experiences, alongside clinician perspectives, to draw parallels against what was presented in the literature. To achieve this, two primary research methods were utilised.

An exploratory survey was designed to capture patient and caregiver experiences, developed after secondary research had identified key knowledge gaps. This survey was deployed alongside interviews with three practicing dialysis nurses, as well as one retrospective interview of someone who had worked within the field. To complement clinical perspectives, a further retrospective interview was conducted with a patient who had previously undergone haemodialysis before receiving a transplant, providing personal experience to contextualise these findings. Deploying two methods of primary research allowed for triangulation of the relevant data, enabling a comprehensive understanding of this qualitative inquiry (Carter et al., 2014).

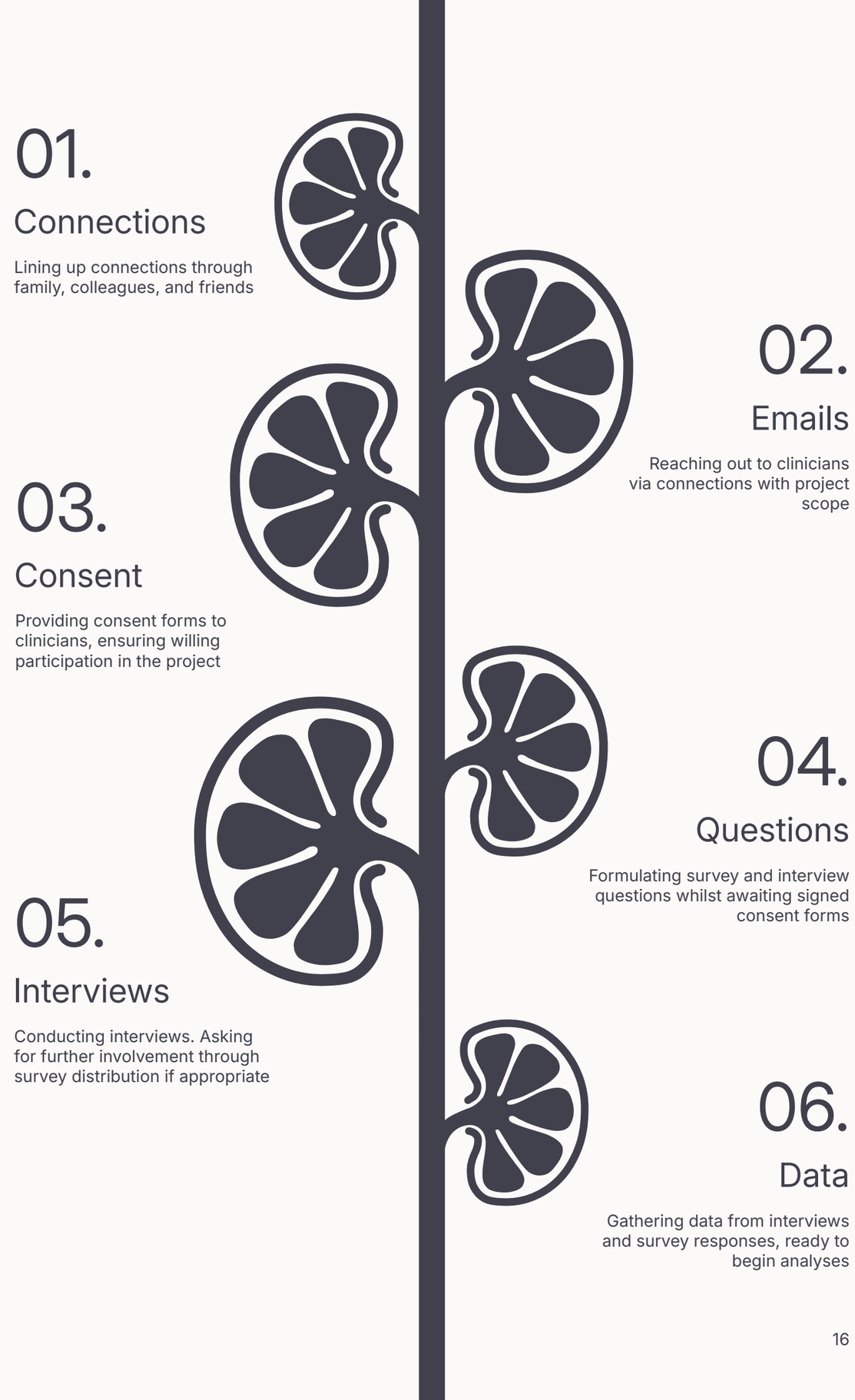
Interviews

Semi-structured interviews were conducted, given their primary benefit of permitting focused questions, whilst giving the investigator the autonomy to explore pertinent ideas that arose over the course of the interview (Adeoye-Olatunde, 2021). Interviewees were recruited via email after being connected to by family, colleagues, or friends. Each participant was recruited based on their relevant ongoing or prior experience.

As outlined in email correspondence, participants received three documents: a project synopsis outlining the aims of the project, an information sheet explaining how collected data would be used, and reasons for recruitment, as well as a consent form to confirm agreement and address any questions. Consent forms were signed and returned prior to commencing interviews. From there, the modality of the interview (Zoom or phone call), as well as date and time, were confirmed.

A key aim of interviews was to capture perspectives across different specialties to mirror the breadth of insights identified in secondary research. To demonstrate this spread, the following participants were recruited. P1-C and P2-C (P = Participant | C = Clinician) are both practicing dialysis nurses within QLD Health, currently working for Capricorn Coast Renal Services. P3-C has had prior experience (20+ years) as a practicing nurse, working closely with renal services and dialysis administration teams as part of the National Health Service, Victoria. Lastly, P4-C is the Nurse Unit Manager for Dialysis at Home, a branch of Western Health's Sunshine Hospital.

The modality, confirmed before commencing each interview, was phone calling. While there may be some disadvantages to this style of interview, the absence of visual cues, representing a loss of contextual non-verbal data (Novik, 2011), there are many advantages to this modality. Telephone interviews may result in respondents feeling more relaxed, allowing them to share otherwise sensitive information (Novik, 2011), potentially leading to higher-quality data in some cases.



Methods and Methodology

Surveys

Patient involvement in this project was important to the quality of the research, to present both sides, and to contextualise barriers identified in secondary sources. However, given the sensitivity of the topic and the physical and emotional tolls of treatment, surveys were used as a less invasive form of data collection. Dispersing the surveys through primary interview connections allowed for patient involvement as deemed appropriate, in an environment that was familiar. This kept data collection ethical and professional.

Strengths

Running the survey in the background enabled the researcher to complete interviews and secondary research whilst autonomously collecting data. Using Qualtrics for its built-in data analytics helped instantly visualise responses as percentages or bar graphs, which streamlined the analysis process. In a general sense, survey data has the potential to be unreliable, as answers are anonymous and participation is open to anyone with the link. However, given the method for deployment, respondents were either patients receiving treatment, or a caregiver or family member.

Weaknesses

Question structure and quality of responses are another area that has been suggested, especially regarding medical surveys, as a hindrance to relevant data collection (Zimba et al., 2023). All efforts were made by the researcher to ensure questions related directly to current treatment and were highly relevant, given the project's aim. However, the quality of responses could be questioned due to the number of multiple-choice questions and the voluntary nature of short responses.

Analyses and Findings

Interview Findings

Interview recordings were first transcribed using Descript.Ai. Transcriptions were thematically analysed as outlined in Virginia Braun and Victoria Clarke's 'Thematic Analyses, A Practical Guide' (Just another University of Auckland Blogs Sites, n.d.). This helped extract themes and codes, which were categorised into four key groups: Knowledge and Practice, Physical Demands, Emotional Experience, and System and Environmental Factors. Themes that emerged were compared across participants within their own category, and then cross-compared to identify similar themes emerging in different categories. Findings are outlined as follows.

Knowledge and Practice

Clinicians (P1-P4) repeatedly emphasized that confidence and independence in home dialysis can be built through training, trial runs, and ongoing education. However, "complacency" within a home setting was identified as a barrier that can decrease confidence and skill over time (P2, P3). To ensure patient safety and skill retention, suggestions of competency checks, training protocols, and simplified learning tools (P3) highlighted the need for more systematic educational support.

"It comes down to education, from the staff... and getting the patients to meet objectives." (P1)

"The challenge is complacency... they get used to doing the same thing over and over again, so they get a little less good at it." (P2)

"Simplifying, the complexity of the process from wo to go... which would enable more individuals to close that knowledge deficit gap." (P3)

Physical Demands

The cannulation process was identified by all participants as a major source of fear and physical challenge, with anxiety about self-needling and managing alarms emerging as consistent themes. Stenosis, vessel occlusions, and infections were highlighted as key root causes (P1, P2, P4). In some cases, the physical demands of setup and supply management were a hindrance to home care (P4), as well as dizziness and fainting during treatment (P5), raising concerns about patient safety when alone. These physical demands underline that training cannot address all challenges when complications arise.

"The cannulation process... we've had patients with, phobias of needles... if say their blood pressure drops, that can be quite scary for them" (P1)

"Physical ability. Some people are just not able to do it physically for different reasons. And if they don't have a support person, then they can't do it on their own." (P4)

" I get... dizzy and... fainty sort of, and then I'd passed out a couple of times during dialysis." (P5)

Emotional Experience

Many emotional factors strongly influence a patient's choice to pursue home dialysis. It was identified that if patients were motivated, employed, or seeking independence, they embraced learning opportunities (P2). However, feeling overwhelmed, fearful of complications, and not wanting to "bring the disease home" also contributed to this home treatment barrier (P4). Other themes included the presence of medical equipment in the home environment and the psychological weight of managing a life-sustaining treatment. P2 and P4 expressed that family and caregiver support increased confidence for some, whilst others prefer the security and predictability of clinical care, at the cost of autonomy (P3, P5).

"The ones that do move forward have a greater motivation. So they're the people that still work... they've got a greater motivation to be at home." (P2)

"The first one is usually not wanting to take the disease home. Some people, it's much better for them to just go to a hospital, get things done and they leave it there" (P4)

"So many patients... are still supported by healthcare professionals, purely because of that gap in comfortability and confidence." (P3)

Environmental Factors

To successfully transition to home care, prerequisites were identified. Plumbing and home adaptations, safety assessments, storage, and the presence of a support person were all vital from an eligibility standpoint (P4, P5). Due to capacity pressure, especially in Victoria, a 'home first' approach is typical (P4). However, clinicians remain cautious about risk management and patient safety in inadequate home settings (P1, P3). It was stressed that training should "start in the clinic, but finish in the home" to bridge the gap between clinical practice and the realities of home treatment (P2, P4).

"We do... [prioritise home first]... especially with the number of dialysis patients as opposed to permanent haemodialysis spots." (P4)

"There is such a demand on the public health service, but we don't want to jeopardize the continuity of care... or put inadvertent risks in place by pushing people out and asking the patient and their family members to take the place of the healthcare professional." (P3)

"One thing that we're focusing on that we're trying as much as we can, is we start off the training in our unit, but we finish it off in the home." (P4)

Analyses and Findings

Survey Data Findings

Survey data was broken down first through Qualtrics' built-in analysis software, allowing the researcher to compile relevant results and compare findings against interview data. While the survey sample size was small, with 13 participants, the responses give insight into the lived experiences of patients and highlighted key themes that align with those presented in broader literature. While this could be viewed as a limitation, a deeper meaning can be extracted from survey responses, given the quantity and quality of data gathered through interviews.

Modality and Access

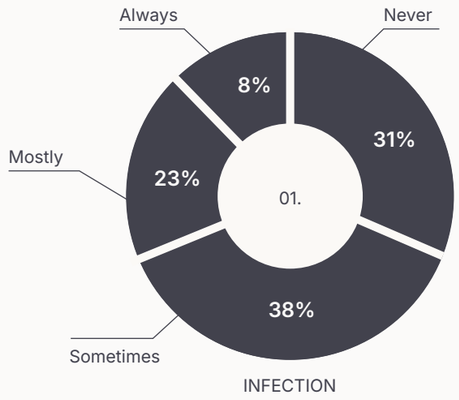
Survey results found that most respondents were receiving clinical dialysis, with 8 on clinical HD, 3 on PD, and 2 already undertaking home haemodialysis. As expected, nearly all haemodialysis patients reported having an AV Fistula, with only 3 reporting CVCs. The remaining 3 respondents had Tenckhoff Catheters, as is common for PD patients.

Support

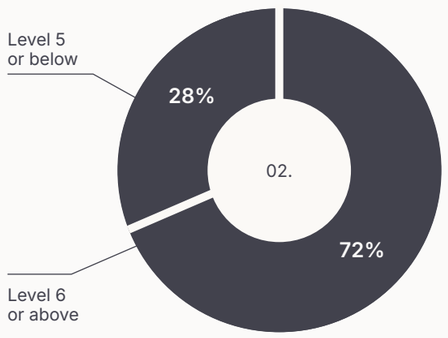
Thirty-eight percent of respondents indicated that a family member or caregiver regularly assisted with their treatment. The survey also allowed caregivers to respond directly, in hopes that additional perspectives on confidence and burden of care could be identified.

Confidence, Training, and Hygiene

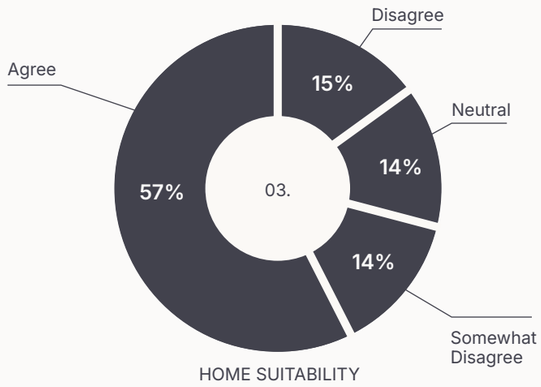
When assessing confidence, results varied. Over half reported being confident (>5 on a 10-point scale)(02.), while the remainder felt less assured. In contrast, infection prevention and hygiene scored more positively. Most rated themselves >6; however, when asked if they had the tools and training to manage complications at home, 2 respondents disagreed, 4 were unsure, and only 7 agreed, suggesting (Figure 04) a need for improved training and education.



INFECTION



CONFIDENCE



HOME SUITABILITY

Emotional Burden

Survey results found that concerns about infection were common, with 4 respondents indicating frequent or constant worry (01.). When asked which aspects of dialysis caused the most anxiety, patients referred to cannulation, infection prevention, order of operations, and drain pain. Troubleshooting alarms and supply prep were also highlighted as stress points, while a minority (1 respondent) reported little or no stress in a clinical setting.

Comfort and Home Suitability

As a key component of the research, patient comfort was assessed regarding day-to-day living with a VA. Most respondents reported little to no discomfort, with only one noting persistent discomfort. Environmental suitability was also positive, with 9 believing their home 'could' support treatment, although 3 disagreed, and 1 was unsure (03.). In terms of training adequacy, 7 respondents rated that their preparedness for home treatment was below average (<5), again, highlighting the importance of ongoing education (Figure 05).

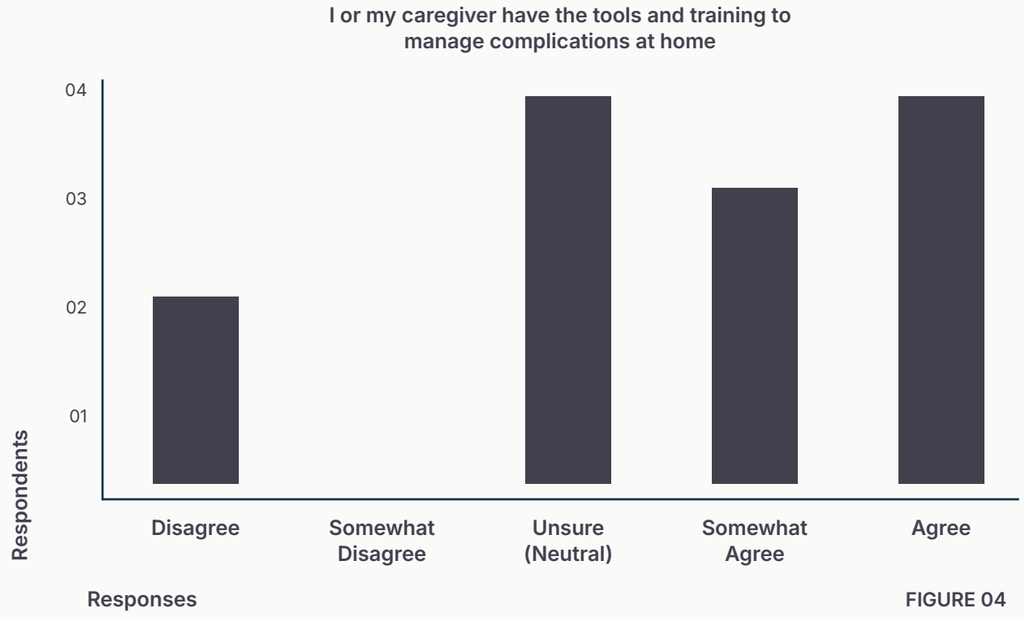


FIGURE 04

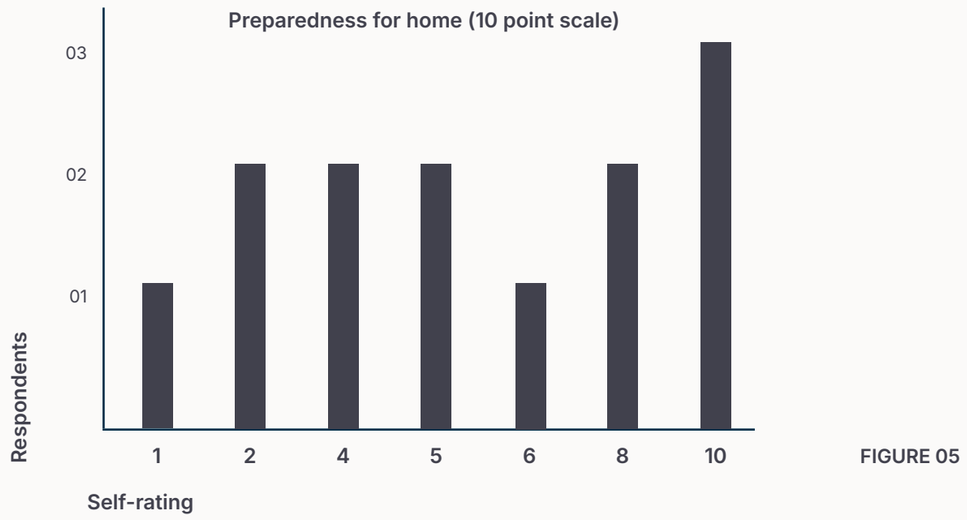


FIGURE 05

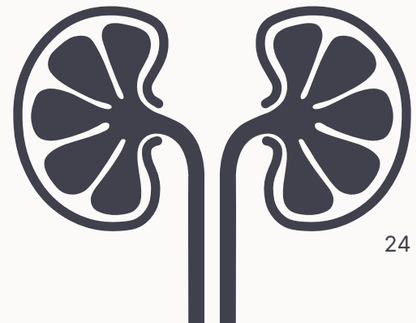
03.

Discussion

Design Implications

Conclusion

References



Discussion

This report aimed to analyse the intersections between patient experience, clinical perspectives, and existing technologies in home dialysis care to understand where innovation could have a meaningful impact. Current literature emphasised the emotional and physical demands of dialysis, as well as the overwhelming complexity of existing systems. Other themes emerged relating to infection control, fears of cannulation, and troubleshooting alarms. First-person research reinforced these findings, whilst providing further meaning and depth, adding layers of nuance around confidence, independence, and the psychological realities of home care transition.

A key insight that emerged across all sources was that while home dialysis does provide greater independence and quality of life, it also shifts physical and emotional burdens onto patients directly, and their caregivers (especially in HD). This was conveyed by clinicians in their recounts of patients disclosing fear, uncertainty, and the emotional weight of managing a life-sustaining treatment in their own living spaces. Other key clinical perspectives related to the steep learning curve of current systems and ongoing infection risks. This aligned with studies suggesting that successful uptake does not hinge on technical proficiency alone; rather, confidence, psychological safety, and usability must be equally present.

Further insights identified barriers in clinical environments, where trust is first established and built between the patient and clinician. From a clinical standpoint, this trust is vital for patient comfort, treatment outcomes, and a consistent routine. However, the complexity of current systems allows for trust to become dependency, forming a psychological barrier for patients who opt for clinical care as a result.

While receiving clinical care suits some, for those who wish to have greater autonomy and normalcy, this approach does not work. It was found that once dependency had been established within a clinical environment, it was difficult for patients to move beyond this setting to a home where greater risks were perceived.

Results after benchmarking revealed that in Australian contexts, current dialysis technologies, particularly HD, remain heavily clinical in design. When placed in a home environment, they increase the need for space and potential environmental adaptations, as well as rigorous training to ensure patient confidence in safe operation. In contrast, the EU and the US demonstrate exemplary models to follow, considering recent advancements that focus on compact, user-friendly systems. In interviews, clinicians revealed that the domestic experience of dialysis, with respect to its emotional toll, spatial intrusion, and perceived risk, remains under-addressed. With strong models to follow and a market trajectory that reflects similar patterns to that of the US, Australia is well-positioned for innovations of its own within this space.

Further, considerable advancements have been made to PD systems through their automation and remote monitoring, reinforced in both the literature and Australian healthcare contexts. This suggests that while there is, of course, room for improvement in PD technology, the more pressing challenge for design lies in HD.

Design Implications

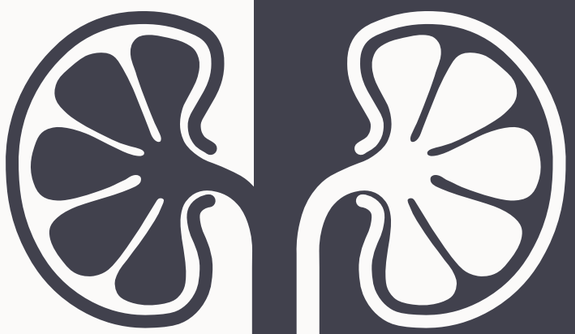
Gaps identified have been reframed through research, not to highlight any lack of technological advancements, but to see them as human-centred design problems. Industrial design is uniquely positioned to bridge the disconnect between clinical functionality and patient experiences. In doing so, usability, emotional comfort, and daily life integration will become the central pillars from which this project will progress. Findings presented point towards opportunities in simplifying machine interfaces, reducing visual and spatial impact, and improving confidence through better training systems and materials.

“Kidney patients are not abnormal people, but normal people in an abnormal situation.”

Gerard Boekhoff (Neokidney Foundation, former dialysis patient)
(NextKidney, 2024)

Design Lens

This project contributes a design perspective to an industry often dominated by medical engineering. The content of this report argues that for an increase in the adoption of home HD to occur, innovation must extend beyond technical performance. The proposed design must prioritise accessibility, patient dignity, and emotional well-being to create an environment that fosters trust, promotes autonomy, and empowers patients.



Non-negotiables

Usability

Clinical training is essential in promoting adoption and building confidence. While a ‘home first’ approach is vital to establish patient autonomy and motivation early, clinical training must still occur. Proposed designs must fit within this existing framework and facilitate the transition from clinical care to home-based treatment. Crucially, caregivers must be involved in the training phase to ease home transition and boost learning retention. Models used in clinical training must remain the same as those administered for home treatment. This will ensure that practical skills developed in a clinical setting transfer directly to the home.

Emotional Comfort

The home reflects a safe and comfortable environment. It was noted that common inhibitors to home treatment involved the emotional burden of bringing current systems into this environment. Aesthetics and ‘emotional design’ must be considered to increase patient comfort, ensuring a willingness to integrate HD machines into home settings. Blending advanced clinical functionality with soft and approachable aesthetics will assist in achieving this balance. Central to this approach is the integration of direct connection lines to clinical staff, through either autonomous system integration or a 24/7 rotational call line available when needed. This will help give patients peace of mind and create a safety net if uncertainty arises. Furthermore, connection to family and caregivers allows for normalcy within a familiar setting.

Daily Life Integration

Patients’ schedules and autonomy reflect key components of a sustainable treatment regime. Structuring built-in schedules for treatment and running times will help build routine and ease integration. These schedules can be developed alongside clinicians to identify acceptable treatment frequency based on a patient’s unique circumstances. It is vital in this approach to note that treatments across patients vary greatly, with certain aspects working for some and not for others. To add to this, different levels of kidney decline require varying treatment volumes and frequencies. By tailoring these factors to the patient, it creates a more personal treatment approach supportive of daily life.

Summary

In summary, Industrial design is positioned in a unique way to facilitate more holistic approaches to home HD treatments that integrate education, emotional support, reliable safety nets, and daily life integration. Thus, improving patient and caregiver confidence in home dialysis administration and treatment sustainability.

Conclusion

This research explored innovation opportunities for home dialysis, combining literature, clinician perspectives, patient experiences, and benchmarked technologies. It was found that while home dialysis offers independence and improves patients' quality of life, the physical, emotional, and practical challenges associated with it limit its adoption and sustainability. Technological advancements in PD have enabled autonomy, facilitated remote monitoring, and have already addressed many barriers within this field. However, with its increasing global prevalence, accompanied by the complexity of current systems, their physical demands, and intimidating nature, innovation in home HD is far more urgent. Findings highlight that moving beyond technical functionality is necessary to make home HD more user-friendly, emotionally supportive, and spatially practical. With patient and caregiver confidence at the forefront, industrial design principles will place a focus on the human experience, as well as form and function. This design lens will reimagine home HD systems to better support family dynamics, balancing clinical excellence with dignity, empathy, and everyday usability.

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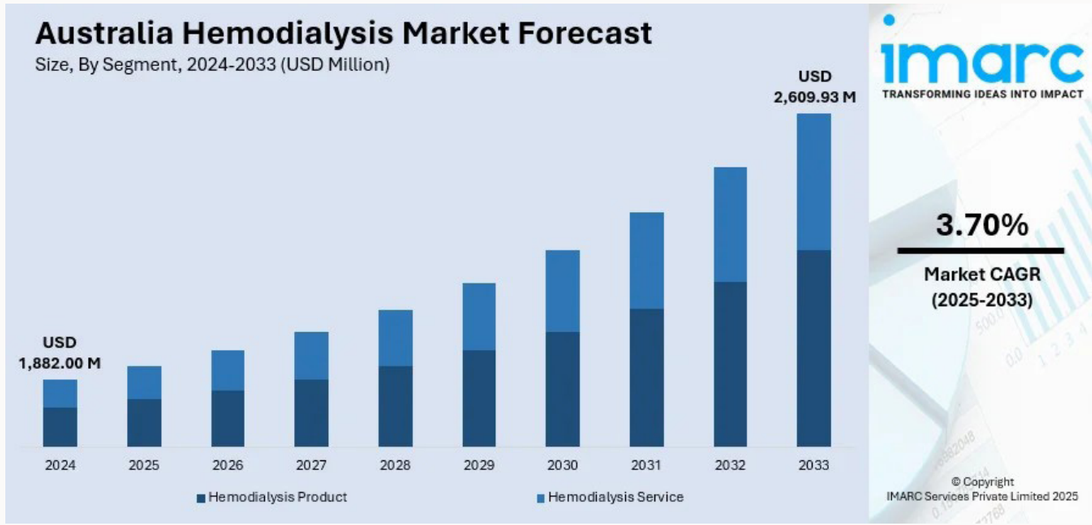
Appendix



(IMARC Group, 2024)

Note - Parts of Appendix have been removed for publication

Tadhg Cullinane

Appendix

Figure 01 shows products as they relate to usability and simplicity, as well as patient comfort and emotional confidence. The scale of more popular models are larger, while non-commercial products or those that are less prominent are smaller. Notice, comfort and simplicity of the PD system seems to trail ahead, due to the innovations within this area. NxStage follows behind due to its small form factor, whilst Tablo by Outset is slightly more prevelant thanks to its clinical adoption rates as well as at home. However, when comparing the Tablo and NxStage, there is a divide when it comes to confidence, largely due to the footprint of the Tablo, and it's slightly more complex interface.

Home Dialysis Systems

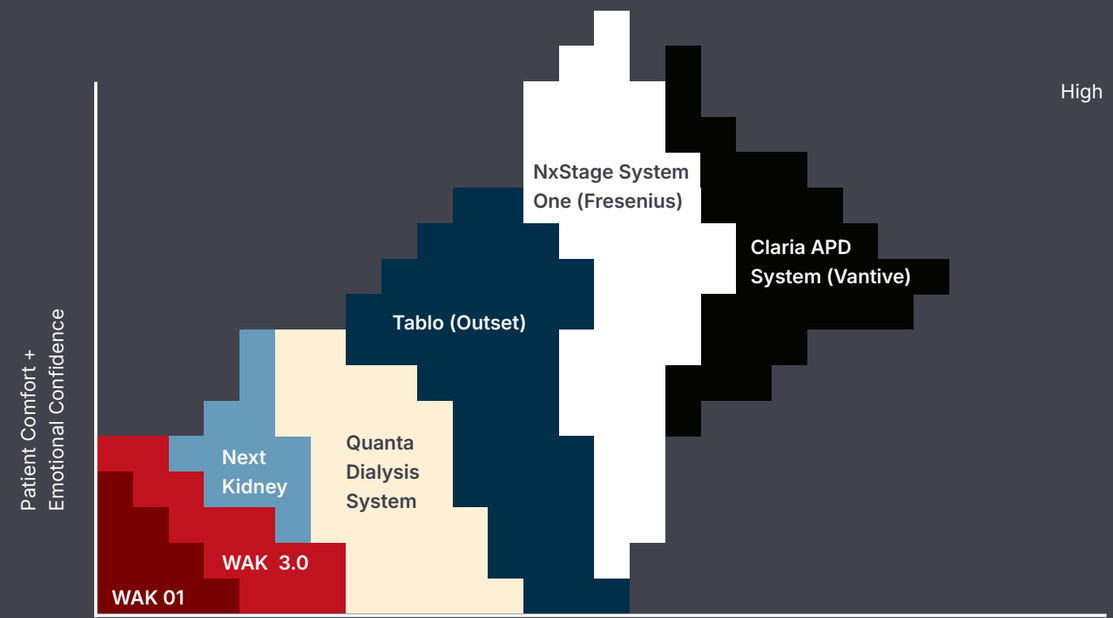
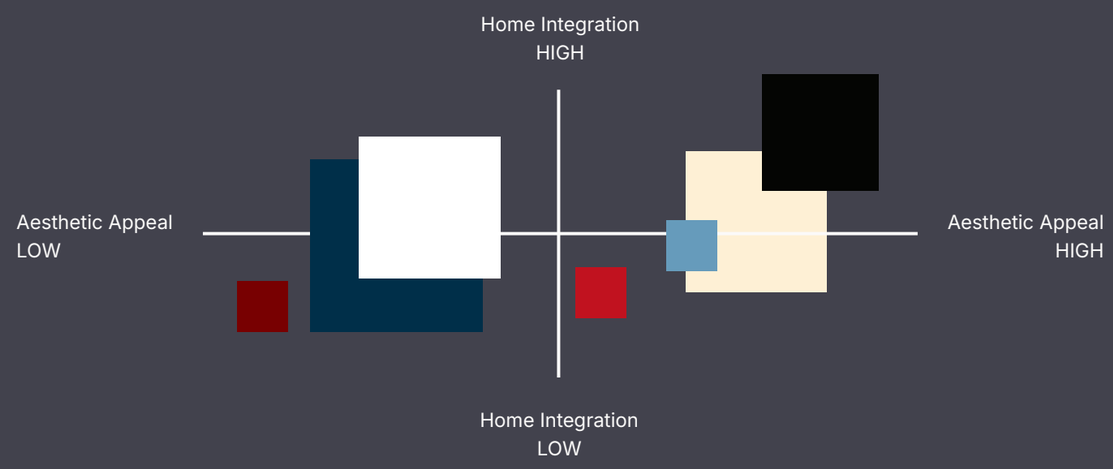
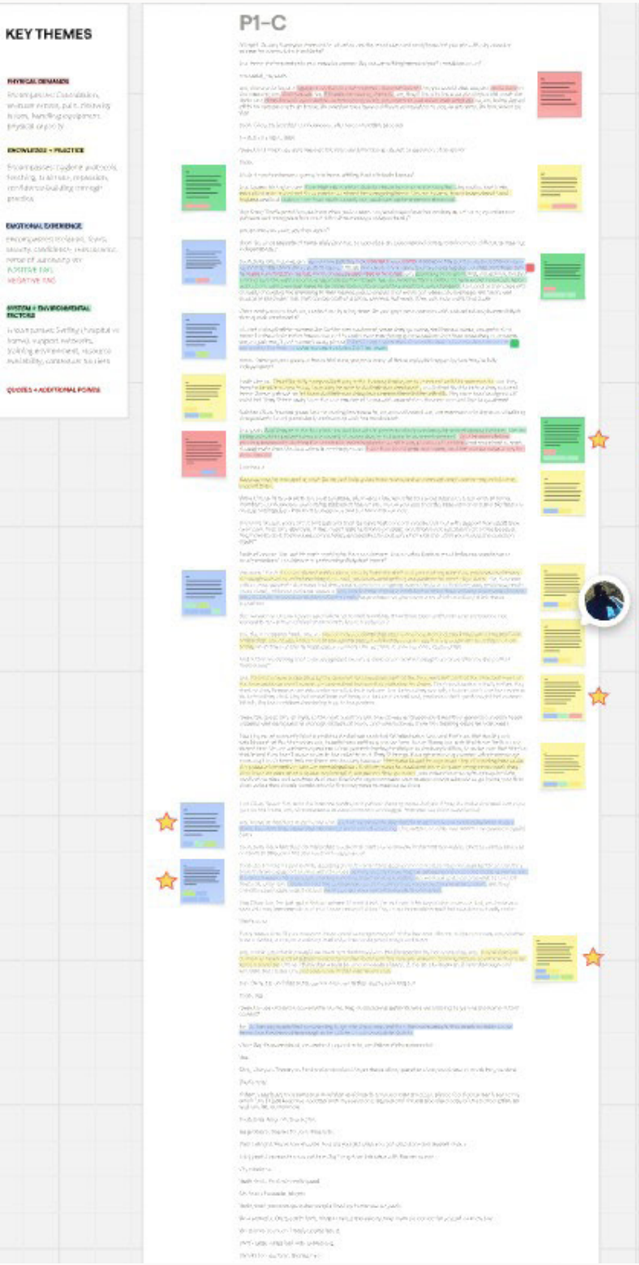


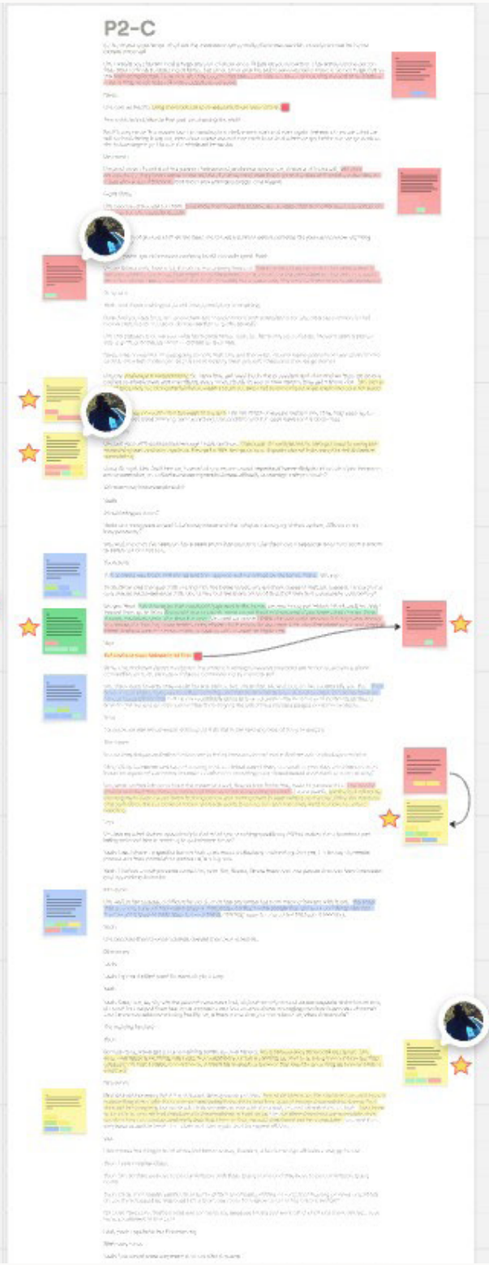
Figure two maps out the same systems in figure one, but in regards to their aesthetics and home integration. Notice the WAK 01/0.3, and the Next Kidney are all smaller - they are non-commercial. While NxStage, scores highly in patient comfort and simplicity, its overall aesthetic appeal and appropriateness for the home, are lower. Again, due to advancements in PD, the PD system is ahead in aesthetics, and home integration, as it is a wearable system. While Quanta scores lower on comfort and simplicity, its overall aesthetics are nice, although could be more 'home appropriate'.

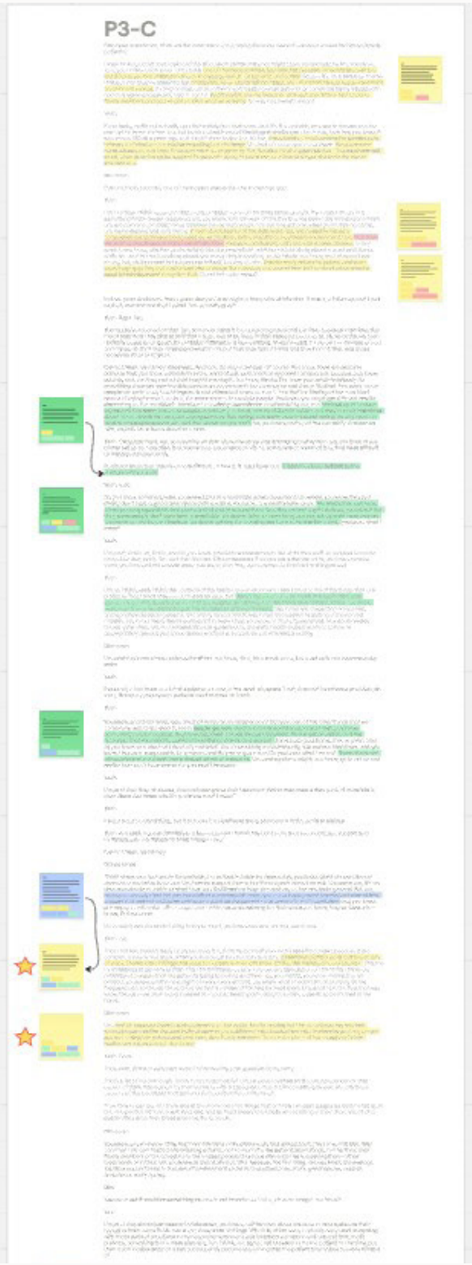
Matrices

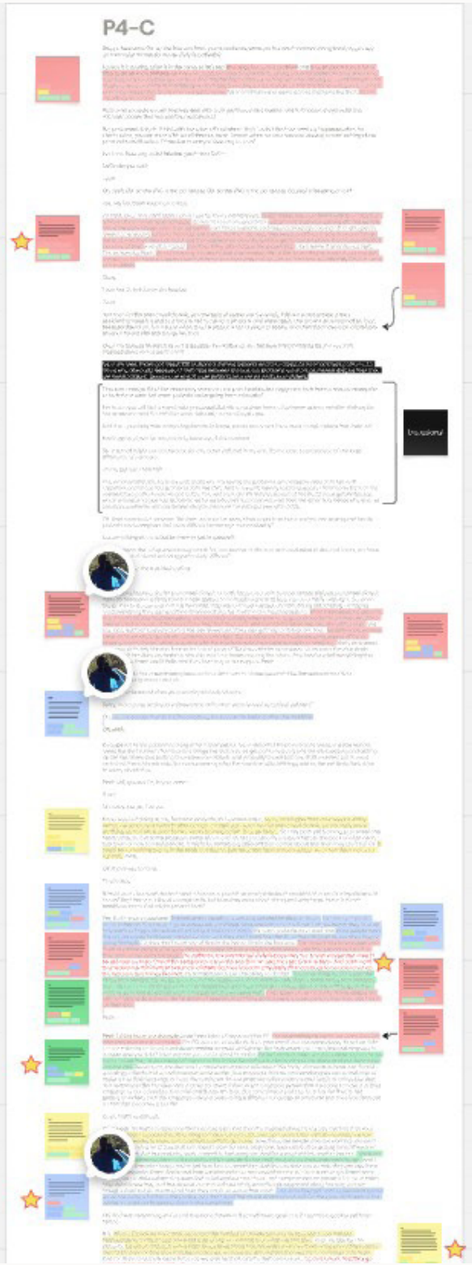


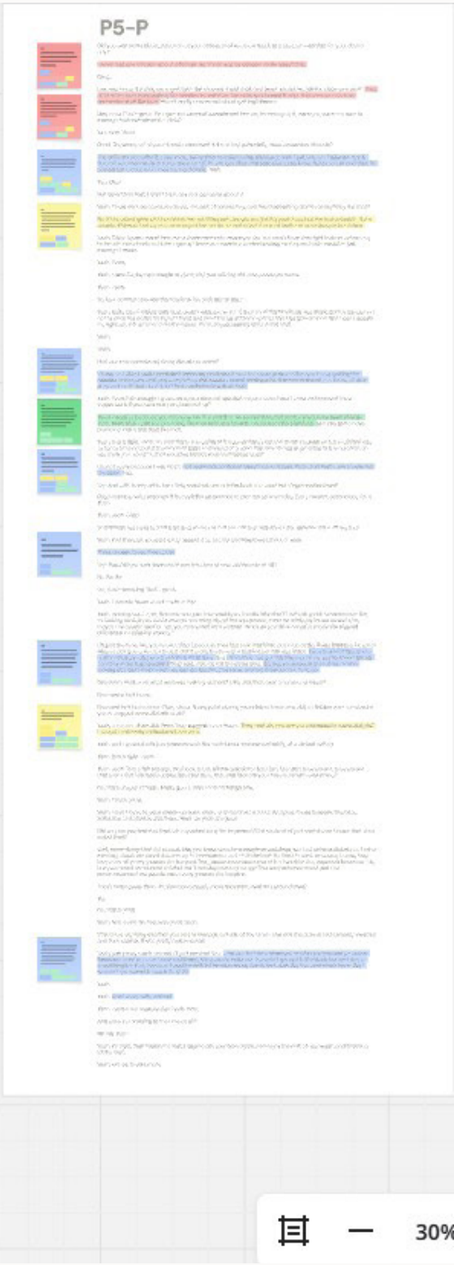
Appendix | Snippets of Thematic Process











Appendix | Snippets of Thematic Process

OK, thank you for that.

That's okay

Now, In your view, what factors most influence a patient or family member's confidence in performing dialysis at home? Say they're in clinical to begin with, but then they think about the opportunity to go home if there's specific barriers that might prevent that?

Yes, that's a very good one. The first one is usually not wanting to take the disease home. So some people, it's much better for them to just go to a hospital, get things done and they leave it there. They go home, they tend to they want to forget about it and not bring the disease home. It's some patients have said, and some people have like maybe young families or things like that, and they don't want their family or their children to see what they're going through. So, they don't want any of that in the home. That's the first one. The second one is no support. So, there are some people who leave alone or maybe I'm just a little bit more elderly and they just cannot do it or they can't either carry the bags. For instance, like periodontal dialysis bags they are, five litre bags that used to be actually six litres. One of the companies is now the one that we use, they are five litre bags. And each night they would use minimum of two, most of them. So, they just can't physically lift those bags to be able to set up the machine and things like that. So sometimes it's just the ability to do that. The other thing for PD is also the home environment. So, we go and do a home assessment. And unfortunately, there's some home environments that are just not safe for patients to undertake their own treatment at home, or safe for the staff to go in if we need to go in and do something for the patient. So, we leave that. And I guess physical ability. Some people are just not able to do it physically for different reasons. And if they don't have a support person, then they can't do it on their own.

Yeah.

Yeah. I think those are the main ones I can think of, especially for PD. For haemodialysis, again, you can't do it on your own, that one is more risky. For PD, you can actually do it on your own if you are home alone, it's not as risky because there's no blood involved or needles involved or high risk like that where you could, if something was to happen and you didn't have anyone, you could bleed to death. So, for haemodialysis, we don't allow anyone to go home unless they've got a support person in the house. So that's a hindrance if you live alone and you don't have anyone else. Second, oh, another one I completely forgot to talk about. We try by all means to have non-English speaking patients. But sometimes that is the barrier, just language. And we try everything we can sometimes to make it into their language or have the family, we do use professional interpreters and family or things like that. And sometimes the families write it down for them if they've got a support person that it's easier to have it in their language or our education material and things like that. But sometimes it just can be a barrier if we're not getting anywhere with the language - even if we're using a different language or whatever and they just don't get it, then that becomes a barrier.

P4
The first one is usually not wanting to take the disease home. So some people, it's much better for them to just go to a hospital, get things done and they leave it there. They go home, they tend to they want to forget about it and not bring the disease home.

POSITIVE Support
Emotional burden NEGATIVE
Contextual Barrier

P4
The second one is no support. So, there are some people who leave alone or maybe I'm just a little bit more elderly and they just cannot do it or they can't either carry the bags.

Physical capacity Support
Contextual Barrier NEGATIVE

P4
The other thing for PD is also the home environment. So, we go and do a home assessment. And unfortunately, there's some home environments that are just not safe for patients to undertake their own treatment at home, or safe for the staff to go in if we need to go in and do something for the patient.

NEGATIVE Safety
Contextual Barrier Home

P4
So, for haemodialysis, we don't allow anyone to go home unless they've got a support person in the house. So that's a hindrance if you live alone and you don't have anyone else.

Support
Dependancy Home Safety
Contextual Barrier

P4
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POSITIVE Support
Emotional burden NEGATIVE
Contextual Barrier

P4
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Physical capacity Support
Contextual Barrier NEGATIVE

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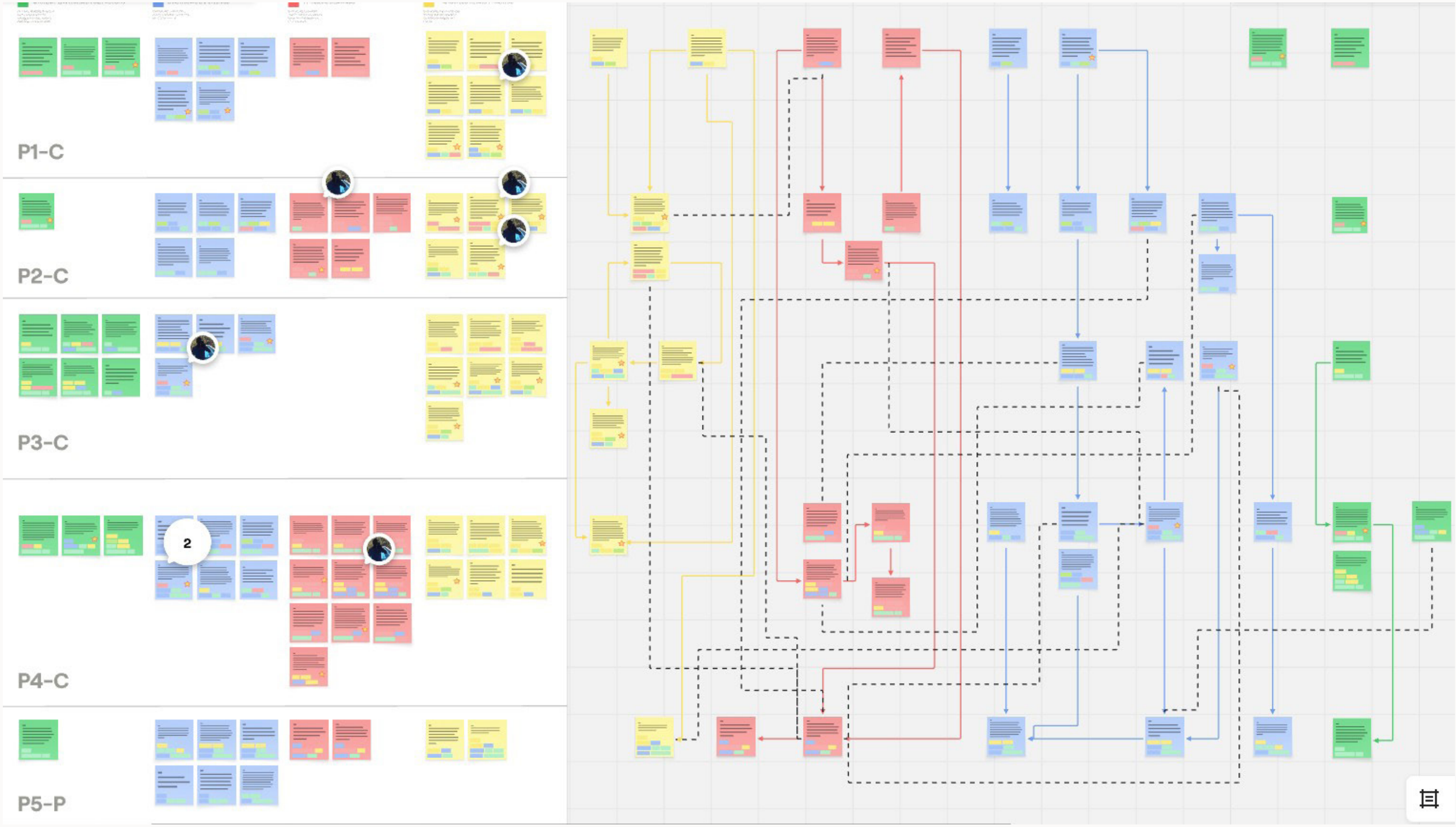
Physical capacity Support
Contextual Barrier NEGATIVE

Appendix | Snippets of Thematic Process



Appendix | Thematic Codes

Category	Sub-category	Highlight Count	Quote Example
Knowledge and Practice	Hygiene	11	The challenge is complacency... We re-check that, they are doing the full fistula wash. I often see them skip that and they'll just wipe it with the core hex swab... they're supposed to do a full wash of the arm (P2)
	Knowledge	21	Having somebody else that just has a bit of a, maybe a bit more, you know, background knowledge to be able to support that patient and carer until such a point as the patient and carer are really, really confident (P3)
	Safety	8	And unfortunately, there's some home environments that are just not safe for patients to undertake their own treatment at home, or safe for the staff to go in if we need to go in and do something for the patient (P4)
	Teaching	36	And while they're on the machine, um, we'll have a nurse sitting down with them one-on-one going through the machine, going through the machine alarms. (P2)
	Trial Runs	8	We normally give them a 12-week training before we send them home to start doing it on their own. And then for peritoneal dialysis, we normally leave anything up to from a week to two weeks training before they go home. (P4)
Physical Demands	Infection Prevention	13	I'd say, it's complacency. They get used to doing the same thing over and over again, so they get a little less good at it. In particular with cleaning the fistula before cannulating (P2)
	Anxiety	1	I think she was quite nervous if things went wrong... she had big notes written everywhere, stuck around in the room... she was very nervous about dealing with any sort of big issues (P2)
	Cannulation	8	The cannulation process, so actually sticking the needles in, we've had patients with, phobias of needles... if say their blood pressure drops, that can be quite scary for them initially. (P1)
	Fear	5	The needle phobia. Not that they have a phobia, but that fear. Fear of needling yourself. (P2)
	Pain	2	So, they'll cannulate in the middle of a vessel and then they'll go to the side of it and the other side of it, just above it, just below it... they know they'll get the access. So yeah, that's a home Haemo complication (P2)
	Physical Capacity	4	And I guess physical ability. Some people are just not able to do it physically for different reasons. And if they don't have a support person, then they can't do it on their own. (P4)
	Vascular Access	6	There's a lot of, stenosis in the veins where it narrows, which is, you know, that might be at the anastomosis, where the artery joints in the vein, or it could be further along. I see a lot of that. (P2)
Emotional Experience	Comfort	2	You feel tired... after dialysis. I used to come home and then [my wife] would wake me and I wouldn't get up till 10 o'clock the next day or something like that, because I used to do it in the afternoons, five o'clock start. So, four and a half hours. So, I wouldn't get home till about 10, 10:30. (P5)
	Confidence	36	The ones that do move forward have like a greater motivation. So they're the people that still work and things like that. They've got a greater motivation to be at home (P2)
	Contact	12	If there's any issues that they can't resolve, like machine alarms or something like that, so we're always available 24/7 for them. (P1)
	Dependency	11	And once they get used to just coming and someone doing it for them, they're like, no, I don't want the hassle of doing it myself. So, they just didn't stay in the centre as opposed to getting them home sometimes. (P4)
	Emotional Burden	4	Some people have like maybe young families or things like that, and they don't want their family or their children to see what they're going through. (P4)
	Support	24	The whole thing with the support person, the families, the support, whoever's going to be looking after, especially for those that do all of it. Because we've got some patients who they don't do any of it, either the wife or the husband or the daughter or the son or the caregiver does everything. (P4)
System and Environmental Factors	Contextual Barriers	25	Just having all that medical equipment in the home... She had it in a separate room to get it out of the home. If you know what I mean. Even though, you know, yeah. She shut the door. (P2)
	Home	40	They can have corresponding equipment and packs and all things around them... that's where it gets difficult... some people don't even have a small little, you know. Table or something you can set up a dressing tray on (P3)
	Hospital	19	Not really real confident about home dialysis. Yeah. Sort that's why I preferred the clinic.(P5)