DNB311 ID Studio 7: Capstone

Research Report

Improving the Home Injection Experience Through Improved

Auto-Injector Design



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Acknowledgement

Queensland University of Technology (QUT) and I acknowledge the Turrbal and Yugara people, as the First Nations owners of the lands where QUT now stands. We pay respects to their Elders, lore, customs and creation spirits. We recognise that these lands have always been places of teaching, research and learning and that sovereignty was never ceded. QUT acknowledges the important role Aboriginal and Torres Strait Islander people play within the QUT community.

Executive Summary

Subcutaneous injections are increasingly administered at home, enabling users to manage their treatment more independently and conveniently. However, the injection process can present physical, cognitive, emotional, usability, and sustainability challenges. This project aims to explore how auto-injectors can be improved to reduce the physical, cognitive, emotional, and usability challenges of administering injections at home, while considering opportunities for more sustainable design.

Secondary research and benchmarking were used to investigate the current home injection experience and identify market gaps. Benchmarking showed auto-injectors perform strongly in the safety and ease of use criteria because automation reduces the tasks required of the user. Sustainability was the weakest-performing criterion, as most benchmarked devices were single-use.

Primary research included seven semi-structured interviews with five self-injectors and two healthcare professionals, plus nine online archival injection observations. Interview findings demonstrated all five self-injecting participants experienced at least one user error. Uncertainty, device control, pain, anxiety, and hesitation were recurring challenges and often were interconnected throughout the entire injection experience. Observations identified injection and preparation stages as the first and second highest concentration of challenges. Comparison between self-injecting individuals and healthcare professionals revealed emotional and cognitive aspects of injection were often overlooked in professional instruction.

Four design implications were identified: reducing uncertainty and user error, improving physical interaction and control, supporting emotional and cognitive needs, and improving sustainability. These opportunities suggest future auto-injector development should move beyond automating medication delivery and consider the complete user experience.



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.

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I have utilised Generative AI in this report to assist in various ways. The AI tools used include ChatGPT and MacWhisper AI. ChatGPT was used to assist with reducing the word count, improving grammar and spelling, and refining the clarity of some sentence while maintaining my original ideas and content. MacWhisper AI was used to transcribe interview audio recordings, converting the recordings into written transcripts that were then reviewed and used for the analysis.

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1.1 Introduction

Subcutaneous Injection at Home

Subcutaneous injections deliver medication into the fatty layer of tissue just below the skin (Usach et al., 2019). Increasingly, subcutaneous injections are administered at home, enabling patients to manage their treatment independently (De Freitas et al., 2023). In Australia, 1.8% of the population (500,000 people) regularly use glucagon-like peptide (GLP-1) medicines via subcutaneous injections (Falster et al., 2026). This represents only one application of subcutaneous injections; many Australians use subcutaneous injections at home for short-term and chronic conditions (Cleveland Clinic, 2023; Tornero Molina et al., 2021) (Figure 1). Consequently, the self-injection device market is projected to grow globally from USD 22 billion to USD 40.5 billion by 2030, increasing the need for devices to better support effective, sustainable, and safe medication administration (Grand View Research, 2024).

Home administration, as compared to clinical settings, is preferred by 84% of patients because it can be more convenient, satisfactory, and potentially cost-saving (Bril et al., 2024). However, in the home setting, this presents physical, cognitive and emotional challenges, including pain, anxiety, needle fear and device interaction difficulties.

Injection delivery systems include standard needle and syringes, pre-filled syringes, injection pens, and autoinjectors, each requiring varying levels of user effort for setup and delivery (Antalfy et al., 2023). Auto-injectors were developed to simplify administration, enabling users to self-administer medication with minimal training (Weinhold et al., 2018). However, challenges related to usability, reliability, and the physical and emotional experience of injection remain (Dostal et al., 2023; Antalfy et al., 2023). Many opportunities exist to improve home auto-injector design, including a significant requirement to reduce environmental impact.

Aim

This project aims to explore how auto-injectors can be improved to reduce the physical, cognitive, emotional, and usability challenges of administering injections at home, while considering opportunities for more sustainable design.

Conditions Using Subcutaneous Injections (Short-term & Chronic)

Short-term

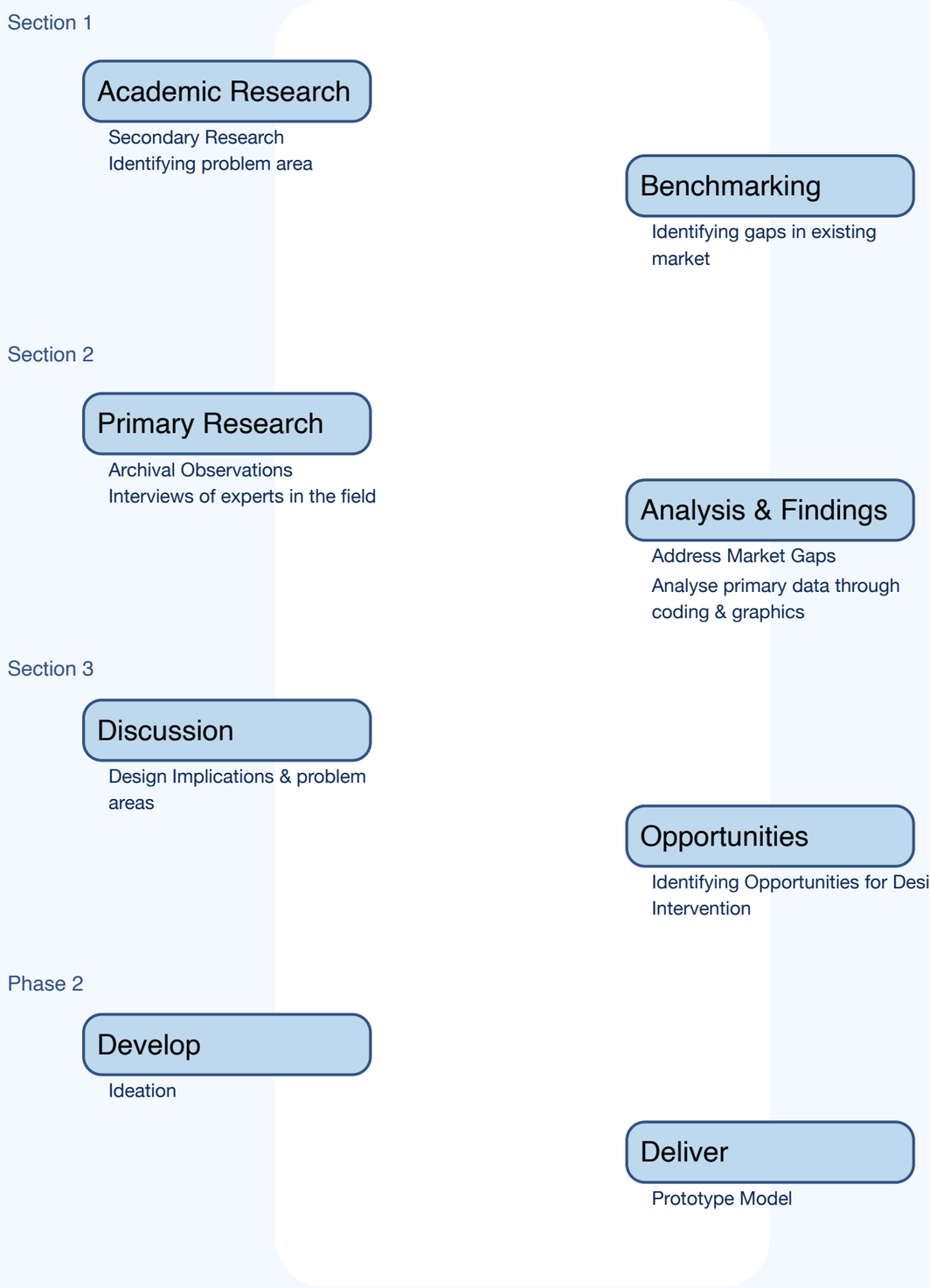
- Post-surgery clot prevention
- Anaphylaxis
- Obesity
- Acute migraine treatment
- Acute hormone treatments
- Fertility treatments
- Palliative-care management
- Temporary anticoagulation
- Acute pain management
- Deep vein thrombosis (DVT)

Chronic Conditions

- Multiple sclerosis
- Rheumatoid arthritis
- Psoriatic arthritis
- Psoriasis
- Crohn’s disease
- Ulcerative colitis
- Osteoporosis
- Haemophilia
- Chronic kidney disease
- Growth hormone deficiency

Figure 1: Conditions using subcutaneous injections (Cleveland Clinic, 2023; Tornero Molina et al., 2021)

1.2 Project Structure



1.3 Background

Overview

To reduce strain on hospital resources, injection administration has shifted to home settings, transferring medical responsibility to patients (Boguszewski et al., 2022). Auto-injectors have enabled patients to administer their own care at home, reduce healthcare costs, and self-administer injections with minimal training (Roy et al., 2021). While self-injection can be more challenging, it improves adherence and fosters independence in managing their health conditions (Mohr et al., 2002). However, despite advances in auto-injector design and technology, users must still independently prepare, operate, and complete the injection process, steps 1-5 in Figure 2 (Case-Lo, 2016). These requirements create physical, emotional, usability, and sustainability challenges.

Physical & Ergonomic Challenges

There are many physical interactions between the user and the injection device effecting the ease and comfort of administration (Alergija I Ja, 2025) (Figure 3). Injection pain is influenced by injection technique, needle characteristics, injection speed, injection site, and medication type (Usach et al., 2019). Current auto-iInjection device models place physical demands on users' grip, dexterity, hand strength, and device positioning (Berman et al., 2023; Ridyard et al., 2016)., These are known problems that highlight the importance of comfortable, controlled interactions, as better technique supports pain reduction.

Emotional & Cognitive Challenges

Needle fear is prevalent, affecting amongst approximately 20–30% of adults, andadults and contributes significantly to treatment avoidance (McLenon & Rogers, 2019). In a study of 1,325 participants with needle fear, 96.1% reported anxiety, 95.5% reported pain, and 95.2% feared something going wrongmistakes occurring during the procedure (Alsbrooks & Hoerauf, 2022). Emotional reactions can increase the perceived stress associated with self-administered injections (McLenon & Rogers, 2019; Alsbrooks & Hoerauf, 2022). Additionally, uncertainty about procedure, steps, and dosage can contribute to user error and reduced confidence (Weinhold et al., 2018) (Figure 4). To alleviate cognitive and emotional challenges, devices can provide clear feedback and user-friendly features to support users during home use (Wegner et al., 2025).

1. Prepare: Wash hands, gather auto-injector, and check medication
2. Choose injection site: (stomach, thigh, arm): clean with alcohol wipe if required
3. Position auto-injector: remove cap and place device firmly against the skin at the recommended angle 90°
4. Inject: activate auto-injector by pushing against skin or button and hold it in place until the injection is complete
5. Disposal: remove auto-injector from skin and place in sharps disposal

Figure 2: Basic auto-injector methodology for subcutaneous applications (Case-Lo, 2016)

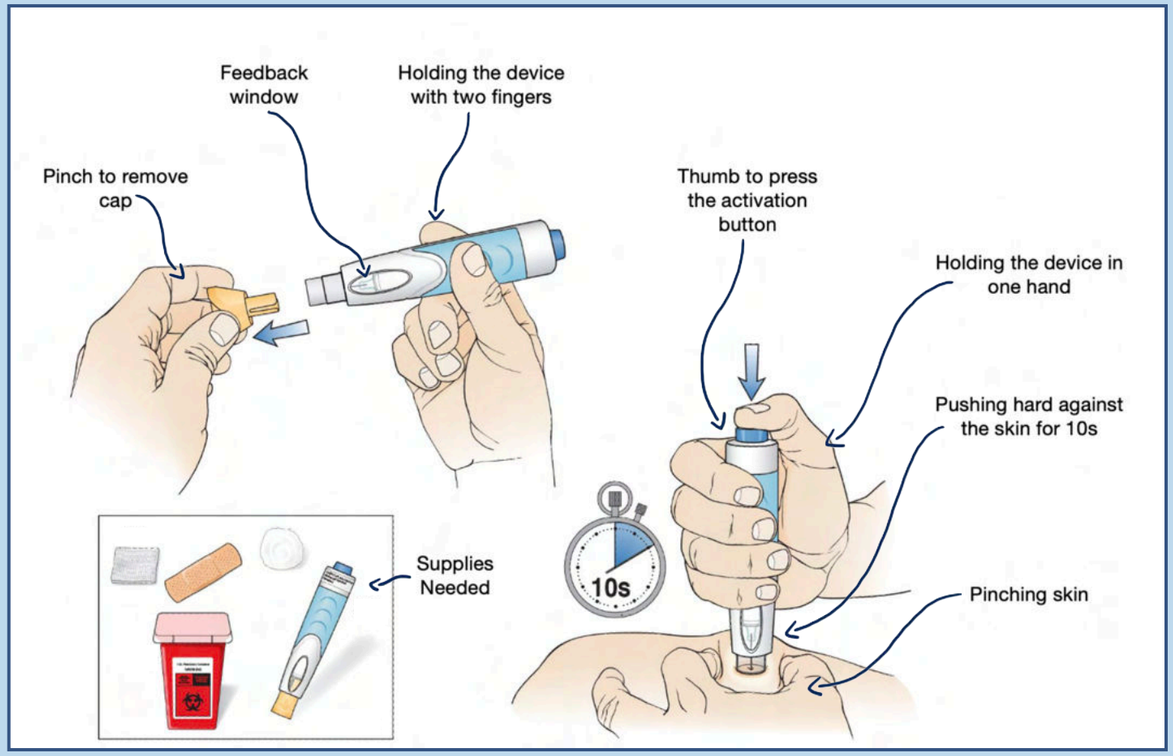


Figure 3: Physical interactions involved in auto-injector use (Alergija I Ja, 2025)

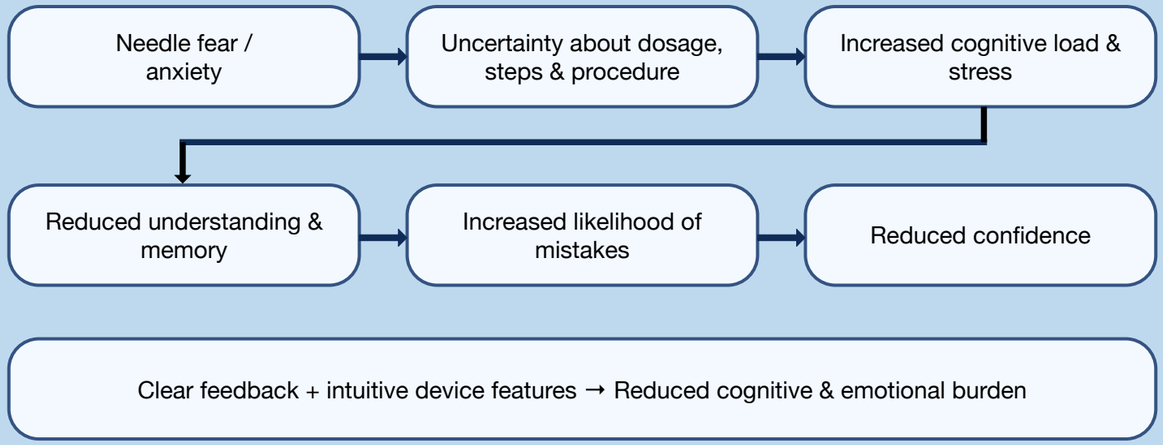


Figure 4: Relationship between emotional and cognitive challenges during self-injection (Weinhold et al., 2018)

1.3 Background

Auto-Injector Usability & User Error

The current auto-injector market models have a range of features intended to simplify self-injection, including automated needle insertion, safety mechanisms, and audible and visual feedback (Wegner et al., 2025). However, user error remains prevalent: in a systematic review of 42 autoinjectors, there were 232 use errors, 2 close calls, and 15 operational difficulties identified (Weinhold et al., 2018). The top three reported errors were incorrect injection duration (28), failure to remove the protective cap (20), and holding the device upside down (17), as shown in Figure 5 (Weinhold et al., 2018). These errors demonstrates users are unintentionally compromise to user safety and to effective medication delivery. It is crucial to ensure auto-injectors reduce reliance on user memory, timing, dexterity and technique.

"more than 7.5 billion needles & syringes are used annually"

Sustainability

The escalating use of disposable subcutaneous injection devices poses a sustainability challenge. Already, more than 7.5 billion needles and syringes are used annually, which drastically increases medical waste (Antalfy et al., 2023). Figure 6 shows single-use auto-injectors make up 68% of auto-injector use (Future Market Insights, 2026). Users must dispose of the entire device after each injection, resulting in significant material waste (Sharma, 2017). Devices are composed of plastic, metal, glass, and a wide range of other materials, making recycling and disposal difficult (Mallick et al., 2022). Recent research identifies injectable drug delivery as an emerging opportunity for more sustainable medical design reducing material use, waste, and environmental impact (Borrelli et al., 2026).

Summary

Despite advances in auto-injector technology, opportunities remain to improve the physical, emotional and cognitive experience of home injection while simultaneously reducing the environmental impact of disposable devices.



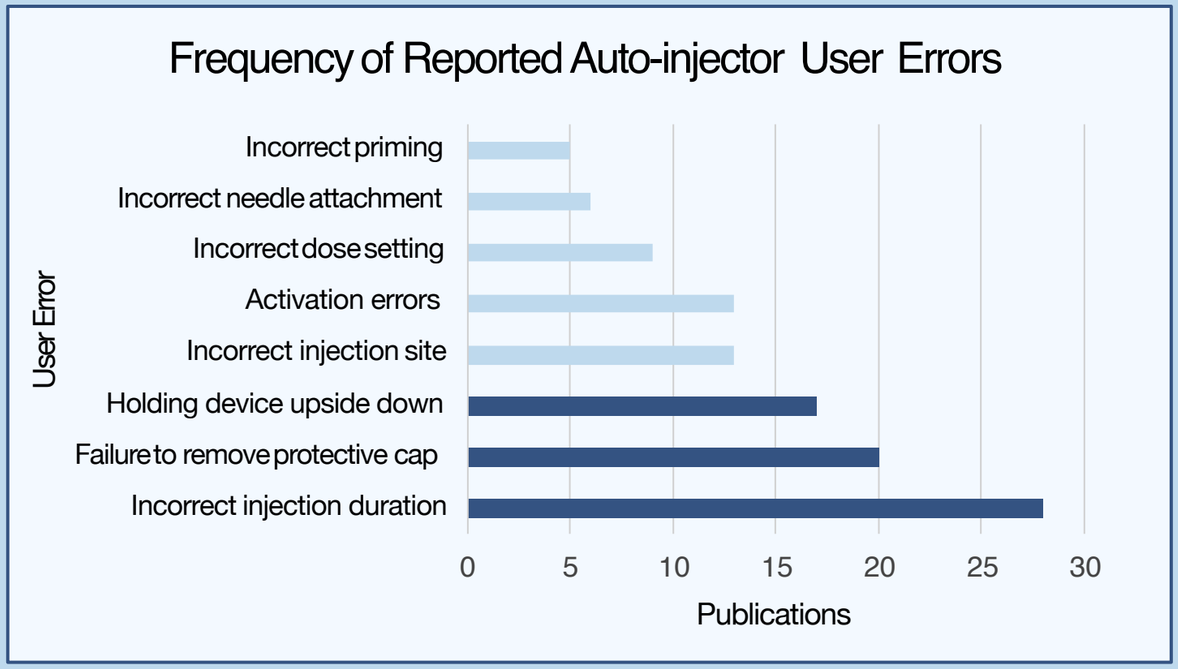


Figure 5: Frequency of reported auto-injector user errors (Weinhold et al., 2018)

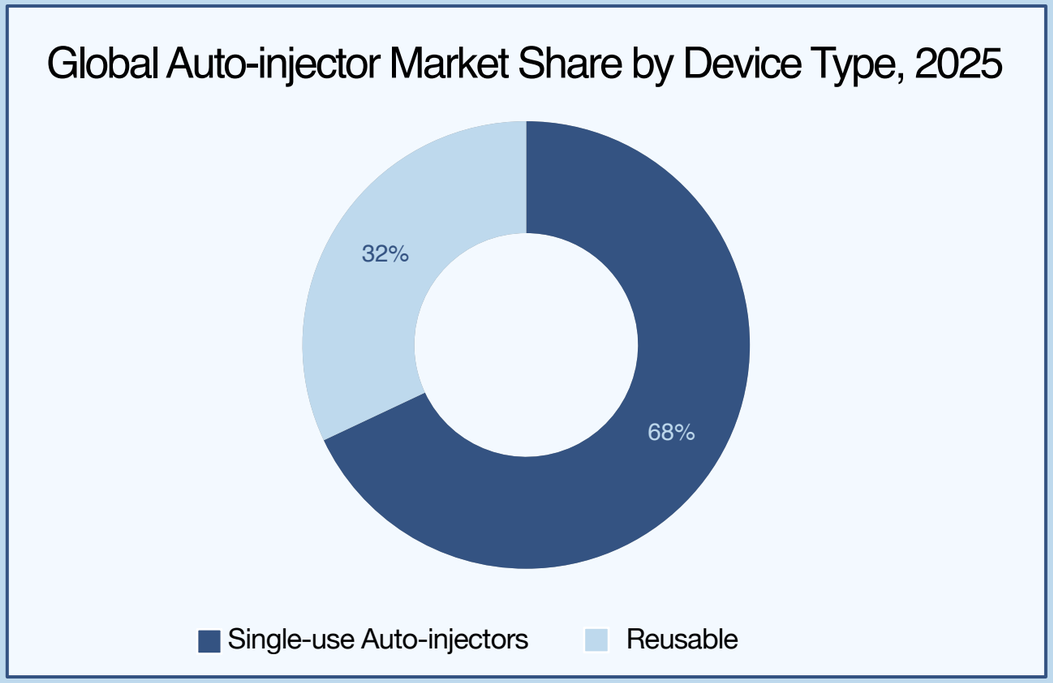


Figure 6: Global auto-injector market share by device type (Future Market Insights, 2026)

1.4 Benchmarking

Overview

Benchmarking was conducted against a range of subcutaneous injection products to assess how they addressed the physical, cognitive, and emotional demands of home injection. Different types of injection methods; auto-injectors, pre-filled syringes, short and long needles were assessed using criteria derived from this project research and wider literature (Table 1). Benchmarking identifies strengths and weaknesses in devices, advocating potential design improvements. Table 2 shows the average of all auto-injectors benchmarked alongside short-needle, long-needle and prefilled syringes to identify performance differences and opportunities for improvement. In total, 11 auto-injectors were benchmarked; the complete benchmarking table can be found in Appendix 1.

Comparison of Injection Devices

Products were compared based on the user's interaction with injection devices throughout the entire injection process, from preparation to disposal. Devices varied in mechanism and form, with most relying on simple needle insertion and automated or semi-automated medication delivery. Less automated devices ranked worse because they placed greater demands on the user control and they required more steps (Figure 8). In comparison, auto-injectors ranked the highest as they facilitate needle insertion and medication delivery, reducing the number of steps and the physical and cognitive user interactions required. Auto-injectors ranked strongest in safety, ease of use, and feedback (Figure 9). This suggests that although automation has addressed some of the challenges of administering subcutaneous injections at home, further improvements are needed, no auto-injectors achieved a perfect score (Table 2).

Criterion Definition	1 Poor	3 Average	Excellent 5
Ease of Use: How simple and intuitive the overall injection process is, error prevention	Complex, confusing, high chance of error	Generally understandable	Simple, intuitive to use correctly
Physical Effort: How much force, grip strength, ergonomics and dexterity are required	High force, strength or dexterity required	Moderate physical effort	Minimal force, strength or dexterity required
Cognitive Load: How many steps, instructions and decisions are required,	Many steps, instructions and decisions	Moderate number of steps/decisions	Few steps, clear instructions
Safety: Protection against accidental activation, needle exposure and misuse	High risk of needle exposure, activation or misuse	Adequate safety features	Strong protection & hard to misuse
Feedback: How clearly the device communicates preparation, injection and completion	Little/no indication of what is happening	Some indication of progress/completion	Clear visual, audible and/or tactile feedback
Emotional Support / Anxiety : How reassuringor intimidating the injection experience feels, needle visible	Intimidating, needle highly visible, low reassurance	Some reassurance but some anxiety remains	Reassuring, low intimidation & minimal needle exposure
Sustainability: Environmentalimpact of the product across materials, manufacturing, use and disposal.	High material use, difficult to recycle, significant waste	Some consideration of material efficiency or waste reduction	Sustainable/recyclable materials/ reuse

Table 1: Evaluation criteria and scoring framework for injection devices

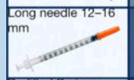
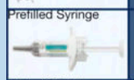
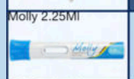
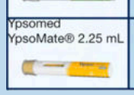
Product	Ease of Use	Physical Effort	Cognitive Load	Safety	Feedback	Emotional Support/ Anxiety	Sustainability	Total
Short needle 4–5 mm 	3	2	2	2	2	2	2	15
Long needle 12–16 mm 	2	2	2	1	2	1	2	12
Prefilled Syringe 	2	3	3	3	2	2	2	17
Molly 2.25Ml 	5	4	4	5	5	4	2	29
SHL Amber® 	4	3	3	4	5	4	2	25
Ypsomed YpsoMate® 1.0 mL 	5	4	5	5	3	5	2	25
Ypsomed YpsoMate® 2.25 mL 	5	4	5	5	4	4	2	29

Table 2: Benchmarking of injection devices against design criteria. A selection of benchmarked devices is shown; see Appendix 1 for the full benchmarking table.

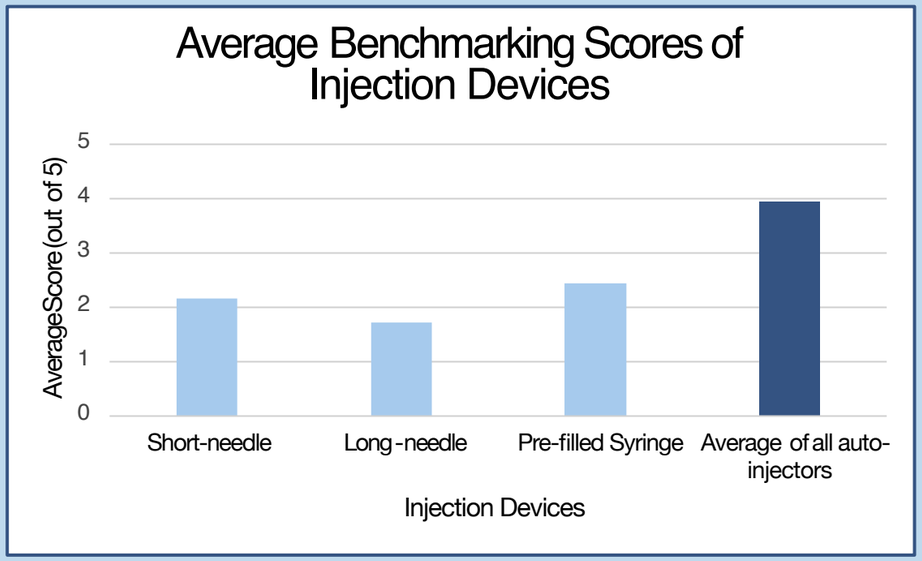


Figure 8: Comparison of average benchmarking scores across injection device types

1.4 Benchmarking

Sustainability

From benchmarking, sustainability was identified as the most significant gap. Most auto-injectors are designed for single use, as evidenced by benchmarking: 11 of 12 devices are single-use. As a result, after each injection, the entire device is disposed of, increasing material waste. Benchmarking supported this, as sustainability had the lowest average score of 2.29 out of 5 (Figure 9). The low score indicates current auto-injectors prioritize safety and convenience but, do not address environmental impact. As sustainability is underexplored, this presents an opportunity to reduce material waste and improve sustainability.

Usability / Mistakes

Auto-injectors have some automation and are generally easy to use, but user error can still occur because some process steps, like preparation, positioning, and activation, must rely on the user. Ease of use strategy should consider the number of steps and how well users perform each correctly. Most auto-injector instructions are complicated and confusing, which can increase cognitive load and lead to user errors. The examples in Figure 10 illustrate the variety in readability and clarity of instruction manuals. There is a market opportunity for simpler instructions and auto-injection devices designed to prevent user error.

Ergonomics

Ergonomics was assessed using the criterion of physical effort, which encompassed all physical interactions during the injection process. Auto-injectors reduce the physical demands of subcutaneous injections by automating certain stages, such as needle insertion. However, the average physical effort score was the second lowest at 3.64 of 5, suggesting opportunities remain to further improve interaction between the user and the device (Figure 9). Automation reduces manual actions, but device handling, grip, activation, and positioning remain important in designing ergonomic auto-injectors.

Summary

Benchmarking of subcutaneous injection devices illustrated automation improves performance by reducing user tasks. Overall, findings suggest an opportunity to develop auto-injectors that maintain the safety and convenience of auto-injectors while improving sustainability, usability and ergonomic interaction.

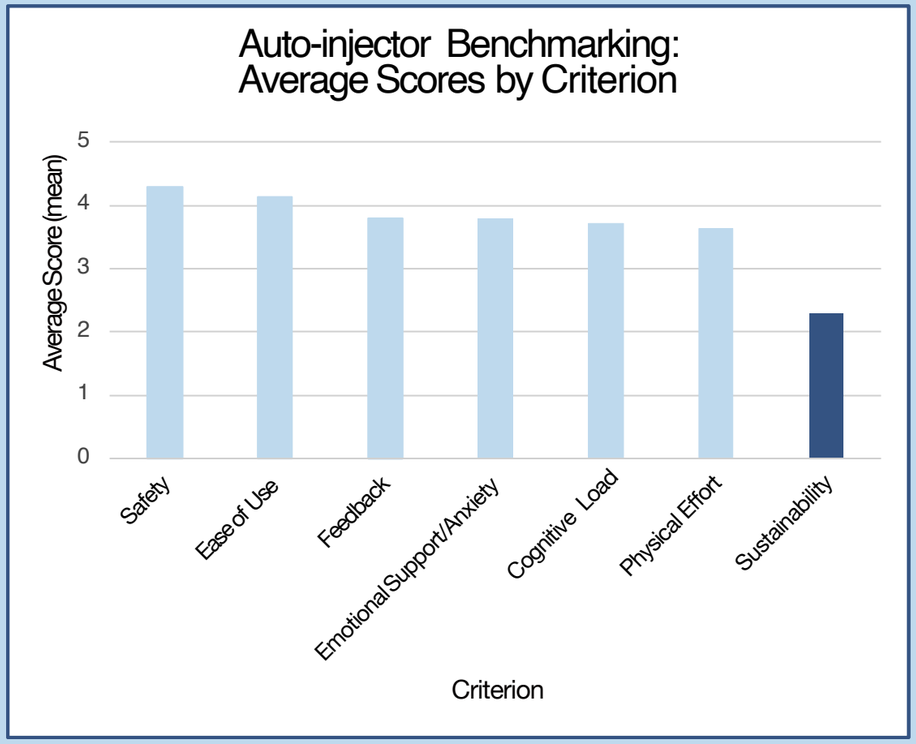


Figure 9: Average benchmark scores of 11 auto-injectors across evaluation criterion

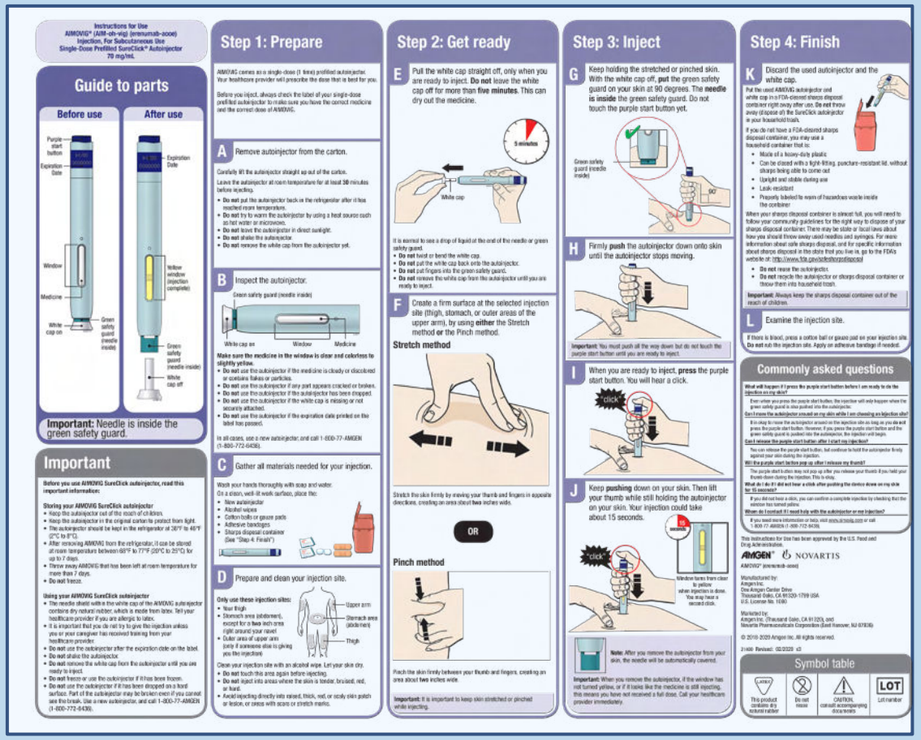


Figure 10: Typical Instruction Manual (Instructions for AIMOVIG SureClick Auto-injector Use, 2018)

2.1 Primary Research

Overview

After conducting secondary research into the physical, cognitive and emotional challenges of administering subcutaneous injections at home, primary research was undertaken to corroborate these findings. The primary research further investigated these findings by exploring participants' experiences in detail to identify more issues and design opportunities. It focused on individuals' experiences with self-injecting at home, alongside healthcare professionals who teach and support at-home injection. Primary research methodology, participant recruitment, and data collection are described below.

Primary Research Methodology

To better understand home injection experiences, behaviours, and challenges a qualitative research approach was selected. Qualitative research is appropriate for exploring personal experiences, behaviours, and emotions associated with home injection, which may not be fully captured through quantitative data.

Methodological triangulation was used by combining semi-structured interviews with online archival observation (Figure 11). Using two research methods provided different perspectives on the home injection experience, enabling findings to be compared across different sources and recurring issues to be identified. Interviews provide personal accounts of participant experience, and online archival observation enables the observation of interactions with home injection devices and participant behaviour. Both methods, used in tandem, contribute complementary perspectives on the physical, cognitive, emotional, and ergonomic challenges of home injection.

The primary research consisted of seven semi-structured interviews and eight online archival observations of injection videos. The seven interviews included five people who self-inject and two healthcare professionals, while the eight archival observations included five self-injecting individuals and three healthcare professionals (Table 3). Archival observation data were primarily collected from publicly available YouTube and social media videos.

Participant Recruitment

All participants were recruited for their first or second-hand experience with subcutaneous injections at home. Five participants who self-inject were recruited for their first-hand experience of administering subcutaneous injections at home. Two healthcare professionals were recruited for their clinical expertise and second-hand experience supporting, administering and teaching patients to self-inject. Participants were recruited through in-person conversations and via email ensuring participant personal and/or professional experiences were directly relevant to the research question.

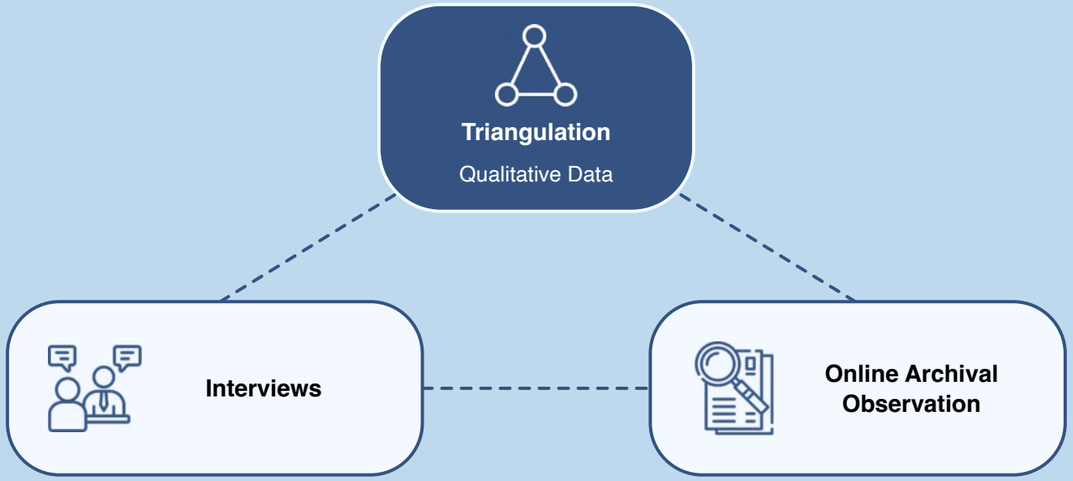


Figure 11: Diagram of method triangulation approach

Method	Recruitment	Selected	Participant breakdown
Semi-structured Interviews	6 healthcare professionals contacted	2 healthcare professionals	P1 Pharmacist; P2 Registered Nurse
	7 self-injector individuals contacted	5 self-injectors	P3 Crohn's disease; P4 migraines; P5 weight management; P6 insulin; P7 IVF
Online Archival Observation	30 healthcare professional videos reviewed	3 selected	Healthcare professional demonstrations
	30+ self-injection videos reviewed	5 selected	People self-injecting at home

Table 3: Overview of research methodology, interviews and archival observations

2.1 Primary Research

Semi-structured Interviews

Open-ended questions were utilised in semi-structured interviews to explore participants' experiences while maintaining consistency across interviews. These questions explored the entire injection process, including user mistakes, physical and cognitive challenges, handling, pain, anxiety, confidence, uncertainty, device interactions, and potential improvements. From these questions, each interviewee provided specific insights and value to the study (Table 4). The flexible interview format enabled follow-up questions when participants shared relevant experiences or unexpected issues. The interviews captured themes identified in secondary research and provided new participate insights. Interviews were transcribed using MacWhisper and manually coded highlighting relevant sections by category (Appendix 2,3,9).

Limitations

The relatively small participant sample size limits the extent to which the findings can be generalised to a broader population. Participants' responses may have been influenced by recall bias, as they were describing a previous injection experience. Researcher bias may also have been introduced through the interviewer's interpretation of subjective topics such as pain, anxiety, and confidence, potentially influencing both data collection and analysis.

Participant Type	Participant	Experience / Role	Contribution to Project Value	Duration (Minutes)
Health Professional	P1	Pharmacist	Identified common injection errors and challenges experienced by patients, particularly older users.	13
	P2	Registered Nurse	Provided insight into effective injection instructions, education, and how patients are taught to self-inject.	22
Self-injector	P3	Crohn's Disease	Compared experiences with an auto-injector and pre-filled syringe, highlighting differences in fear, pain, and device interaction.	25
	P4	Migraines	Provided insight into the challenges faced by new auto-injector users and how quickly user errors can occur.	29
	P5	Weight Loss	Revealed challenges caused by inadequate instruction, dose uncertainty, and difficulty physically operating the auto-injector.	25
	P6	Diabetes	Provided insight into the long-term experience of regular self-injection and challenges that can develop through repeated use.	25
	P7	IVF	Provided insight into administering injections in the home environment with children present and the additional emotional challenges involved.	30

Table 4: Interview participants overview and contributions

Online Archival Observation

Online archival observation was conducted alongside interviews analysing how subcutaneous injections are performed at home. After reviewing over 60 videos, eight publicly available online videos were purposefully selected for analysis as they were most relevant to the research question (Table 5). Three videos were of healthcare professionals demonstrating how to inject, and five videos were of people self-injecting at home. To analyse the videos, visible and verbal communication from both groups were documented throughout the injection process.

Limitations

Online archival observations were limited by availability and accessibility to online videos. There was no control over how the video was recorded and whether the user behaviour shown represented an individuals' typical injection practices. The sample size was also limited to eight videos based on their relevance to the research question. Therefore, these observations indicate potential user behaviours rather than representing the broader population of people who self-inject at home.

Summary

This primary research used a qualitative approach and methodological triangulation to develop a comprehensive understanding of the home injection experience. Seven semi-structured interviews and eight online archival observations provided insight from both healthcare professionals and individuals who self-inject. Interviews provided personal experiences and challenges, while archival observation identified insights into injection behaviours and device interactions. Triangulating data through two methods identified recurring physical, cognitive, emotional, and ergonomic challenges, providing evidence to inform design opportunities.

Participant Type	Participant Video	Experience / Role	Project to Value
Health Professional Demonstrations	V1	Pharmacist	Provided insight correct technique and observed hand stability challenges
	V2	Registered Nurse	Correct technique and observed hard to press activation button
	V3	Registered Nurse	Insight to correct technique and showed a tip of how to pinch skin with hair clip
Self-injector Videos	V4	Dupixent Injection Eczema	Insight into the emotional and physical experience of learning to self-inject and coping strategies.
	V5	Remsima injection Crohn's Disease	The challenges of pain, anticipation, fear, mistakes and hesitation.
	V6	Infliximab Injection Colitis	Insight into the consequences of an incomplete injection and the confusion and emotional distress this causes
	V7	A Jovi injection Migraines	Cap removal and grip was observed to be difficult
	V8	Enrol injection Rheumatoid Arthritis	How familiarity can reduce injection anxiety

Table 5: Archival Video Observations and Project Value

2.2 Analysis & Findings

Coding Method

Both interviews and observational videos were coded thematically to identify recurring issues with home administration of subcutaneous injections. A hybrid deductive–inductive approach was used, with five initial categories (User Error & Safety, Device & Design, Pain & Physical, Emotional & Cognitive, and Training & Context) and several associated subcodes. More subcodes were added when coding the interviews and observations. This framework provided an initial coding structure while still flexible to add more subcodes. The same coding method was used to ensure the data could be compared; however, several subcodes were only relevant to one method. Additionally, observational data also included injection stages to show when sub-codes occurred. Appendix 9 presents the complete coding framework, showing the categories, sub-codes and observational stages. All coding tables are in the appendix.

Observation Analysis

As online observations were coded by injection stage, this enabled analysis to identify which stage had the most frequent challenges. The injection stage, followed by preparation, site selection, and post-injection, had the highest frequency of challenges identified (Figure 12). This demonstrates challenges identified are not evenly distributed across the injection process. The higher concentration of problems at the injection and preparation stage suggests these are the most important opportunities for design intervention.

Online observation data was compared between self-injectors and healthcare professionals. Each participant group had a different number of videos, so frequencies were normalised to allow comparison (Figure 13). Comparisons indicated differences in what each group focused on. Self-injectors focused mainly on emotional and cognitive aspects, with the highest frequency score of 4.6 of 5. In comparison, the healthcare demonstration videos did not identify any health professional emotional or cognitive behaviours or contextual strategies for home injection. This supports the interview findings that auto-injector home use support requires more than technical ability, with users also needing confidence and emotional preparedness to inject.

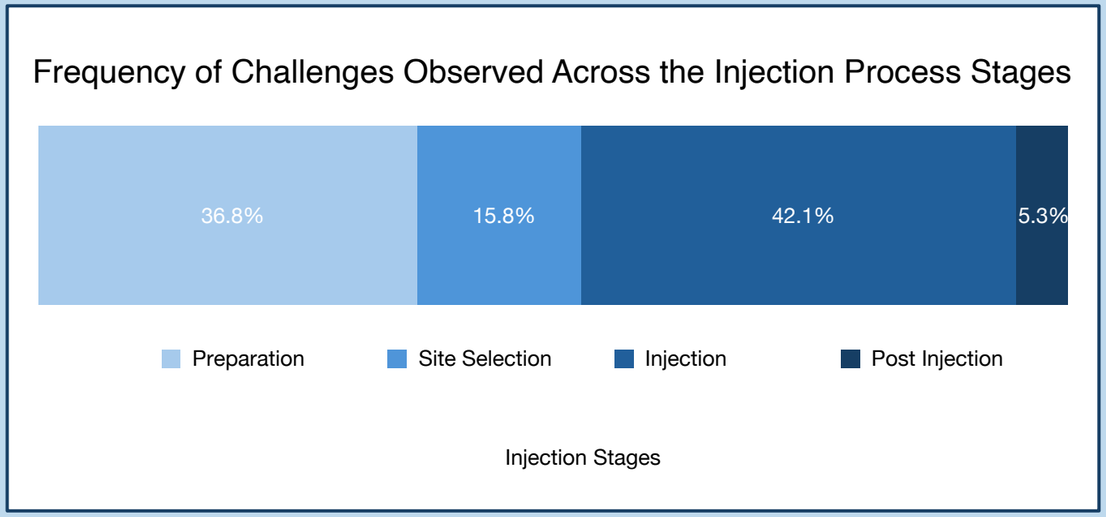


Figure 12: Frequency of challenges observed across the injection process stages

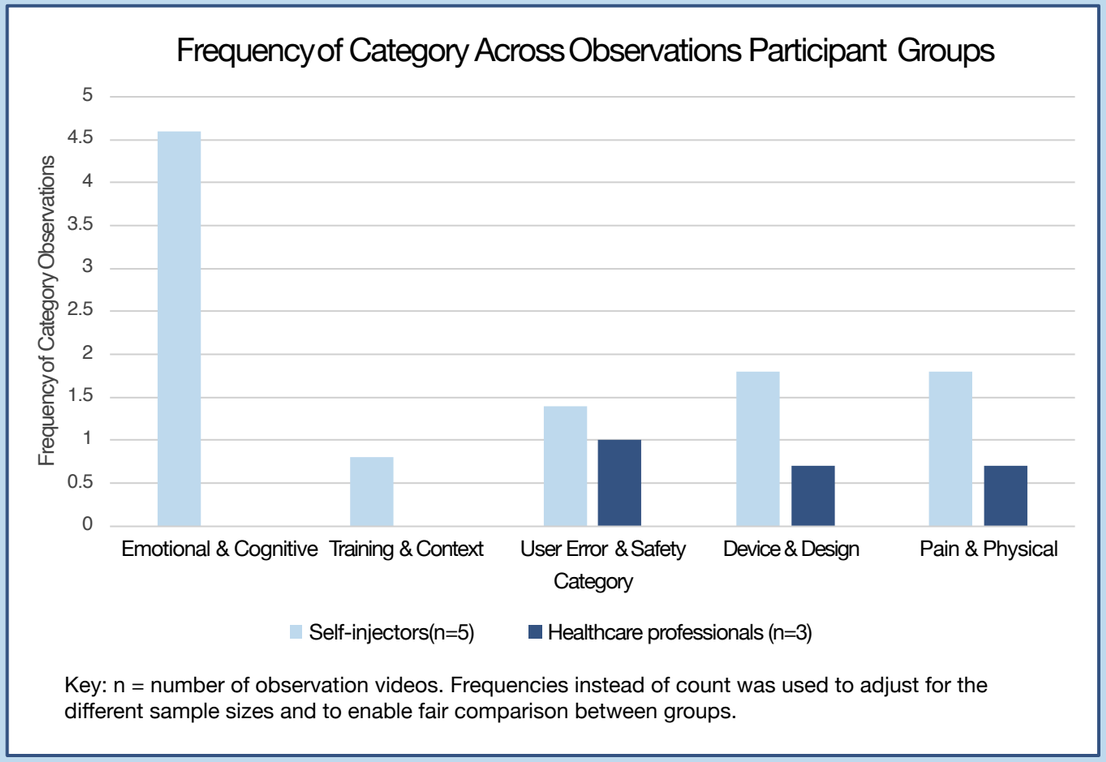


Figure 13: Frequency of category across observation participant groups

2.2 Analysis & Findings

Interview Analysis

A frequency analysis table was created to show the most prominent subcodes for interviews (Appendix 13). This reveals the most prominent subcodes related to user error, physical aspects, and emotional and cognitive burden, which were selected for further analysis.

Interview data were analysed to identify all the types of user errors reported by self-injectors. Figure 17. documents the number of users who made user errors throughout the injection process; errors included incomplete injections, dosage accuracy errors, needle pricks, and improper disposal. Every self-injecting participant reported experiencing at least one form of user error. This indicates user error is not an isolated problem but, a recurring issue for home injection. This data shows a range of user errors at different process stages, suggesting there are many problems with auto-injector devices. These user errors are significant as auto-injectors deliver medication and errors can affect treatment and user safety.

User Errors & Uncertainty

Uncertainty about injection completion was prevalent, with 4 out of 5 participants (80%) uncertain about completion. While uncertainty is not considered user error, it can contribute to potential user error. Participants reported uncertainty about whether all medication was delivered and if the injection was complete. This suggests the autoinjectors may have insufficient feedback, as users relied on their own judgment or "guessed" to determine whether the injection was complete (Figure 14). If the user cannot confidently determine whether a dose has been delivered or completed, uncertainty may contribute to early device removal or administering an additional dose.

P3 "I leave it there, and I'm like, I feel like it's all in… it's just a fair bit of guessing."
P4 "Did that go in right? Do I need to do it again"

Figure 14: Quote uncertainty

Pain

Physical challenges such as anticipated pain, injection-site accessibility, and device stability and control were reported by all five self-injecting participants. Pain was a significant factor that affected users not only during injection but, throughout the process, including anticipation before and soreness after Figure 15.

Before: P4: "How much is this kind of gonna hurt?"
During: P5: "The medicine going in was painful."
After: P3: "Sometimes you get a bruise"

Figure 15: Quote pain

Physical Challenges

Device stability and difficulty applying sufficient pressure posed ergonomic challenges, affecting user ability to control the device effectively during injection Figure 16. Participant 3 also described the activation mechanism as "the hardest" part and the experience as feeling like "you're stabbing yourself," reflecting on limited control. This suggests better device ergonomics and greater physical control may help users feel more in control of the injection process.

P5 "Trying to get that whole button in with my little thumb… I've got to kind of… scooch it so that I can get my thumb on the top"

Figure 16: Quote ergonomics

Type of User Error	Participants Reporting Error	Frequency	Example Evidence
Incomplete injection	P3, P4, P6, P7	4/5 (80%)	P4: "The needle wasn't in my… leg anymore."
Dosage accuracy / errors	P3, P5, P6, P7	4/5 (80%)	P6: "I've definitely given like the wrong dose or too much or too little."
Improper disposal	P3, P6, P7	3/5 (60%)	P7: "There was no process, like we were throwing it in the bin here."
Needle prick	P6	1/5 (20%)	P6: "I've pricked myself a few times before."

Every self-injecting participant reported experiencing at least one form of user error.

Figure 17: All interview participants recorded user errors

Emotional and cognitive burden was the most frequently identified and the largest category (Appendix 9,13). This highlights the emotional and cognitive subcodes most reported by self-injectors. These user experiences underline that self-injection is more than a physical procedure, but also an emotional and cognitive challenge experienced before, during and after the injection process. Users require not only physical support but, also emotional and cognitive support throughout the process.

Healthcare professionals recognised patients have uncertainty and anxiety; however, they primarily focused on procedural instruction and correct technique. The only strategies for managing emotions identified were taking a deep breath, "just doing it," or having someone provide encouragement. This illustrates emotional and cognitive support is underrepresented in current approaches to teaching self-injection.

All participants interviewed suggest desired improvements to current auto-injector design, highlighting the opportunities for further auto-injector improvement. (Table 6).

Participant	Desired Improvement	Supporting Quote
P1 – Pharmacist	Clearer step-by-step guidance and feedback	"It's mostly the fear that they might be doing it wrong…so maybe better teaching and feedback"
P2 – Registered Nurse	Simpler, more intuitive instructions	"Colour coordinate it…just one two three. Very basic."
P3 – Crohn's disease	Greater control over needle insertion	"Control over how fast you put the needle in."
P4 – Migraines	Easier cap removal	"The main one…the cap was easier to get off."
P5 – Weight loss	Clear completion feedback and easier activation	"It'd be great if there was like a little click or something when you know you'd done the full dose."
P6 – Diabetes	A simpler, more integrated device that reduces preparation	"It is a bit like annoying screwing the needle cap like off and all of that."
P7 – IVF	Reduce preparation	"If you could eliminate all the…preparation and things are all pre-loaded…absolutely."

Table 6: Interview participants' desired auto-injector improvements and supporting quotes

2.2 Analysis & Findings

Interview & Observation Analysis

The interview and observational findings were combined to identify the largest themes and areas of convergence between the two research methods. A bubble diagram visually represents the key categories and subcodes across the combined interview and observational findings, with larger bubbles indicating more mentions by participants (Figure 18). The convergence analysis identified user error, device interaction, cognitive uncertainty and physical burden as challenges (Table 7). These four areas have the highest convergence and were considered stronger findings, as they were identified in more than one research method.

Interviews provided insight into participant personal and emotional experience, while observations provided behavioural evidence of how injections were performed. Combining the findings establishes that home injection challenges are interconnected. Uncertainty can increase cognitive load, which can contribute to hesitation or error; device interaction can affect physical control; and anticipating pain can lead to emotional distress. Observational findings and interview data were valuable because they showed where challenges occur within the injection process. Interviews captured how participants experienced and felt, while observations helped identify which stage these issues occurred in.

Summary

Both these research methods enable a comprehensive understanding of the home injection experience and identify opportunities for design to address not only the technical delivery of medication, but also the physical, cognitive and emotional experiences of users.

Finding	Interview Findings	Observation Findings	Convergence
User Error	All 5 self-injectors reported at least one user error	Errorsidentified: incomplete injections, incorrect preparation	High
Device Interaction	Participants identified difficulties with grip, activation, cap removal and controlling the device	Difficulties with grip, activation, cap removal and device control were observed	High
Cognitive Uncertainty	Participants reported uncertainty about dosage, injection completion, steps and whether the injection was successful	Uncertainty around preparation, activation and completion was observed.	High
Physical Burden	Participants reported pain, grip difficulty, and activation challenges.	Pain was observed and difficulty with applying pressure were observed.	High

Table 7: Convergence of interview and archival observation findings

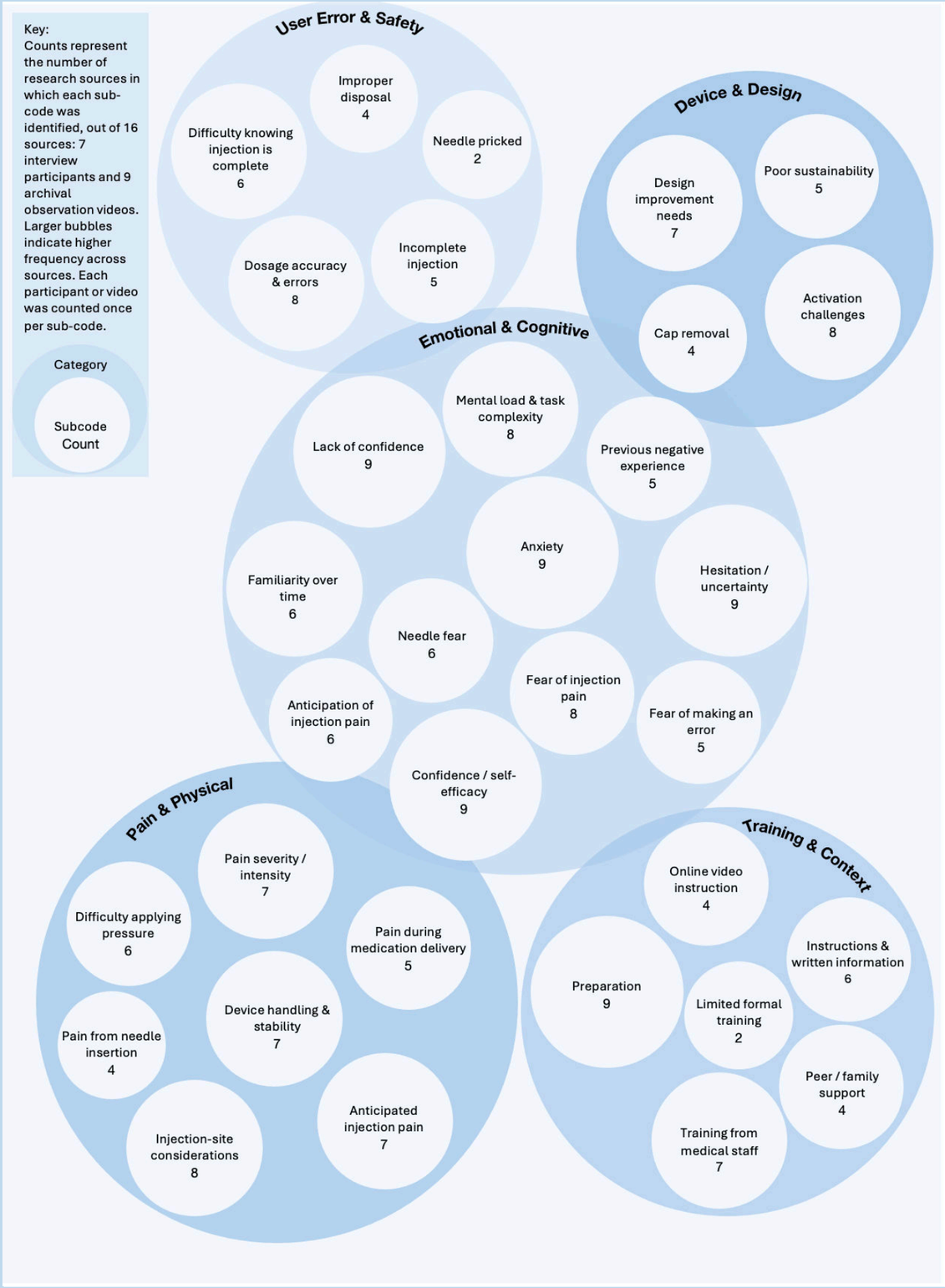


Figure 18: Bubble Diagram. Bubbles overlap symbolizing how all these challenges/categories are interconnected

3.1 Discussion

Overview

This research indicates current auto-injectors have reduced some of the practical demands of administering subcutaneous auto-injectors at home. However, the overall experience remains physically, cognitively and emotionally demanding. Literature supports these challenges, including user error, pain, ergonomic difficulties, anxiety, and uncertainty (Usach et al., 2019; Berman et al., 2023; Dostal et al., 2023; Wegner et al., 2018). Primary research extends existing knowledge, exposing these challenges are interconnected and occur across different auto-injector stages rather than as an isolated problem.

Physical Challenges

Physical challenges were evident in both existing and primary research, with all five interviewed self-injecting participants reporting issues related to pain, grip, positioning, or device control. Pain was reported before (anticipation), during, and after injection, showing pain can extend beyond needle insertion. Benchmarking identified physical effort as a weaker criterion. Although auto-injectors reduce some physical demands through automation, participants still experienced difficulties with device stability and pressure application, highlighting limitations in device ergonomics.

Uncertainty, Cognitive Load & User Error

Existing research into injections identified cognitive and emotional factors surrounding needle fear, anxiety, and uncertainty as significant barriers (McLenon & Rogers, 2019; Alsbrooks & Hoerauf, 2022). Primary research exposed participants were uncertain about injection completion, users would rely on their own judgement. This uncertainty may increase cognitive load, reduce confidence, and contribute to hesitation or potential user error. User error was a prominent finding, with all 5 self-injector interview participants reported at least one form of user error. This confirms challenges experienced during home injection extend beyond procedural accuracy, as uncertainty, emotional distress, cognitive load, and user errors all contribute to successful injection. However, education on home injection mainly focuses on procedural safety and accuracy, with limited consideration of managing emotional distress or reducing cognitive load.

Sustainability

Existing research and benchmarking identified sustainability problems with auto-injectors (Antalfy et al., 2023; Mallick et al., 2022). Benchmarking revealed sustainability as the lowest criterion, as most auto-injectors are single-use. Interviews revealed 4 of 5 self-injectors believed auto-injectors were unsustainable and desired more sustainable alternatives. These findings suggest auto-injector design must consider environmental sustainability alongside safety and usability as a desired user requirement.

Summary

The findings show that home injection challenges are interconnected. Physical, cognitive, emotional, usability, user error, and device interaction all influence each other throughout the injection process. This extends existing research showing the importance of understanding the complete home injection experience, rather than focusing solely on the technical delivery of medication. These insights will inform design opportunities.

3.2 Design Implications

Overview

The findings revealed that design intervention could reduce physical, cognitive and emotional challenges associated with administering subcutaneous injections at home. Current auto-injectors have reduced some physical demands; however, uncertainty, user error, emotional distress, device interaction and sustainability remain unresolved. These results indicate four key design implications to improve subcutaneous home injections.

01

Reduce Uncertainty & User Error

User error was evident, as all five self-injecting participants reported at least one form of user error. Errors ranged from incomplete injections and dosage errors to needle pricks and uncertainty about completing the injection. There is an opportunity to provide clearer, more immediate confirmation and feedback throughout the injection process. Feedback should communicate key stages, particularly correct activation and injection completion. Effective feedback is clear, specific, actionable, and provides context about what happened, whether the interaction was successful, and what to do next. Reducing reliance on user judgment could also improve user confidence and reduce opportunities for user error.

02

Improve Physical Interaction & Control

Auto-injectors have reduced some physical demands through automation; however, participants still struggle with device handling and stability and find applying pressure difficult. An opportunity exists to improve the physical interaction between the user and auto-injector, by making it more manageable to hold exhibiting mor user control. Improving activation, grip, stability, and pressure application would improve device ergonomics and usability. Providing greater physical and functional control over the injection device would help users manage and respond to pain by increasing their perceived control and reducing the feeling of “stabbing themselves.” Auto-injector design should consider how users interact with the device and how to minimise unnecessary mental and physical discomfort during administration.

03

Support Emotional & Cognitive Needs

Results illustrate the injection experience extends beyond the physical act of injecting. Participants report anxiety, needle fear, anticipation of pain, hesitation, uncertainty and a lack of confidence. However, education on subcutaneous injections at home mainly focuses on the procedure and safety. This highlights an opportunity for auto-injectors to support users emotionally and cognitively through clear guidance, reduced decision-making, and reassurance throughout the process. Simplifying the injection process and making instructions easy to understand can reduce cognitive load. If the process was more intuitive and manageable, anxious or inexperienced users would feel more confident and more able to administer injections independently.

04

Improve Auto-injector Sustainability

Existing research and 4 of 5 interview participants describe devices as unsustainable. Most devices are single-use, creating unnecessary material waste after each injection, increasing environmental impact. This creates an opportunity to reconsider auto-injector material use, end-of-life, and how to reduce waste. Future auto-injector design should explore how to make auto-injectors more sustainable while maintaining safety, usability, and reliability.



3.3 Conclusion

This report examined the challenges of administering subcutaneous injections at home using auto-injectors and identified opportunities to improve their design. Secondary research and benchmarking established auto-injector automation has reduced some user demands, but physical, cognitive, emotional, usability, and sustainability challenges remain.

Primary research revealed these challenges are interconnected. Uncertainty, pain, device control, anxiety, and hesitation overlap and influence the overall user auto-injector experience. All five at-home self-injecting interview participants experienced at least one user error, highlighting user error as a recurring challenge. Observations identified that the injection and preparation stages had the highest concentration of challenges. A comparison between self-injectors and healthcare professionals revealed emotional and cognitive aspects of auto-injectors were overlooked by healthcare professionals.

This report underscored four design implications: uncertainty and user error, improved physical interaction and control, support for emotional and cognitive needs, and improved sustainability. Addressing these design opportunities can create a safer, more intuitive, safe, comfortable, and sustainable home auto-injector experience. Future auto-injector development should move beyond automating medication delivery to support the complete user experience.



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4.2 Appendix: Benchmarking Tables

Appendix 1: Benchmarking Table with all Devices

Product	Application	Ease of Use	Physical Effort	Cognitive Load	Safety	Feedback	Emotional Support/ Anxiety	Sustainability
Short needle 4–5 mm 	Subcutaneous injections when shorter needle appropriate (Insulin Therapy)	3	2	2	2	2	2	2
Long needle 12–16 mm 	Subcutaneous injections when longer needle appropriate (Vaccines)	2	2	2	1	2	1	2
Molly 1.0Ml 	Biologics and other SC medicines; examples include rheumatoid arthritis	5	4	4	5	4	4	2
Molly 2.25Ml 	Higher-volume biologics; examples include atopic dermatitis and other inflammatory conditions	5	4	4	5	5	4	2
SHL Amber® 	Fixed-dose PFS delivery	4	3	3	4	5	4	2
Ypsomed YpsoMate® 1.0 mL 	chronic therapies including autoimmune/ inflammatory conditions	5	4	5	5	3	5	2
Ypsomed YpsoMate® 2.25 mL 	Higher-volume SC biologics; examples include atopic dermatitis	5	4	5	5	4	4	2
Owen Mumford Autoject® 2 	Insulin delivery using a conventional syringe	4	4	4	4	3	5	4
PiccoJect™ 	SC delivery of biologics and other medicines using a PFS	5	5	4	5	5	4	3
SHL Rotaject® 	formulations requiring controlled injection forces	4	4	3	5	3	4	2
Rebiject II® 	Interferon beta-1a (Rebif); multiple sclerosis	3	3	4	4	4	3	4
One-Press® (STELARA) 	Crohn's disease and ulcerative colitis	4	4	4	5	4	4	2
SHL DAI® 	SC biologics; examples include rheumatoid arthritis	4	4	4	5	5	4	2
BD Physioject™ 	Fixed-dose rheumatoid arthritis, autoimmune diseases	5	4	4	5	4	5	2

4.3 Appendix: Coding Tables

Appendix 9: All categories and sub codes

Categories & Sub codes used for Interviews & Observation

🟨 **User Error & Safety**
- Incomplete injection
- Dosage accuracy & errors
- Difficulty knowing injection is complete
- Injection-site uncertainty
- Needle pricked
- Cleanliness & contamination (Observation only)

🟦 **Device & Design**
- Desired improvements
- Cap removal
- Activation challenges
- Poor sustainability / waste (Interviews only)

🟧 **Pain & Physical**
- Device handling & stability
- Difficulty applying pressure
- Pain severity/intensity
- Pain during medication delivery
- Pain from needle insertion
- Injection-site considerations
- Anticipated injection pain (Interview Only)

🟩 **Emotional & Cognitive**
- Anxiety
- Fear of injection pain
- Anticipation of injection pain
- Hesitation/uncertainty
- Lack of confidence
- Confidence/self-efficacy
- Previous negative experience
- Mental load & task complexity
- Familiarity over time
- Needle fear
- Fear of making an error (Interview Only)

🩵 **Training & Context**
- Online video instruction
- Instructions & written information
- Preparation
- Training from medical staff (Interview only)
- Limited / no formal training (Interview only)
- Peer/family support (interview only)

Observation Coding Note: Stages were added to the observation coding framework, with 5 stages identified: Preparation, Site Selection, Injection, Post-Injection and Overall Experience

Appendix 10: Example Table showing how each observation video was coded

Category	Stage	Sub-code	Your observation
🟨User Error & Safety	Preparation	Cleanliness & contamination	The user describes seeing someone blow on the injection area after using an alcohol wipe, which could compromise sterilisation.
🟦Device & Design	Preparation	Cap removal	The user takes more than three seconds to remove the cap and applies significant pressure while doing so.
	Injection	Activation challenges	The user describes the device as sometimes being difficult to operate and stiff to push.
🟧Pain & Physical	Injection	Pain severity / intensity	The user states that the injection hurts and describes the pain as something they need to work through.
	Injection	Pain during medication delivery	The user explains that going slowly helps them manage the pain during the injection.
🟩Emotional & Cognitive	Overall experience	Previous negative experience	The user describes feeling faint during their first injection when standing.
	Preparation	Anxiety	The user describes being nervous about performing the injection.
	Preparation	Hesitation / uncertainty	The user describes being hesitant before performing the injection.
	Injection	Fear of injection pain	The user takes a deep breath and explains that going slowly helps them get through the pain.
	Overall experience	Lack of confidence	The user states that they had a lot of trouble learning how to perform the injection.
	Overall experience	Confidence / self-efficacy	The user explains that being able to perform the injection independently helped them feel capable of taking care of themselves.
🩵Training & Context	Preparation	Preparation	The user gathers all the items needed for the injection before beginning the process.

Appendix 11: Example of how each interview was coded

Category	Subcode	Quotes
🟨User Error & Safety	User mentions Mistake (user error)	Yes P4: "The auto-injector actually…failed part way through the process."
	Mistake consequences	
	Incomplete injection	P4: "The needle wasn't in my…leg anymore.", P4: "There was like…about a 5 millimetre kind of circle of the liquid on my skin." Yes P4: "The auto-injector actually…failed part way through the process."
	Difficulty knowing when injection is complete	P4: "Did that go in right? Do I need to do it again?"
	Device feedback	P4: "It gave the signal that it all drained, it sprang straight back up."
	Device feedback	P4: "It was a very loud click."
🟦Device & Design	Desired improvements	P4: "The main one…the cap was easier to get off."
	Activation	P3 P4: "If you don't push hard enough, then the device doesn't work.", P4 the force of the cap going back up is the mechanism of the needle going in
	Auditory feedback/clicks	P4: "There's an audible click when it's all gone in."
	Window	P4: "There's…an indicator on it…like the window…to tell me when it's done."
	Cap removal	P4: "The hardest thing is to get the cap off of it."
	Knowing injection is complete	P4: "Wait until the bars drain, listen for the click."
	Device control	
	Device positioning	P4: "Put it into your skin at a right angle."
	Device preference	P4: "The auto-injectors definitely make it easier."
	Autoinjector, syringe, needle, prefilled	
	Disposal	P4: "We have a sharps bin at home."
	Sustainability	P4 "single use"
	Supportive products	
🟧Pain & Physical	Pain out of 10	P4: "I would say it's fairly on par with any vaccine I've gotten."
	Injection pain	P4: "It hurts a little bit."
	Needle pain	P4: "The pain starts just kind of like, a pinprick kind of feeling."
	Anticipated pain	P4: "How much is this kind of gonna hurt?"
	Pain during insertion	P4: longer it stays in as they're putting the liquid in, that's when I tend to get the pain. Um, doesn't hurt too badly, but, you know, at about the halfway mark, I'm going, "Okay, I'm ready for this to be done. This is kind of hurting. When's it gonna click?"
	Reactions after injection	
	Injection-site positioning	P4: "I've so far only done it into my thigh."
	Body positioning	P4: "Sitting on a chair…tends to make it easier to kind of reach."
	Hand stability	P4: "I probably just didn't keep enough pressure pushing down."
	Difficulty pressing/holding	
🟩Emotional & Cognitive	Anxiety	P4: "There was a lot more nervousness beforehand."
	Needle fear	P4: "Wow, I hated needles."
	Fear of pain	P4: "How much is this kind of gonna hurt?"
	Anticipation of pain	P4: "I'm ready for this to be done. This is kind of hurting. When's it gonna click?"
	Hesitation/Uncertainty	P4: "Did that go in right? Do I need to do it again?" P4: "Where do I inject it? Is this too far up? Is it too far down?"
	Fear of making a mistake	P4: "Did that go in right?"
	Fear of incorrect angle	P4: "Put it into your skin at a right angle."
	Mental load/Remembering steps	P4: "Clean it, take the cap off it, make sure you don't turn it, line it up."
	Lack of confidence	P4: "You vaguely know how to do it."
	Confidence	P4: "It's been a fairly straightforward process."
	Previous negative experience	P4: "I totally psyched myself out about it."
	Normalisation over time	P4: "The process is quite good."
	Don't want to change devices	P4 I'm trialling it for another three months... semi-similar medication
💗User Experience	Overwhelming	P4: "There was a lot more nervousness beforehand."
	Embaresment	
🩵Training & Context	Well-trained	P4 "by neurologist"
	Watched Videos Online as instructions	
	Use the instruction	P4: "The instructions are fairly clear. A lot of pictures, which is quite good." P4 "There's not much instructions given on how much…force you should be exerting." P4 P4: "The zone's not the clearest on the pamphlet either."
	Training from	P4: "The neurologist that administered the medication showed me how to do it." P4 "Was sent home and told, 'You'll be fine.'"
	No formal training	
	Preparation	P4: "I tend to set everything up beforehand."
	Storage	P4: "I have to leave it out of the fridge for an hour."
	Cleanliness	P4: "Clean it."
	Travel	
	Routine	
	Medication management	
	Familiarity & Peer Support with experience	P4: "I made her (mum GP) stay with me the first time I did it." / P4: "Having seen my dad do it before…made me feel more comfortable about it."

4.2 Appendix: Coding Tables

Appendix 12: Completed thematic coding table interviews

Category	Sub-code	Self-inject — Participants	Self-inject — Quotes	Healthcare professionals	Healthcare professional — Quotes
User Error & Safety	Incomplete injection	4/5	P3: "Pulled it away…Mighthave taken it off too early…I'vedone that once or twice."	1/2	P2: "Other nurse did it…kicked back."
	Dosage accuracy & errors	4/5	P6: "I've definitely given like the wrong dose or too much or too little, a few times before."	2/2	P2: "Don't know how much dosage you've given."
	Difficulty knowing injection is complete	3/5	P5: "I leave it there and I'm like, I feel like it's all in…it's just a fair bit of guessing."	2/2	P1: "Dose window, it was still quite full… first time using it…she injected herself another dose."
	Improper disposal	3/5	P7: "There was no process, like we were throwing it in the bin here…"	1/2	P2: "Disposal…shocking…even though you're not meant to."
	Needle pricked	1/5	P6: "I've pricked myself a few times before."	—	—
Device & Design	Desired improvements	5/5	P7: "if you could eliminate all the… preparation and things are all pre-loaded… absolutely."	1/2	P2: "Colour coordinate it…just one two three. Very basic."
	Cap removal	1/5	P4: "The main one…the cap was easier to get off."	0/2	
	Activation challenges	3/5	P4: "If you don't push hard enough, then the device doesn't work."	2/2	P2: "Push down and make sure it's not exactly the best."
	Poor sustainability / waste	4/5	P3: "They are very wasteful…So wasteful."	1/2	P2: "should be biodegradable plastic."
Pain & Physical	Anticipated injection pain	4/5	P4: "How much is this kind of gonnahurt?"	—	—
	Pain from needle insertion	3/5	P7: "that 1st little bit when a needle 1st goes in…so that was always painful."	—	—
	Pain during medication delivery	3/5	P4: "the longer it stays in as they're putting the liquid in, that's when I tend to get the pain."	—	—
	Pain severity / intensity	4/5	P7: "I reckon probably 5 out of 10… probably up to 7 or 8 out of 10."	—	—
	Injection-site considerations	5/5	P6: "I was really scared to do injections on my stomach. I didn't do that for like, 5 years."	1/2	P2: "Stomach always easiest…hurts less."
	Device handling & stability	4/5	P3: "if you like relax your hand a little bit… it might actually like just push the pen out."	—	—
	Difficulty applying pressure	3/5	P5: "I just don't think my thumbs long enough."	—	—
Emotional & Cognitive	Anxiety	5/5	P3: "There was anxiety around…actually doing it."	1/2	P1: "Quite stressed."
	Needle fear	5/5	P4: "Wow, I hated needles."	1/2	P1: "Still afraid of needles."
	Fear of injection pain	4/5	P3: "I knew that I was about to get a bit of a jab of pain, so it was more preparing for that"	1/2	P2: "How hard do I press? How far do I press? Is it gonna hurt?"
	Anticipation of injection pain	3/5	P5: "Every time the needle…is about to go through the skin, I look at it and there's a part of my brain that's like, ew."	—	—
	Hesitation / uncertainty	4/5	P4: "Where do I inject it? Is it too far up? Is it too far down?"	1/2	P2: "Am I doing this right…doing it wrong…what happens if I do it wrong."
	Fear of making an error	3/5	P7: "that pressure of not wanting to waste a dose or get it wrong."	1/2	P1: "Mostly the fear that they might be doing it wrong."
	Mental load & task complexity	5/5	P4: "Clean it, take the cap off it, make sure you don't turn it, line it up."	1/2	P2: "Not too many steps…no fiddle bits."
	Lack of confidence	4/5	P5: "I don't feel 100% confident with it."	2/2	P1: "Wasn't confident doing it herself."
	Confidence / self-efficacy	5/5	P6: "I can like do them all myself."	2/2	P2: "Done a few time…oh yea ok."
	Previous negative experience	3/5	P5: "I got quite scarred from the DVT injections."	—	—
	Familiarity over time	4/5	P5: "Now when I do it, it's not a bother at all."	1/2	P2: "People are more comfortable… know exact steps."
Training & Context	Training from medical staff / others	5/5	P3: "I was in a room with a pharmacist who supervised me."	2/2	P2: "Probably a diabetic nurse."
	Online video instruction	1/5	P5: "It was 100% the Online YouTube videos…WhenI saw them do it…I felt more confident."	2/2	P2: "I tend to look at YouTube."
	Instructions & written information	4/5	P4: "The instructions are fairly clear. A lot of pictures, which is quite good."	1/2	P2: "Always just get out and read the instructions."
	Limited / no formal training	2/5	P3: "No one necessarily showed me what to do (prefilled syringe)."	—	—
	Preparation	5/5	P7: "I had to actually…put it all together… each time I had to use the…injection."	1/2	P2: "Set up before you start."
	Peer / family support	3/5	P5: "I also had a friend that had been taking Monjaro for about 6 months…I messaged her and I was like, do you freak out before the injections?"	1/2	P2: "Friend…partner, 'come on you can do it'."

Appendix 13: Frequency Analysis Interviews

Category	Key theme	Frequency	What this indicates
User Error & Safety	User error	5/5	All self-injectors experienced some form of error
	Incomplete injection	4/5	Difficulty ensuring the full dose was delivered
	Dosage accuracy	4/5	Difficulty accurately administering the intended dose
Device & Design	Desired improvements	5/5	Everyparticipant identified an opportunity for improvement
	Device preference	5/5	Strong preference for auto-injection solutions
Pain & Physical	Injection-site accessibility	5/5	Site selection and access influenced injection experience
	Device stability / control	5/5	Users experienced difficulty maintaining device control
	Anticipated pain	5/5	Pain was considered before injection
Emotional & Cognitive	Anxiety	5/5	All participants experienced anxiety associated with injection
	Needle fear	5/5	Needle visibility/presence contributed to emotional burden
	Mental load & task complexity	5/5	Injection involved multiple cognitive demands
	Lack of confidence	5/5	Participants experienceduncertainty in their ability to inject
	Confidence / self-efficacy	5/5	Experiencecould increase confidence over time
Training & Context	Trainingfrom medical staff / others	5/5	Formal instruction was an important part of learning
	Preparation	5/5	Preparation was a consistent part of the injection process