Design, Health and Innovation

Co-design for improved cold chain compliance

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2023

An exegesis presented in partial fulfilment of
the requirements for the degree of

Master of Design at Massey University,
Wellington, New Zealand

Figure 1.
Ward Preparation Room

ACKNOWLEDGEMENTS

This research has its genesis in the collaboration and establishment of a memorandum of understanding documented as an 'Individual Access Agreement', between Massey University, namely the College of Creative Arts (CoCA) - Toi Rauwharangi, and Capital and Coast District Health Board – Ūpoko Ki Te Uru Hauora, namely the Centre of Clinical Excellence 2DHB/He Pūtahi Kairangi Taurima Tūroro | Hutt Valley & Capital & Coast District Health Boards, approved 19th July 2021. Latterly, due to New Zealand's health system reform, this agreement has transitioned to Te Whatu Ora – Health New Zealand, namely Improvement & Innovation, Capital, Coast and Hutt Valley (CCHV). The overarching mission for the collaboration between these two parties is to contribute to improved health outcomes for New Zealanders through education, research and design.

Within this agreement the first project undertaken was established under the 'Project Terms' and titled:
Cold Chain – Quality Improvement,
approved 28th July 2021.

This research project sets out to

"Develop solutions for cold chain management of vaccines and medicines so that drug efficacy is maintained, and enhance fridge usability, packaging, and utility, through the development of new features and fridge accessories that collectively enhance and measurably improve the systems performance."

(Wellington School of Design & Capital & Coast District Health Board, 2021)

SUPPORT

To Deb Cumming and Rodney Adank,
Thank you for supporting and guiding the development of this research.

To the Cold Chain – Quality Improvement Project Team,
Thank you, in particular to our Te Whatu Ora team members Lynette Collis and Richie Perry, your expertise, passion and generosity is invaluable and an inspiration for this research. In extension the Wellington Regional Improvement and Innovation team.

To Ezra and my family,
Thank you for your endless and unwavering support.

To my peers and CoCA community,
Thank you, your talent is inspirational and your drive, contagious.

FUNDING

Funding for this research was obtained by the Cold Chain – Quality Improvement research team's success in winning the Massey Innovation Prize 2021. This funding covered tuition fees and provided a modest stipend. Additional funding and support were provided by part time employment within Te Whatu Ora: Capital, Coast and Hutt Valley's Improvement and Innovation Team to develop the project.

Abstract

Effective design approaches for multiple disciplinary collaborations are increasingly sought to benefit users and medical communities. This research seeks to develop effective explorative design research methods and identify their applicability to design teams operating in a hospital environment.

This research is situated and trialled within the ‘Cold Chain – Quality Improvement’ project, which aims to improve the reliability of refrigerated pharmaceutical efficacy and the internal spatial management of pharmaceutical refrigerators. This is in order to reduce cold chain breaches, excursions, failures and subsequent wastage of valuable refrigerated pharmaceuticals. Further, the project is intended to support the ‘human factor’ in cold chain compliance, reducing performance pressure on staff who pack and access refrigerated medicines and vaccines. This consequently improves usability and reduces costs due to breaches, excursions, and failures.

A combination of design research methods are employed; co-design workshop, semi-structured observations, iterative design developments, semi-structured interviews, and a pilot trial. These activities were used to inform communication across the design team, the broader research team, and stakeholder communities, along with end users to improve the focus and resolution of design activities. Within this process, design outputs are generated and assessed with regards to their valued experience to participants.

This explorative and reflective design process has application to the ongoing larger project, and other emerging projects from the collaboration between Massey University and Te Whatu Ora, which seek approaches that enrich design research suitable for a hospital context.

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INTRODUCTION

Figure 2.
Ward Pharmaceutical Refrigerator

1.1 DEFINING COLD CHAIN

In this research, 'cold chain' refers to the low temperature-controlled supply chain that transports temperature sensitive pharmaceuticals (TSP) from place of manufacture through to the consumer (National Immunisation Programme Cold Chain Management, 2021). The cold chain is necessary for the transport of all vaccines in New Zealand as well as a variety of temperature sensitive medicines.

TSPs must be kept within a range of +2°c and +8°c to ensure their potency and efficacy. When TSPs are outside of this range it is a cold chain breach (Cold Chain Breaches, 2022). A breach can cause the TSPs' active component to degrade, which occurs at varying rates dependent on the TSP, the temperature it's exposed to and the length of exposure. TSP degradation means that the active components are broken down and no longer able to produce a desired outcome (Galazka et al, 1998); this is known as a cold chain excursion and the product must be destroyed (Cold Chain Breaches, 2022). On occasion a cold chain failure can occur, which is when an excursion has not been identified and a degraded TSP is administered to the consumer.

Each section of the cold chain has protocol in place to ensure the optimal temperature window is maintained and provides actions to follow if a breach occurs. CCHV's cold chain management protocol is outlined in the Annual Cold Chain Record in Appendix A.

The scope of the Cold Chain – Quality Improvement project is limited to cold chain storage of TSPs in pharmaceutical refrigerators located in preparation rooms in hospital wards. Figure 3 specifies this scope in relation to the wider cold chain.

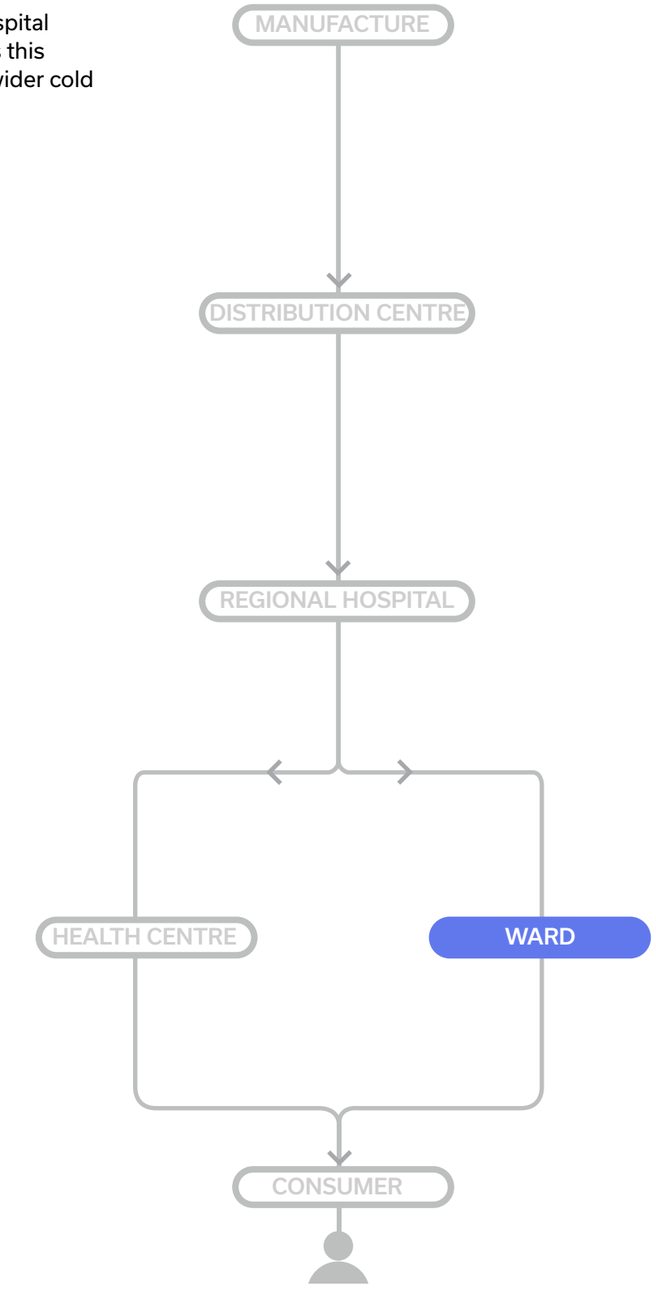


Figure 3.
Cold Chain Overview

1.2 PROJECT AIM

The Cold Chain – Quality Improvement project is the first project developed under the collaborative 'Individual Access Agreement' between CoCA and CCHV. The project subject matter was identified by Richie Perry: Improvement and Innovation Manager, CCHV, and supported by Lynette Collis: Cold Chain Lead of the Quality Improvement & Patient Safety Directorate, CCHV. The nature of the project, its range, and opportunities for collaboration with design were discussed and agreed upon with Rodney Adank: Associate Professor Industrial Design, and Jason Mitchell: Senior Lecturer Design, CoCA.

Consequently, the Cold Chain – Quality Improvement project has been a means to familiarise organisations, individuals participating within them, the organisational culture, and structures that each has in place or are required. It has provided a foundation to build a productive ongoing relationship for future projects between these two parties.

The Cold Chain – Quality Improvement project aims to improve the reliability of TSP efficacy and management in order to reduce cold chain breaches, excursions and failures, as these are costly in both time and money for hospitals. CCHV's annual report (2018) shows that approximately $4,000 NZD worth of temperature sensitive pharmaceuticals (TSPs) are destroyed every month in this district due to cold chain excursions. CCHV perform regular cold chain audits to inform and monitor change ideas that may improve management and therefore efficacy of TSPs. These change ideas have traditionally been targeted at processes and procedures conducted by staff.

1.3 RESEARCH OBJECTIVES

This design research seeks to develop expertise in explorative design research methods and their applicability to multiple disciplinary design and health teams operating within hospital environments. The following questions are being asked of this project:

How can a combination of design research methods be used to strategise communication across a design team, stakeholder communities, and end users to improve the subsequent focus of design activities?

What provision of design collateral would provide a rich creative experience to participants in this design process?

What designs result from creative practice informed by this strategy, and how would they be valued?

A review of a range of approaches commonly used in early-stage innovation will be undertaken to identify methods and combinations of methods suitable for the hospital environment. Selected approaches and design collateral will be trialed within the Cold Chain – Quality Improvement project.

1.4 SCOPE OF RESEARCH

The scope of this research is to:

Build on early concepts focused on achieving required cold chain spacing of vaccines and refrigerated medicines, and the elimination of thermal bridging, along with the managed location of data loggers used in monitoring internal fridge temperatures

Implement design research methods and activities that develop definition and detail of design solutions, and functional prototypes for a pilot trial

Analyse and implement a range of design methods to increase effective collaborative communications and understanding of stakeholder contributions

Facilitate reflection of co-design activities for effective design and health collaborations informed by a pilot trial

Critically reflect on the successes and limitations of the pilot trial

Recommend further design refinements prior to broader hospital trials

As depicted below this Master of Design's research contributes to a portion of the Cold Chain – Quality Improvement project's ongoing development.

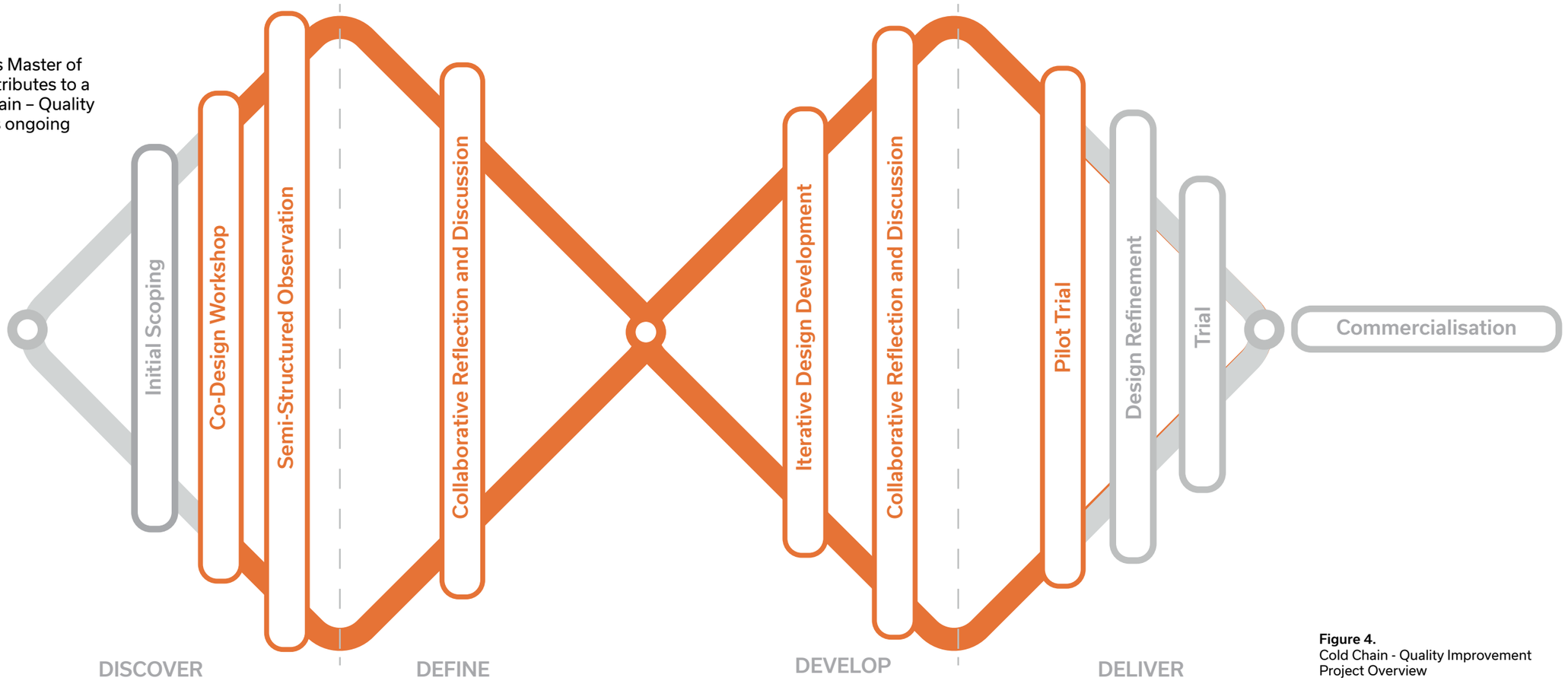


Figure 4.
Cold Chain - Quality Improvement Project Overview

Figure 5.
Multiple Disciplinary Team Collaboration

2.1 NEW ZELAND'S HEALTH SYSTEM

As of July 2022, New Zealand is undergoing a national health reform. This reform is a result of an independent audit of New Zealand's health and disability services, commissioned by the government. As stated in Our Health and Disability System (2021) released by The Department of the Prime Minister and Cabinet, the audit findings indicated that the health care system is struggling, and will continue to struggle with heightening patient demand, an increasingly ageing population, and the burden of chronic disease.

New Zealand's future vision of healthcare practice places increasing emphasis on proactive holistic health and less on Western reactive reductionist care that has been traditionally institutionalised in New Zealand hospitals (Chamberlain & Craig, 2017). This paradigm shift is mirrored in the health reform hybridising the "overly complex and fragmented" (Our Health and Disability System, 2021, p.1) health system constituted of 20 geographically determined district health boards into two national entities: Te Aka Whai Ora/Māori Health Authority and Te Whatu Ora/Health New Zealand. The centralisation of these entities intends to synthesise processes to streamline Pae Ora/Healthy Futures by accentuating and integrating the voice of stakeholders in the system, driven by five pillars: equity, partnership, sustainability, person and whanau centred care and excellence (Our Health and Disability System, 2021).

The necessity to have collaborative symbiotic relationships in shaping the future of New Zealand's health system was notably discussed in the New Zealand Health Strategy: Future Direction (2016) and New Zealand Health Research Strategy 2017-2027 (2017). These reports stated the need to adopt new ways of thinking to improve health services, emphasising the need for creativity, collaboration, and lateral thinking in shaping the future health system.

A situation that was forecast almost forty years earlier by Schön (1983) who commented on the crisis of confidence in professional knowledge as indicated below.

> **As physicians have turned their attention from traditional images of medical practice to the predicament of the larger health care system, they have come to see the larger system as a "tangled web" that traditional medical knowledge and skill cannot untangle**
>
> (p.14).

2.2 CO-DESIGN

The value of co-design has been recognised and explored increasingly in the health sector as it shows promise as a more "effective, democratic or innovative alternative to conventional approaches" (Blomkamp, 2018).

Healthcare systems are complex environments managing individualised care for patients through community-based support, specialists and medical facilities connecting hundreds of unique journeys through a web of expertise (Shepley & Watson, 2013). The cold chain is one of these multi-layered systems within the health environment relying on a range of products, participants, experts, processes and procedures to achieve satisfactory levels of performance.

Co-design is often recommended for addressing problems in a complex system because of its strong emphasis on collaboration among team members from multiple disciplines (Blomkamp, 2018; Eisenhardt et al., 2016, as cited in Heiss & Kokshagina, 2021). Heiss and Kokshagina (2021) discuss the necessity of sharing information across disciplinary boundaries, as it stimulates an increased volume of opportunities to explore and address a challenge. In extension, van der Bijl-Brouwer (2019) recommends that complex issues require "knowledge flows" (p. 2) as opposed to individualised expertise, advocating for a reframing of how we understand "work" and "practice" to develop a sense of comfort in the state of being a beginner that comes with continuous learning.

However, despite the volume of literature discussing the strengths and applications of co-design, a succinct definition of this practice remains unresolved (Slattery, 2020; Toko King, 2020). The nuances in the language of co-design discussions make it challenging to navigate the literature and provide effective critique of the method (Blomkamp, 2018).

Research defining co-design tends to be in agreement that the "design" aspect of this method refers to the implementation of a design process (Sanders & Stappers, 2008; Freire & Sangiori, 2010 as cited in Toko King, 2020; Kimbell, 2015; Britton, 2019; Zamenopoulos & Alexiou, 2018; Blomkamp, 2018; Thabrew et al., 2018).

The differentiation lies in the "co" aspect in co-design. Sanders and Stappers (2008) and Toko King (2020) specify that a co-design process requires the multiple disciplinary collaboration between participants with design expertise and with non-design expertise. In a design and non-design collaboration the designer can ensure the design process is implemented meaningfully and productively and the non-designer provides specialist contextual insights.

Freire and Sangiorgi (2010) as cited in Toko King (2020), Kimbell (2015) and Slattery et al. (2020) insist that the "co" aspect of co-design must include end users and stakeholder communities in the design process, as experts of their personal experiences. Interestingly, there is little emphasis from these authors on multiple disciplinary collaboration challenging Sanders and Stappers (2008) and Toko King (2020) that designers are embedded in co-design.

This research draws on both co-design narratives by utilising the participation of design expertise and non-design expertise from end users and stake holder communities in a co-design process.

The definition of co-design that is most relevant to this study primarily is;

> **"...the essence of co-design lies less in its attachment to a specific 'phase' of a process...than in its recognition of shared agency or collaboration between those involved in the initial and on-going configuration of the service..."**
>
> (Britton, 2017, p.36)

Furthermore, the discussion becomes increasingly convoluted as to "how" to practice co-design. The key characteristics of co-design are its ability to be collaboratively crafted by a multiple disciplinary team to serve their unique requirements. As a result of this adaptability it can be difficult to define what does and does not classify as co-design. Sanders and Stappers (2008) discussion and Britton's (2019) insistence that co-design occurs across a spectrum of collaboration provides a means to connect the variability of co-design.

2.3 A SPECTRUM OF COLLABORATION

The spectrum of collaboration represents the amount of influence non-design expertise has in the design process, positioning along this spectrum is defined by the manner of engagement within a multiple disciplinary team. This spectrum evolves respectively from each team member contributing their disciplinary expertise at predetermined phases in a project to achieve a set goal, toward the abolition of disciplinary boundaries and unhindered knowledge sharing to define and achieve a shared process and goal (Choi and Pak, 2006; van der Bijl-Brouwer, 2019).

The commonly recognised modes of multiple disciplinary teamwork are: multidisciplinary, crossdisciplinary, interdisciplinary and transdisciplinary. A consistent definition of and differentiation between these terms is not present across the literature, with the terms often being used interchangeably (Choi & Pak, 2006). However, Figure 6 draws on the research of Choi and Pak (2006), Alexander Refsum Jensenius (2012) and Jo Bailey (2019) to visualise and articulate the spectrum of multiple disciplinary collaboration.

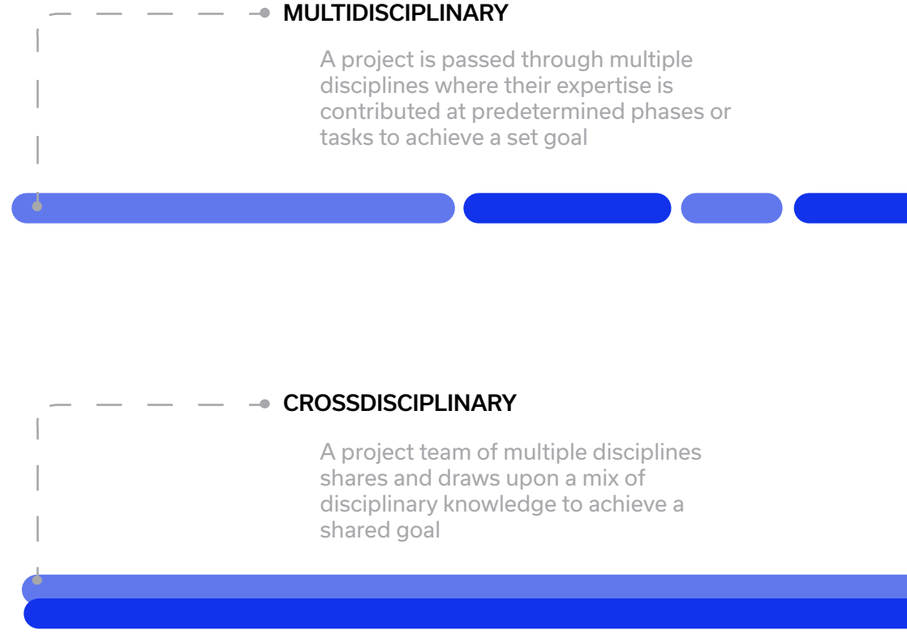
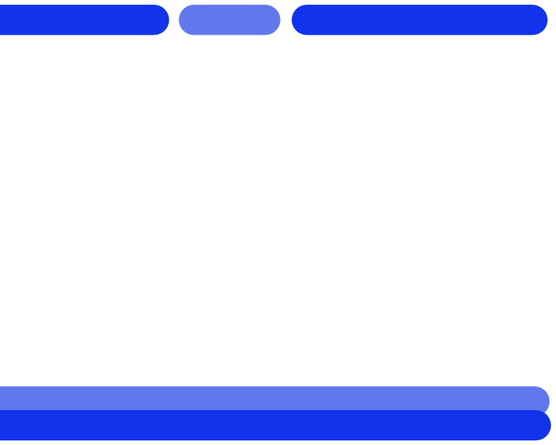


Figure 6.
The Spectrum of Collaboration



Depending on a project's scope and objectives, a degree of collaboration on the spectrum should be strategised, with careful attention paid to the selection of team members as this significantly and directly impacts the quality of collaboration (Choi & Pak, 2017).

In complex health systems with a significant number of stakeholders and users, a project will often impact a range of communities and professional disciplines. In improvement and innovation projects where this is the case, the project team should aspire to position themselves further along the spectrum of collaboration to encourage the development of new ways of thinking that the New Zealand Health Strategy: Future Direction (2016) and New Zealand Health Research Strategy 2017-2027 (2017) state is essential to shape the future of healthcare. As Choi and Pak (2017) discuss one of the major contributors to the success of a multiple disciplinary collaboration is having sufficient time to meaningfully and productively collaborate, something New Zealand's healthcare staff don't tend to have (Our Health and Disability System, 2021; Reay et al., 2021).

The Cold Chain – Quality Improvement project moved through each stage of the spectrum of collaboration as the research shared by CoCA and CCHV progressed and over time a team culture evolved that fosters trust and knowledge flows. In the early stages it presented as multidisciplinary, as design and health disciplinary experts recognised that collaboratively their shared perspectives could enable cold chain innovation.

The foundational engagements, such as initial scoping and relationship building activities moved the collaboration into crossdisciplinarity as knowledge flows were established.
As the project advanced, workshops and continual communication synthesised processes and expertise to develop shared ownership of knowledge, concepts, and ideas, moving the team into interdisciplinarity.

The latter development of this collaborative project has seen a position established within Te Whatu Ora: Capital, Coast and Hutt Valley's Improvement and Innovation Team committed to the integration of design expertise in the progression of the Cold Chain – Quality Improvement project. This is the position I held and signifies a move to transdisciplinary engagement.

2.4 DESIGN AND HEALTH AS COMPLEMENTARY DISCIPLINES

It is commonly perceived that design and health as disciplines are polar opposites, the former considered creative, lateral thinking and disruptive, the latter pragmatic, linear and risk-adverse (Craig et al., 2019; Driver et al., 2011). This is also evident in the way that health and design may view each other. This thought paradigm has the potential to limit engagement and trust between the disciplines and so requires careful unpacking and acknowledgement of expertise, culture and practice (Driver et al., 2011).

The reality is, however, that design and health disciplines are connected through aligned people-centric approaches and values (Crowe et al., 2022). Both disciplines examine and explore evidence and observation, using a specialised skillset. This informs the delivery of an interventionist service that is adaptable and customisable to individual requirements and a rapidly evolving professional practice (Rowe et al., 2020). This bonded value underpins the foundations and goal for any given project.

There is rich potential for collaboration between the disciplines as their respective approaches complement one another (Crowe et al., 2022; Rowe et al., 2020).

As visualised in Figure 7 health research predominantly utilises quantitative research to identify a need for intervention and measure its success.

Taking a positivist approach, health research tends to be deductive looking for solutions that are either true or false in nature (Arghode, 2012), utilising only verifiable data to produce objective results. Quantitative research enables control and precision, returning verifiable data that is black and white. A strength of this method for health environments is that they are typically data rich, making data very accessible, reliable, and current. However, quantitative research has a very limited ability to address the "human-factor" such as personal beliefs, experiences, and motivations.

The author's interpretation of health research is visualised on a scale of minimal to maximal investment into a given approach shown in Figure 7 below.

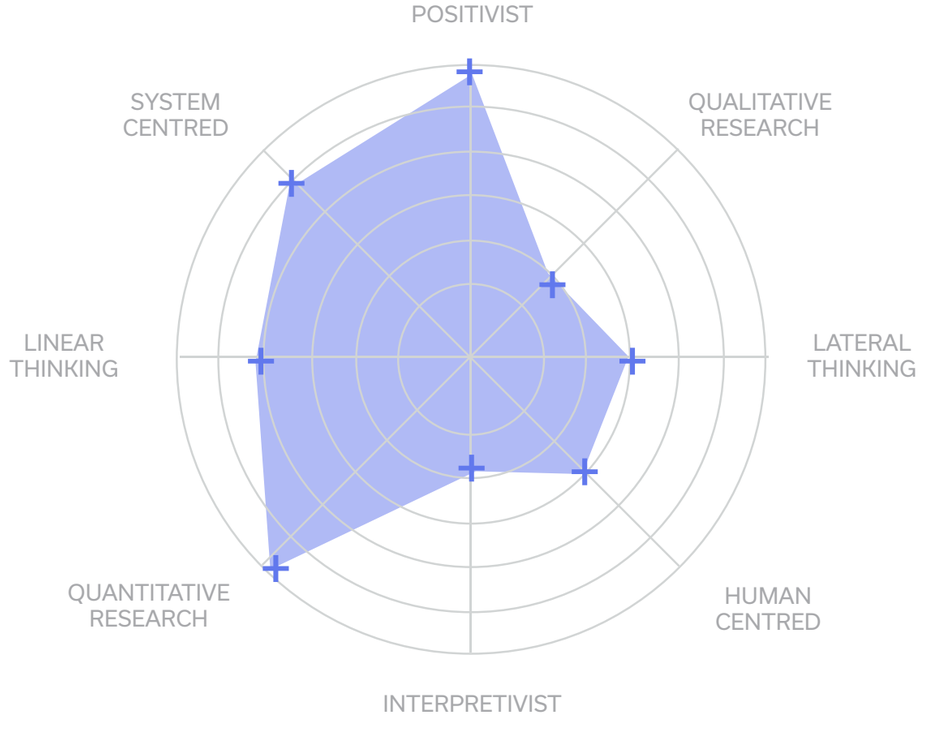
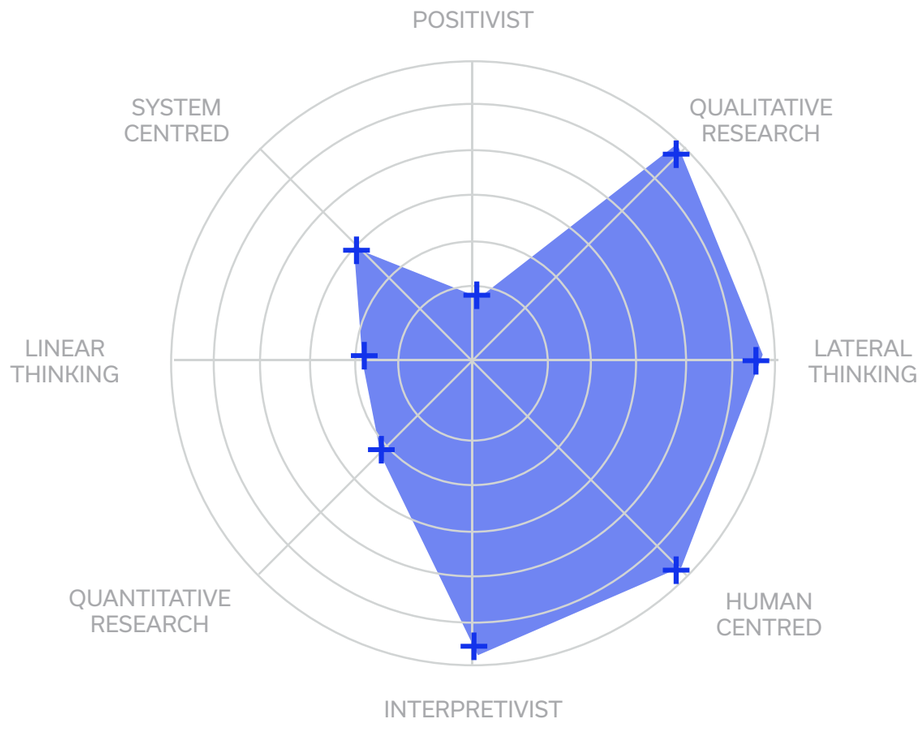


Figure 7.
Health Discipline Polar Chart

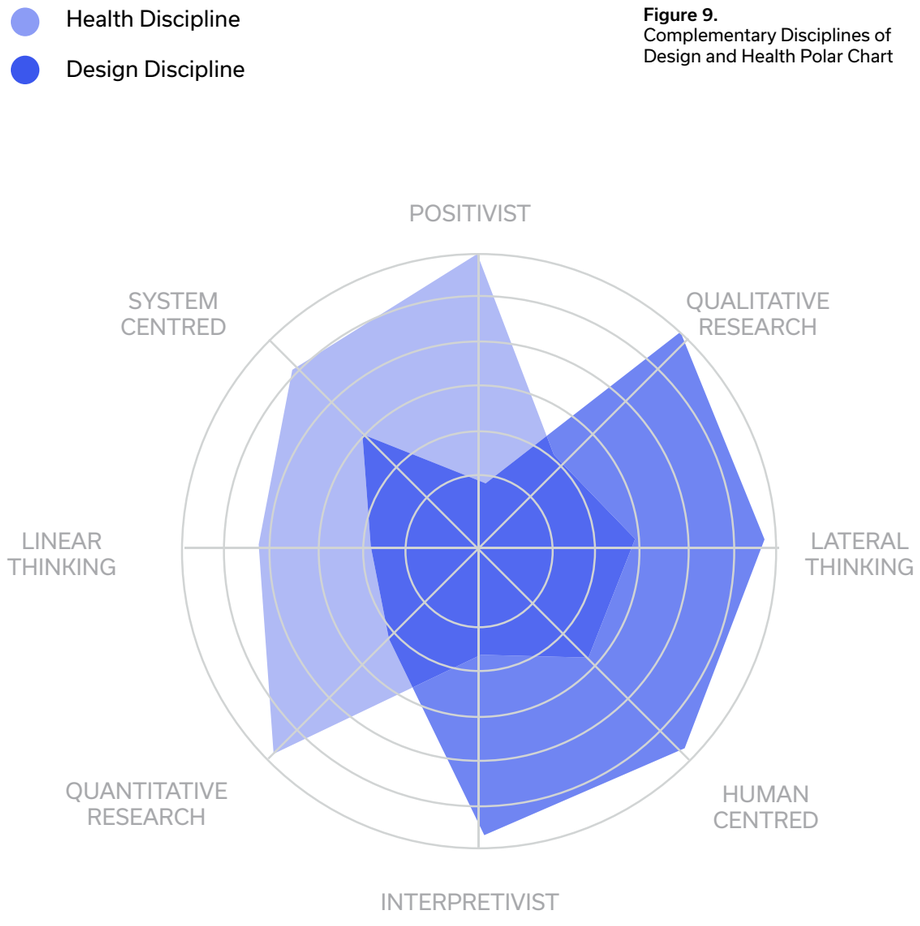
Design research predominantly utilises qualitative research to explore user journeys and perspectives to identify the need for an intervention and measure its success. Leaning into interpretivism, design research works to unpack subjective meanings that people bring to situations, addressing the grey areas quantitative data doesn't (Arghode, 2012), see Figure 8. The subjectivity of qualitative research can be viewed as a limitation, as the researcher's interpretation defines the insights gathered.

Figure 8.
Design Discipline Polar Chart



A collaboration between the two disciplines expands the breadth of research expertise across both quantitative and qualitative methods as shown in Figure 9. As each discipline's traditional approaches are grounded in the same human-centred values a multiple disciplinary team can strategically implement quantitative or qualitative processes determined by how to best meet the needs of the project and stakeholder community.

Figure 9.
Complementary Disciplines of Design and Health Polar Chart



2.4a FRAMEWORKS

In the health context quality improvement projects are typically addressed using the Model for Improvement framework (MFI) and Plan, Do, Study, Act (PDSA) cycles shown in Figure 10.

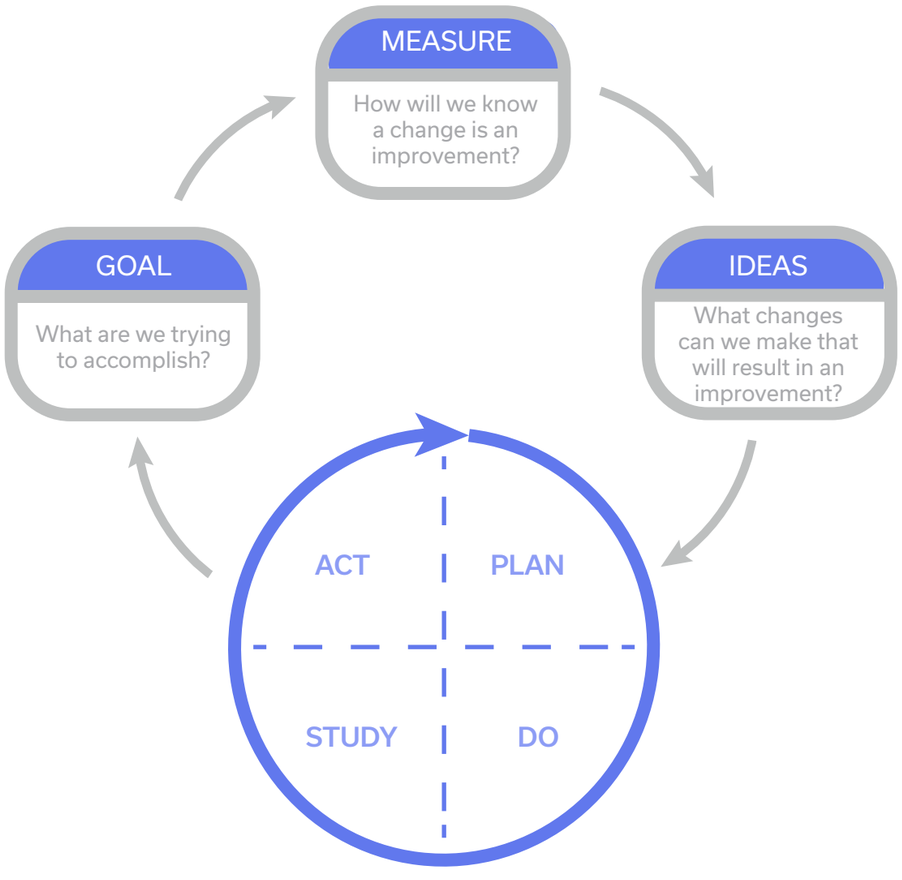


Figure 10.
Model for Improvement & PDSA cycles

Note. Adapted from "The improvement guide: Practical approach to enhancing organizational performance, 2nd Edition," Langley et al., 24, Copyright 2009 with permission from John Wiley and Sons.

In response to the growing complexity of health environments and networks these methods are purposefully designed to analyse and unpack systems (Crowe et al., 2022). MFI and PDSA instruct an iterative series of interventions, where the impact of each intervention is quantifiable (Langley et al., 2009).

Complementary to this, design thinking is purposefully designed to analyse and unpack the human perspective within a system (Crowe et al., 2022). However, design research is notoriously non-linear, which is a characteristic that Raposo et al. (2022) suggest can be alienating to non-designers wishing to engage in a design process. Over time the necessity for designers and non-designers to collaborate to tackle wicked problems has continued to increase, with the deepening interconnectedness of systems. Therefore, designers must master the development of a product and a contextual understanding of the system it is housed within (Raposo et al., 2022). As such, the demystification and clarification of the design process to non-designers has become vital.

Several models have been developed to represent the design process. In this research the Double Diamond model has been selected for its widely accepted and accessible depiction of the design process (Ball, 2019). Shown in Figure 11 the Double Diamond model depicts the process as a series of divergent and convergent thinking labelled Discover, Define, Develop and Deliver.

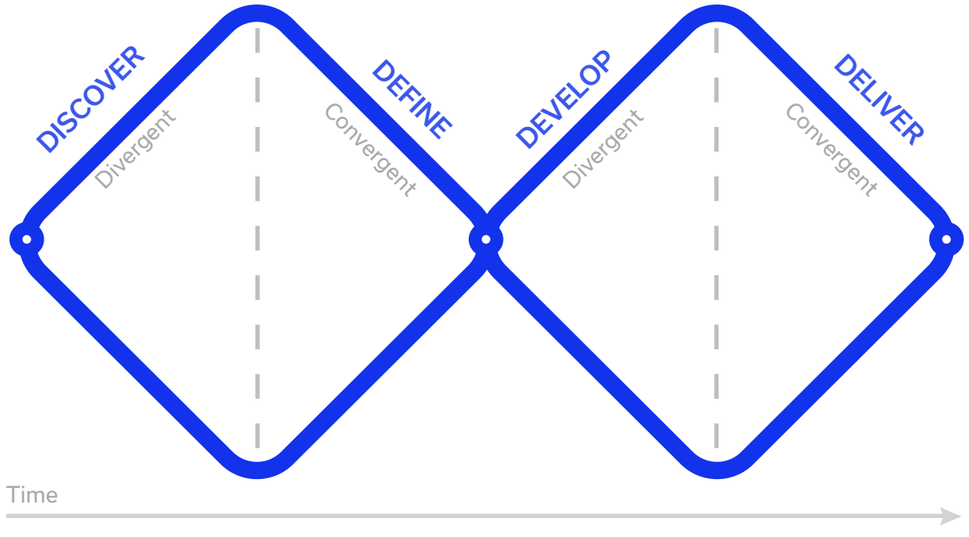


Figure 11.
Double Diamond

Note. Adapted from Design Council, n.d. CC BY 4.0

The benefit of the Double Diamond model is its non-prescriptive simplicity (Raposo et al., 2022). It is a palatable externalisation of a design process which suggests to designers and non-designers alike where they are positioned in their journey and what their current objective is. However, the design journey is largely undefined. Leaning into Schön's theory of Reflective Practice (1983), multiple disciplinary teams must critically reflect on their implementation of methods to define their path forward. This reflection and discussion can bring together a shared understanding for collaboration throughout the process.

> **A tremendous opportunity exists to further enhance contemporary healthcare improvement efforts by integrating the human-centred methods of design thinking**
>
> (Crowe et al., 2022, p. 70)

Crowe et al. (2022) recognised that the Double Diamond and MFI are grounded in the same principles but designed to address different aspects of an overall experience. Recognising how the frameworks complement one another they developed a hybridised model shown in Figure 12. This hybridised model serves less as a functional tool to shape a process than it does a bridge to unify the two disciplines. This allows each discipline to view the framework of the other in relation to their existing paradigm.

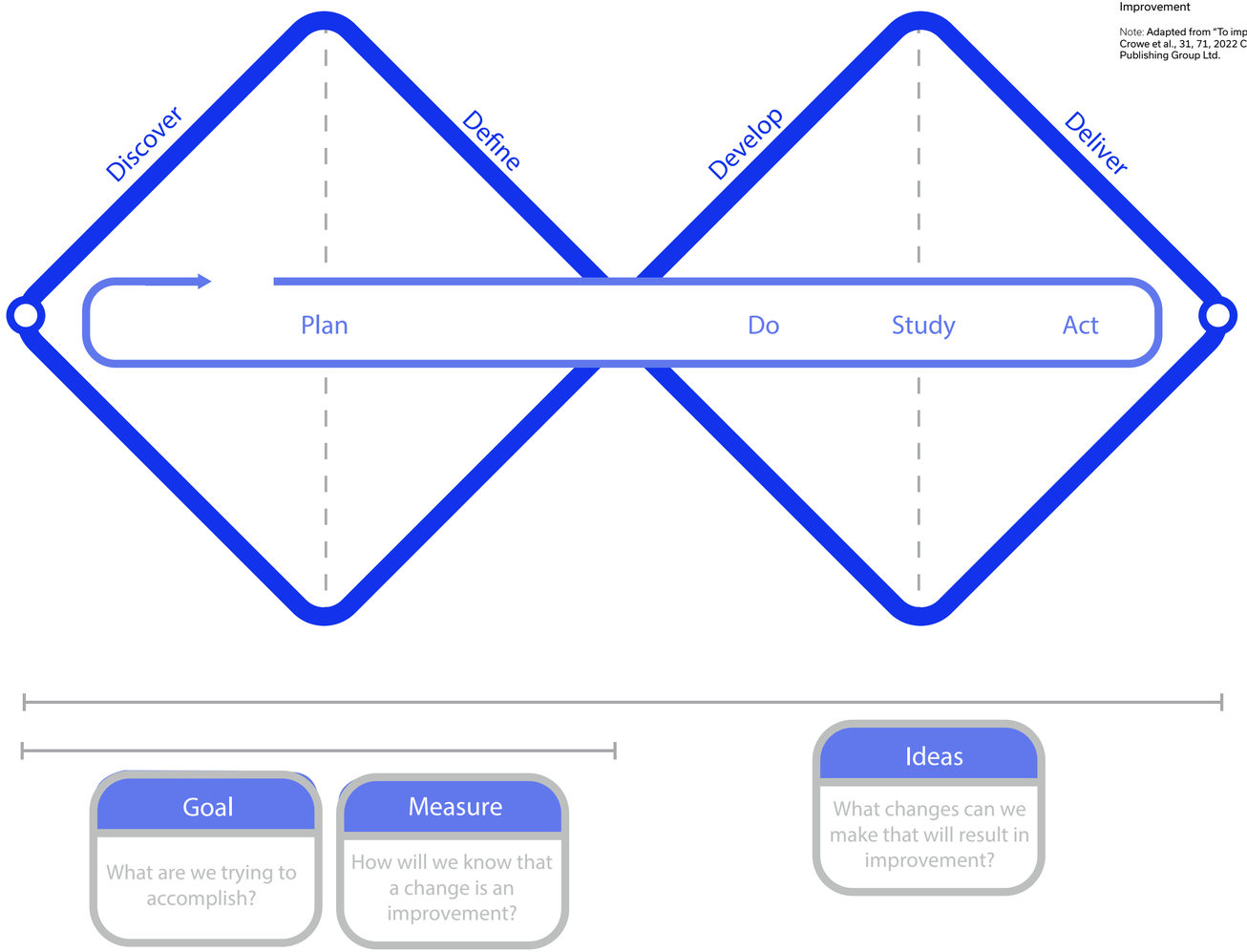


Figure 12.
Integrated Double Diamond and Model for Improvement

Note: Adapted from "To improve quality, leverage design," Crowe et al., 31, 71, 2022 CC BY-NC with permission from BMJ Publishing Group Ltd.

The hybridised model shows that the MFI has particular emphasis on the iterative development of a particular solution. Most of the project's time and energy is spent in the second diamond – develop and deliver. The Double Diamond of design thinking helps health care practitioners to take a step back and invest time in exploring and researching the context, users and existing technology that could improve the situation before defining and implementing PDSA cycles.

> **When applied together, they can be complementary and synergistic, creating balance between clinical and process goals and human emotions, forces that are commonly in tension in healthcare.**
>
> (Crowe et al., 2022, p. 71)

2.4b CASE STUDIES: COLLABORATIVE IMPROVEMENT PROJECTS

CASE STUDY ONE

Integrated Co-design:
A model for co-designing with multiple stakeholder groups from the 'fuzzy' front end to beyond project delivery

Kerr et al., 2022

The Kerr et al. (2022) designed inclusionED is a digital platform for the Australian education system designed to support diverse learners and their teachers, funded by the Australian Government. The design research team collaborated with stakeholder communities including students with Autism Spectrum Disorder (ASD), their parents and teachers in varying frequencies throughout the project to gather a collection of insights on user-experiences, perspectives, and values to inform the design process and outcomes. Participants were selected through the researchers' existing networks and a range of methods were implemented, including co-design workshops, concept critiques and user testing.

From this project Kerr et al. (2022) extrapolated an 'Integrated Co-Design Concept Model' for application to future co-design projects. Figure 13 is an adaptation of this model.

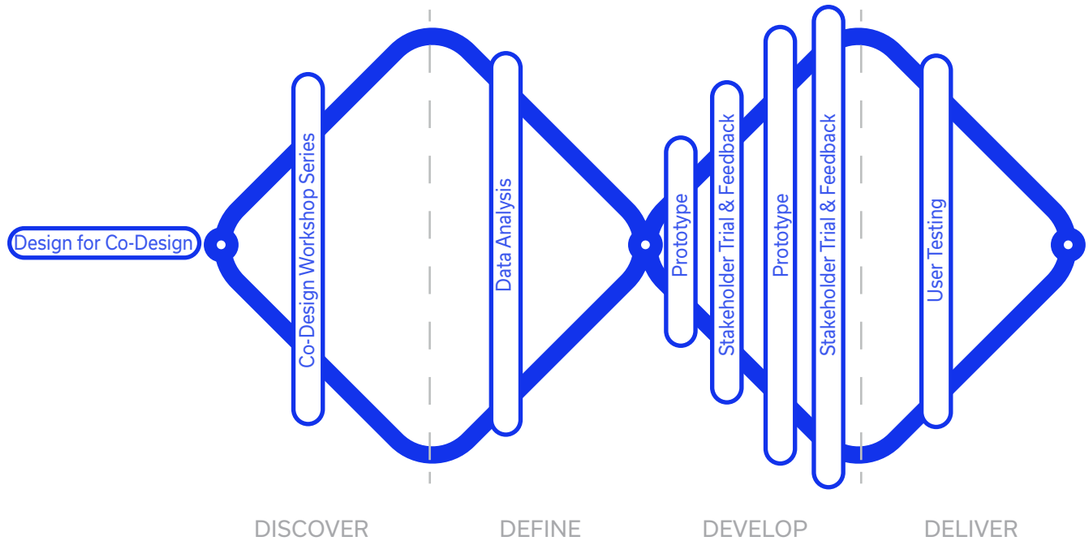


Figure 13.
Integrated Co-Design Model

Note. Adapted from Kerr et al., (2022). Integrated co-design. International Journal of Design.

Notably, Kerr et al., (2022) recognise the significant time investment required in the 'behind the scenes' aspects of co-design, introducing a pre-design phase into the framework termed "Design for Co-Design".

This case study successfully demonstrates the benefits of integrating end users and stakeholders across the design process, particularly how each method within a design process influence and enriches the following steps and consequently the overall design outcome.

For example, during a co-design workshop attended by students with ASD researchers identified a strong preference toward the disuse of language that directly referred to autism. This insight shaped the framing and language used in subsequent co-design methods, to create a positive collaborative environment and ultimately a design outcome that presented a positive experience for the communities it served.

Additionally, in workshops attended by parents and teachers of students with ASD the participants identified that teachers were required to meet the needs of a wide range of diverse learners, not solely ASD. Therefore, the tool could benefit a wider stakeholder community than initially anticipated. As a response to this the language used in the research, development and final design of inclusionED was broadened to reflect the diversity in this community.

After incorporating stakeholder insights, a prototype was developed and presented at two inclusive education forums for feedback. The positive feedback served as design validation and thus inclusionED has been launched and is now an active online tool for educators in Australia, USA, UK, India, and China.

Two characteristics of successful co-design are knowledge flows and shared ownership of a process (Bijl-Brouwer, 2019). Therefore, a limitation of this case study's co-design process is the isolated engagements between design researchers and stakeholders. It would be valuable for the design researchers to make an active effort to address and dismantle the traditional researcher-subject hierarchy to establish meaningful relationships with the participants. This would be valuable as it would empower the participants to take an honest and active role in shaping the research, reducing the social complexities that may result in participants saying what they think should be said.

Figure 14.
The Neo Project Co-Design Model

CASE STUDY TWO

Patient Involvement 2.0:
Experience-based co-design supported by action research

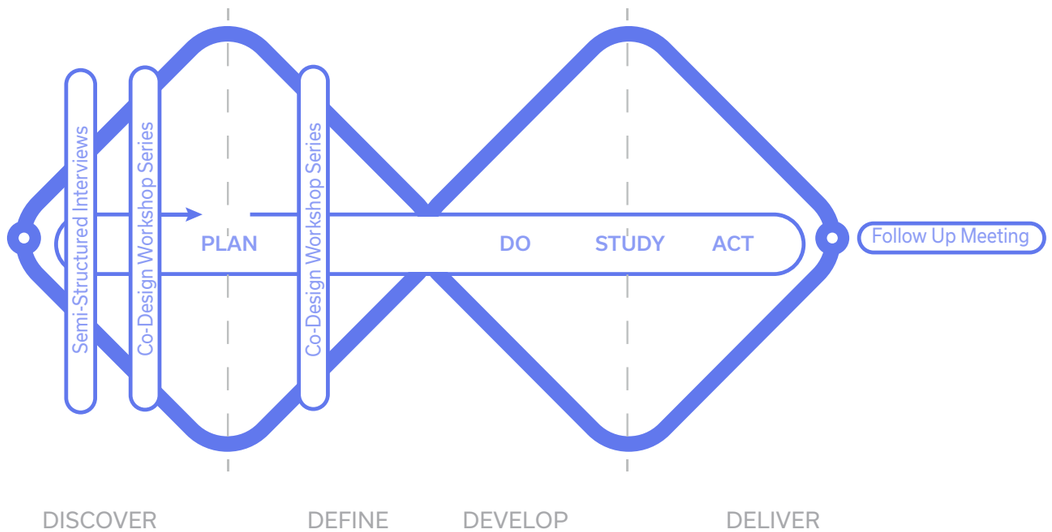
Gustavsson + Anderson, 2019

Gustavsson and Andersson (2019) facilitated a co-design project that aimed to improve the experience of paediatric care in a Swedish Hospital, namely, the neo project. The co-design process was facilitated by a researcher with midwifery experience, who gathered and analysed empirical material from a variety of stakeholder communities. These included nurses, midwives and nursing assistants from maternity, delivery, and neonatal wards and five parents with experience delivering in the hospital and having a child in neonatal care.

The neo project prioritised shared ownership of the process and outcomes by encouraging adaptive roles and reflective thinking across all stakeholders.

Interestingly, the researcher found that their role as facilitator caused the participants to view them as an outsider to the process, whose role is to provide process guidance as opposed to disciplinary specific insight, despite the researcher's extensive experience in midwifery care.

The process implemented four methods depicted in Figure 14.



This project exemplifies the hybridised Double Diamond and MFI process, through its use of PDSA cycles to trial and refine ideas generated in the “discover and define” phases.

A notable characteristic of the neo project’s process is it’s utilisation of reflective thinking. Phases of focused reflection were used as a tool to analyse and inform the co-design process allowing it to be responsive and adaptable to insights from the diverse range of participants. As the project’s outcomes were not defined at the commencement, the solutions evolved through collaboration across the various stakeholder participants producing outcomes that were in response to a genuine need.

A strength of this project is the diversity of stakeholders, representing many perspectives from both professional practice and consumer engagement. However, while the variety of opinions and personal experiences with paediatric care systems enriches the process it also poses a challenge. Innovation is driven by lateral thinking and often familiarity and lived experience with a system makes it difficult to think openly and broadly about improvement opportunities (NHS England, n.d).

The outcomes of the neo project were improved beds for partners, free coffee on the maternity ward, extra training for staff, an improved help alarm, and implementing cross ward meetings (Gustavsson, 2014). It may have been beneficial to introduce outside perspectives, such as those of designers, to facilitate innovative, lateral thinking. The introduction of design expertise particularly in the “discover” phase may have helped to challenge existing assumptions and modes of thought to stimulate idealistic future focused ideation.

2.5 CHALLENGES OF CO-DESIGN

Health contexts, particularly hospitals, are uniquely complex environments, constituted of large, ad-hoc, revolving teams with geographical dispersion (O’Leary et al., 2012), which designers tend to underestimate (Reay et al., 2021). Consequently, co-design within a complex system comes with challenges.

Practically, it is found that challenges lie within the variance in regulation across and within health entities (Nakarada-Kordic et al., 2021). Reay et al. (2017) discuss how a lack of resourcing and the unpredictability of workloads for healthcare practitioners can slow down the design process, as well as add challenges when engaging with consumers. These challenges of consistent engagement can prolong a design process and cause challenges in generating a high-quality design outcome (Donetto et al., 2015).

Due to the dynamicity of health care teams, a characteristic that should be noted by designers is hierarchy (Ní Shé & Harrison, 2021). As health practitioners often work across multiple disciplines in health contexts, for example one patient may have a nurse, a doctor, a dietician, and a physiotherapist to support them, hierarchies are commonly at play (O’Leary et al, 2012).

Generally, Nakarada-Kordic et al. (2021) observed how differences in disciplinary values, priorities, intentions, methods and frameworks can cause tension between health and design disciplines. For example, the time invested in co-design often doesn’t align with traditional work plans and key performance indicators (van der Bijl-Brouwer, 2019), because most of the work goes on behind the scenes and time investment is required to build authentic relationships (Ní Shé & Harrison, 2021). This barrier can inhibit the richness of a co-design team as designers may find themselves having to prove the value of the process (Nakarada-Kordic et al., 2021).

A traditional health research paradigm of evidence-based practice considers experimental design and the randomised controlled trial to be paramount (Chamberlain & Craig, 2017) with little consideration of lateral methods, and qualitative trials that design processes lend themselves to. These fundamentally different approaches cause health and design disciplines to create box definitions for one another (Chamberlain and Craig, 2017). This is exemplified by Driver et al . (2011) who conducted three case studies of collaborations between industrial designers and scientists at a UK university. Overall, Driver et al. (2011) found that scientists viewed designers as a service only required in the final stages of a project to “tart it up ” (p. 9), as opposed to a collaborator. This insular mode of thought inhibits problem solving (Verkerke et al., 2013) and is a significant barrier to realising the potential power of health and design collaboration (Chamberlain & Craig, 2017).

These practical and cultural factors all contribute to a reduced quality of communication across a co-design team and requires deliberate thought to navigate.

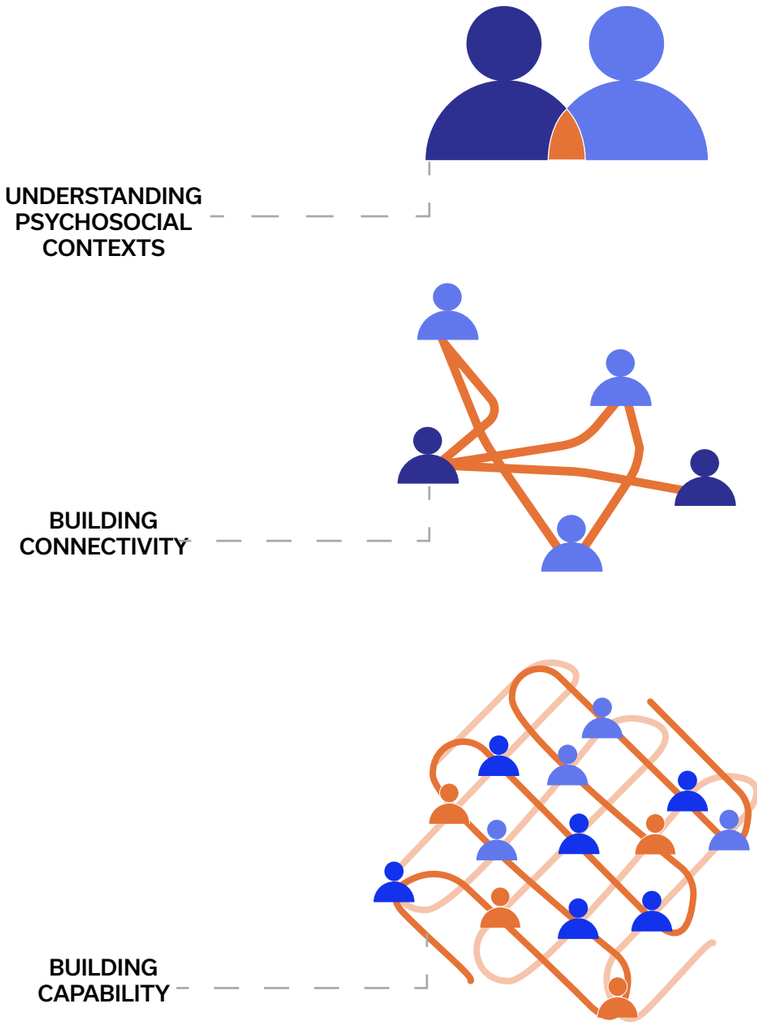


Figure 15.
Design for Health Framework

2.6 MANAGING COLLABORATIVE COMMUNICATION

Nakarada-Kordic et al. (2021) uses the Design for Health (D4H) framework to illustrate how teams can engage in mutually beneficial, productive, creative and engaging co-design processes within design and health disciplines. This framework consists of three fundamental objectives: understanding psychosocial contexts, building connectivity and building capability, shown in Figure 15. This framework is interwoven with the spectrum of collaboration and with the achievement of each objective, a team can move through cross, inter and transdisciplinary collaboration.

Much of the co-design process is invisible and based on building relationships (Ní Shé & Harrison, 2021) therefore, at the outset of a co-design project it is essential to establish an understanding of psychosocial contexts across disciplines. This phase is the foundation work that supports the building of a successful co-design project, and it's important to clarify that all parties see benefit and opportunity in the collaboration. Co-design requires self-reflection to unpack personal assumptions, paradigms and contexts before communicating this transparently to the team. This foreshadows the vulnerability and risk required to shape new ways of working to produce innovative and creative outcomes. Expressing differences within the team allows members to then laterally explore, critique and redefine the context and existing knowledge in order to create a shared understanding of perspective and language (Ní Shé & Harrison, 2021).

Building connectivity stems from understanding psychosocial contexts. In this phase, co-design teams collectively define a shared goal, values and vision and begin building towards it. Revolving roles in the process allow members to explore different disciplinary methods shaping an enrichened creative experience. It is often a designer's role to facilitate creative engagement by building the scaffolds for other disciplines to express their creativity (Chamberlain & Craig, 2017). Ní Shé and Harrison (2021) suggest that throughout this phase and into phase three, building capability and continuous reflective conversation within the team is beneficial. The flexible nature of co-design means that that these reflective conversations allow team members to critique the contribution methods achieving the shared goal, to inform the most effective and productive way forward, tailored to the strengths of the team and needs of the project (Schön, 1983: Donetto et al., 2015).

A practical tool to build capability is having a "champion", a term commonly used in product development and hospital contexts, which refers to someone who supports and pushes for the implementation and successes of a project. In the context of co-design and health it is important to have a champion who is currently practicing in the environment the team is designing for; this acts as a bridge of trust and facilitates engagement with other stakeholders (O'Leary et al., 2012; Shepley & Watson, 2013).

2.6a CASE STUDIES: CO-DESIGN TOOLKITS

The following section explores two co-design toolkits designed to strategise and improve the quality of communication across a design team and stakeholder communities.

CASE STUDY ONE

Initiate. Collaborate:
A design for health collaboration toolkit

Reay et al., 2021

The "Initiate. Collaborate" practical toolkit is informed by the D4H framework and is designed to assist co-design teams to achieve transdisciplinarity by embodying the three pillars of the D4H framework. "Initiate. Collaborate" is a gamified workshop where a deck of cards facilitates the development of a shared agreement of how the team will collaborate. This journey is visualised by displaying the completed cards on the provided mapping poster.

The strength of this tool is the externalised facilitation through the game which allows all team members to play an equal role in shaping the expectations for collaboration. A game format was selected as it doesn't assume existing knowledge or experience, placing participants from varying disciplines on a level playing field. As the game progresses participants share disciplinary specific knowledge to build a shared resource.

The toolkit was iteratively developed within the project team, tested through various hypothetical situations, and trialled engagement with different users and personality types as they tested how the game could manage and direct the creative flow with different personality types.

Figure 16.
Initiate. Collaborate Cards

Note. From "Initiate.collaborate. Design for health collaboration toolkit" by Reay et al., 2021, Design for Health, 5(3), 307 (DOI 10.1080/24735132.2022.2045091). Copyright 2021 with permission from Elsevier.

Figure 17.
Initiate. Collaborate Poster

Note. From "Initiate.collaborate. Design for health collaboration toolkit" by Reay et al., 2021, Design for Health, 5(3), 307 (DOI 10.1080/24735132.2022.2045091). Copyright 2021 with permission from Elsevier.

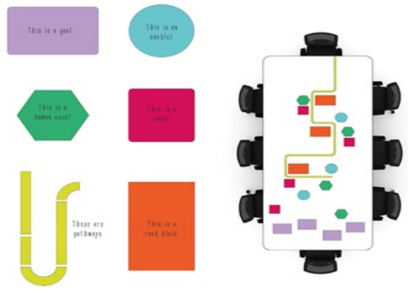
CASE STUDY TWO

Tactile co-design tools for complex interdisciplinary problem exploration in healthcare settings

Heiss + Kokshagina, 2021

Design researchers Heiss and Kokshagina (2021) developed a tactile toolkit for co-design workshops to improve the quality of communication in multiple disciplinary teams. This toolkit addresses establishing a common language, challenging social hierarchies and having equal opportunities in decision making.

The participants in this co-design workshop comprise of stakeholders including clinicians, allied health workers, social support working and existing consumers. The facilitator and observer roles are occupied by designers. The toolkit is to be used on a papered table and consists of a variety of mobile coloured tiles. Each variety of tile corresponds to a prompt, these include, goals, roadblocks, workarounds, pathways or moments of empathy.



In the co-design workshop, interdisciplinary teams of 4-5, are provided with a persona. Through the shared examination and discussion of this persona the teams establish a goal. Using the aforementioned tiles, a map is built to achieve this goal informed by the participants' disciplinary insights.

The Tactile Co-Design Toolkit also fosters iterative development of the journey, allowing unresolved ideas to hold space and relationships within the journey to evolve as more information is shared. As teams continue to work through the co-design toolkit and their collaborative vision becomes more defined and clear they can revise how they've defined an object to align with their desired vision more effectively.

Interestingly, not only does the toolkit facilitate co-design but the toolkit itself is co-designed. The comparative case study of the implementation of this tactile toolkit in co-design workshops from 2015-2019 compares the strengths and weaknesses in the iterative development. A reflection on the outcome's quality is measured both through observations by designated designers as well as through structured feedback from participants.

Figure 18.
Tactile Co-Design Toolkit Components

Note. From "Tactile co-design tools for complex interdisciplinary problem exploration in healthcare settings," by Heiss, L., & Kokshagina, O, 2021, Design Studies, 5(3), 9 (DOI 10.1016/j.destud.2021.101030). Copyright 2021 with permission from Elsevier.

Figure 19.
Tactile Co-Design Toolkit in use

Note. From "Tactile co-design tools for complex interdisciplinary problem exploration in healthcare settings," by Heiss, L., & Kokshagina, O, 2021, Design Studies, 5(3), 15 (10.1016/j.destud.2021.101030. Copyright 2021 with permission from Elsevier.

Initiate. Collaborate (Reay et al., 2021) and the Tactile Co-Design Toolkit (Heiss & Kokshagina, 2021) require collaboration from the outset of the exercise, providing participants with prompts to discuss and create their own definitions and objectives. This encourages knowledge flow as a foundation, allowing participants to gather insights into each other's perspectives and expertise to unpack their psychosocial contexts. This strategy exemplifies the strengths of establishing a unified goal at the outset to improve the quality of communication between stakeholders in sequential phases.

Notably, both toolkits draw on the principles of tactility to facilitate externalisation, each utilising an object, whether it be a card or a tile, as a tool for participants to apply a meaning to. This process moves the ownership of an idea away from the individual and to the collective, reducing the influence of social hierarchies and personal attachments.

The act of building and defining is prevalent in both Initiate. Collaborate and the Tactile Co-Design Toolkit and is an innately creative process, demonstrating the ability of non-design participants to contribute to a design process meaningfully and actively. This helps to challenge and unpack thought paradigms and build confidence in engaging across disciplinary boundaries.

Although both of these toolkits are centred on understanding psychosocial contexts across disciplines, it is important to note the variation between toolkits in what is required of the participants to achieve this. The differences in exercises exemplify that there is no "one-size-fits-all" tool that is applicable for all co-design teams. These toolkits are to be utilised and strategised by each team, with thought paid to the best way of working for their disciplinary experiences, personalities, and modes of knowledge sharing.

The semi-continuous adaptation and development of the toolkits aligns with Schön's (1994) reflection in action model and allows fluidity in the toolkit to be tailored to best support a given team.

2.7 INITIAL REFLECTIONS

In my contextual research, I have found clear value in integrating designers and design thinking into co-design for shaping the future of healthcare systems. However, there is much variation in the role of the designer in a co-design process across the cases studied. I am interested in exploring how to navigate the balance of facilitation and contribution, through facilitating a creative co-design process with non-designers and contributing disciplinary expertise.

The emphasis throughout the literature on the importance of trust, understanding and communication between individuals and disciplines in co-design projects and the subsequent positive impact this nurtures bring a human-centred perspective to the research design. As the Cold Chain – Quality Improvement project is the first project developed under the collaborative 'Individual Access Agreement' between CoCA and CCHV, this will be an aspect of significant benefit for both parties and will require intentional thought and time investment.

I expect that as the Cold Chain – Quality Improvement project develops, the role I play as an industrial designer and the methods put in place by the team to facilitate creating a trusting, safe, collaborative environment between disciplines will allow the team to identify and discuss any misnomers, preconceived attitudes or ideas about the other discipline. These discussions may help to reframe thought paradigms and demystify the other discipline and their processes, facilitating knowledge flows and building confidence in the teams' ability to implement methods and processes that are traditionally found in the other.

Personally, as an industrial designer with limited experience working in a health context I am eager to discover what challenges and opportunities arise in this collaboration, what methods facilitate effective communication across disciplines and produce insights and experiences which are rich and valuable to the progression of the Cold Chain – Quality Improvement project and the team. I am curious as to how the designer's perspective will influence the project's development, challenging existing thought paradigms and perhaps catalyse potential outcomes. Furthermore, as the Cold Chain – Quality Improvement project progresses I am interested to assess if there are challenges that can be predicted in co-design projects with health and design, that have been identified in this context review or if these are ever changing dependent on the individuals that constitute a team.

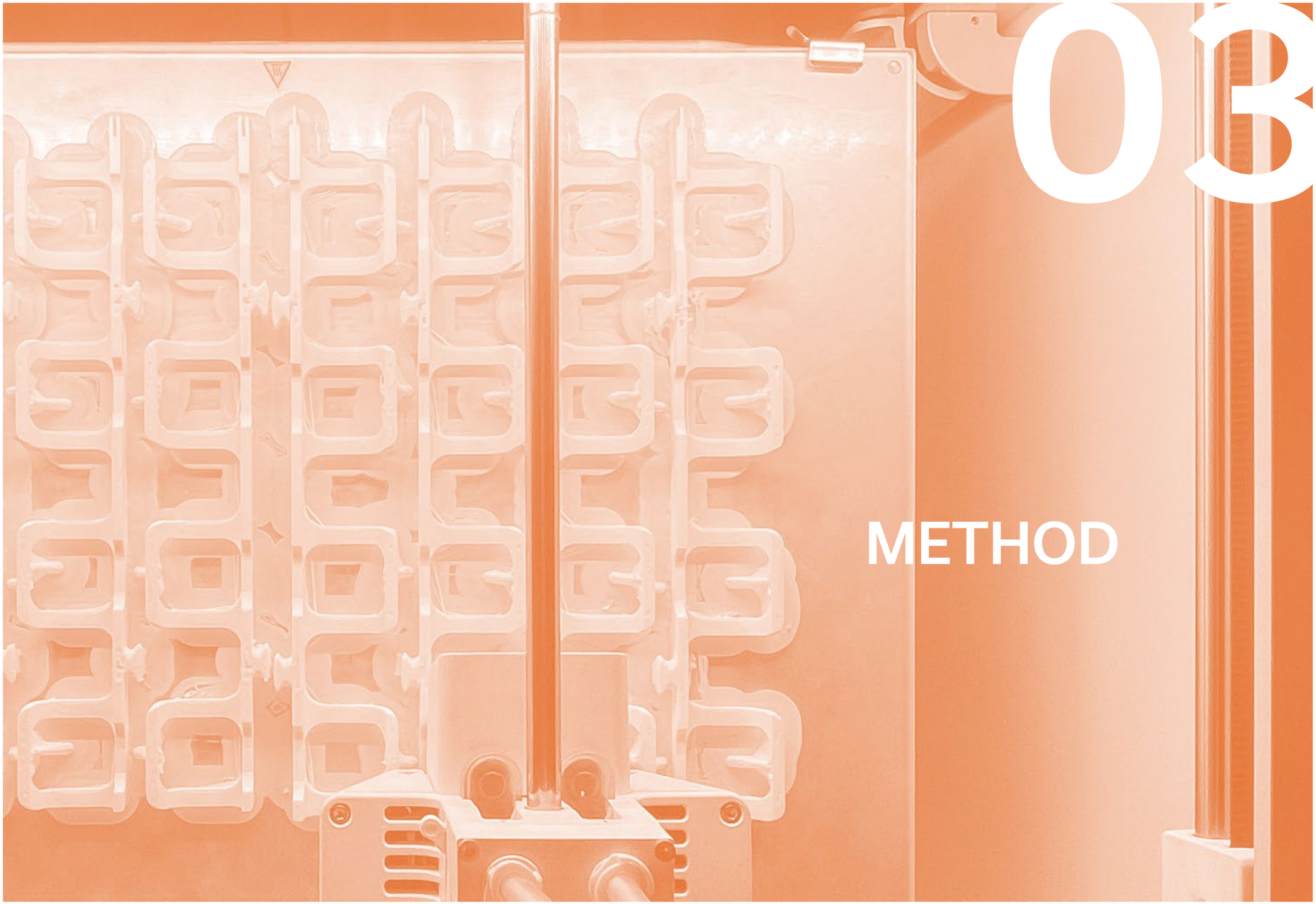


Figure 20.
3D Printing 01

The following chapter is a case study of the mixed methods approach implemented in the development of the Cold Chain Project with Te Whatu Ora: Capital Coast and Hutt Valley (CCHV) and Massey University, College of Creative Arts – Toi Rauwharangi (CoCA). This process drew on co-design methodology to inform the meaningful and engaging development of a design solution which aims to improve the reliability of temperature sensitive pharmaceutical's (TSP) efficacy and management in order to reduce cold chain breaches and failures.

A mixed methods approach was selected to support the complementary nature of health and design disciplines, as discussed in Chapter 2.4.

This case study draws upon quantitative insights and data that justified the need for further innovation to improve cold chain compliance in pharmaceutical refrigerators on hospital wards. These insights triggered this research investigation to develop an understanding of the user interactions and behaviours that may cause these quantitative characteristics.
This case study emphasises the value of both quantitative and qualitative data collection to:

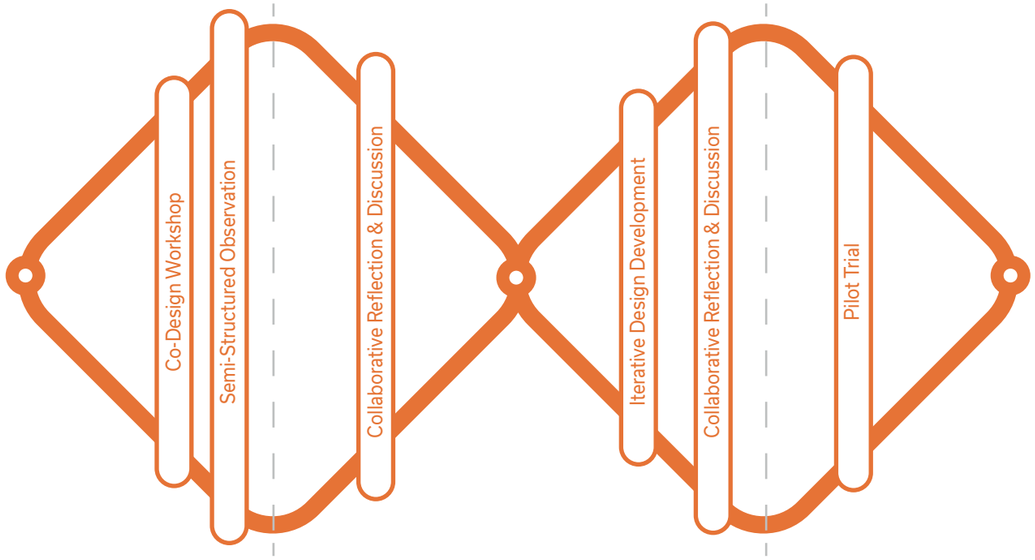
+ Inform meaningful design development and outcomes

+ Create a process that is engaging, conceivable and valuable to participants and team members from both contributing disciplines

This mixed methods approach consists of a co-design workshop, semi-structured observation, iterative design development and a pilot trial. These research methods are woven together with collaborative reflection and discussion as well as engagements centred on relationship building within the multiple disciplinary team.

Figure 21 is an adapted visualisation of the Double Diamond model, demonstrating how each method contributed to the design development process.

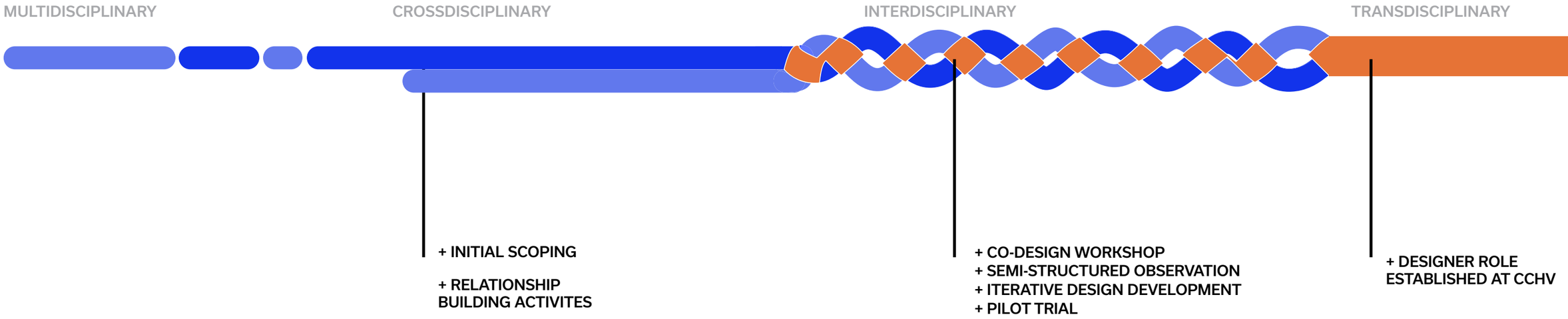
Figure 21.
Adapted Double Diamond Process Map



It is important to note that the adapted Double Diamond model was not a project plan built at the project's commencement, rather, a retrospective visualisation. Informed by the principles of "the Reflective Practitioner" by Schön (1983), this process was shaped as it progressed through collaborative reflection of the subsequent method, this informed the consequent one.

Furthermore, the following diagram depicts how the series of methods implemented in this process contributed to the multiple disciplinary team's progression through the spectrum of collaboration.

Figure 22.
The Spectrum of Collaboration in Practice



04

PROCESS

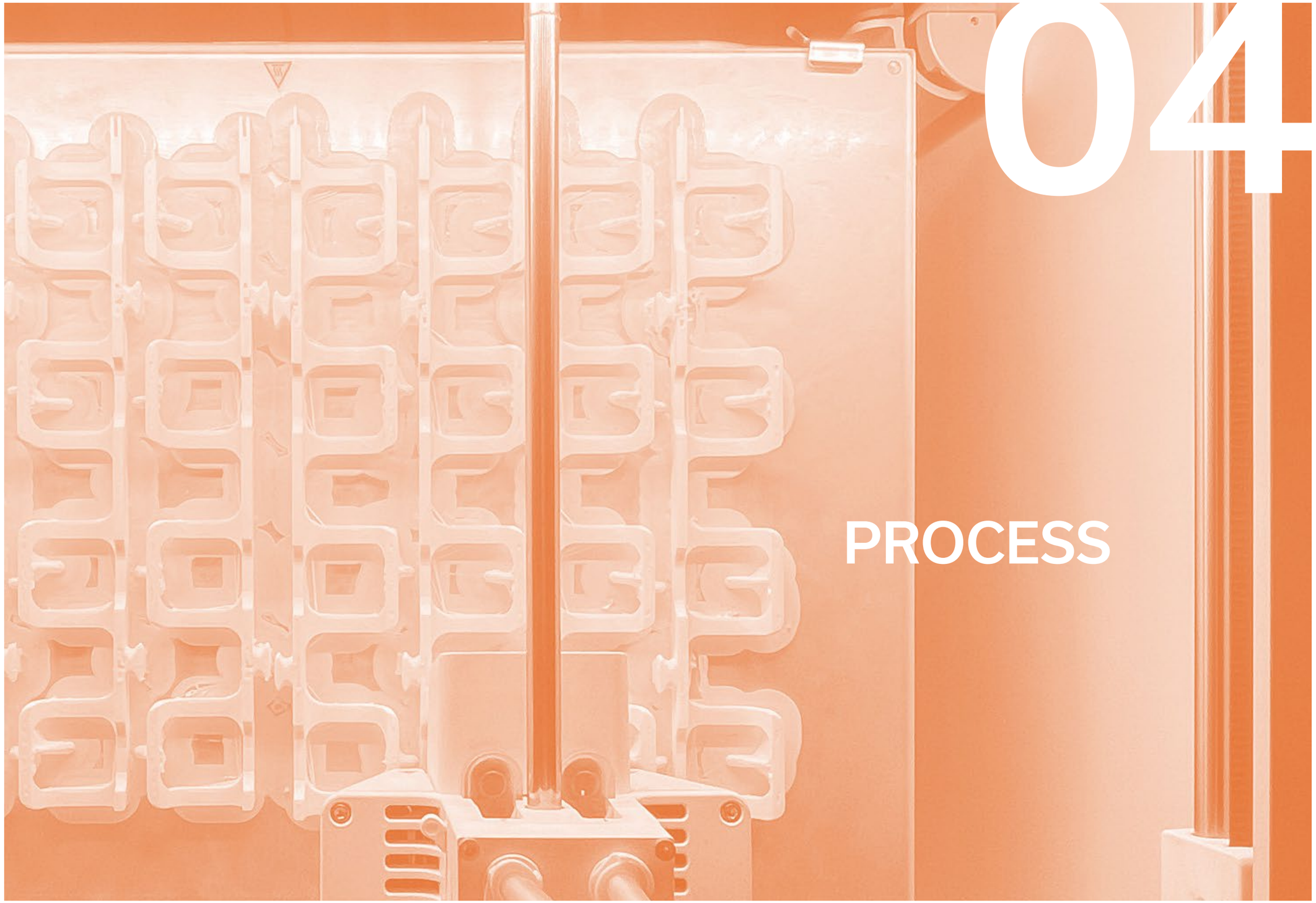


Figure 23.
3D Printing 02

RELATIONSHIP BUILDING AND KNOWLEDGE EXCHANGE

At the outset of the project there was a necessity to build genuine relationships, trust and understanding in multiple disciplinary co-design teams as depicted by Reay et al. (2021).

The mixed methods approach implemented in this master of design was woven together by collaborative reflection and discussion and relationship building activities.

These discussions and activities were not targeted to further the design development of the Cold Chain – Quality Improvement project, rather to shaping and fostering a culture which encouraged knowledge flows, creativity and trust within the multiple disciplinary team. Occurring throughout the research these activities helped team members to build rapport, form genuine relationships and understand psychosocial contexts between disciplines, thus strengthening communication (Nakarada-Kordic et al., 2021) and moving the collaboration into crossdisciplinarity.

The activities included:

- Team members from CoCA completing CCHV's on-boarding process
- FabLab Wellington, situated in Block 11 of Massey University Wellington, hosting an educational session on 3D printing for CCHV's Improvement and Innovation team
- Team members from CoCA supporting the application for funding to purchase of a 3D printer for CCHV's Improvement and Innovation team and assisting in the set up
- CCHV's Improvement and Innovation team displaying healthcare specific industrial design honours projects at their roadshow in two of the region's hospitals
- Team members from CoCA attending information sessions at Wellington Regional Hospital. These included a Rollex Pharmaceutical Refrigerator information session presented by Wellington Regional Hospital's refrigerator technician, and an improvement and innovation workshop
- The researcher completing the Immunisation Advisory Centre, New Zealand's vaccine storage and transport course (see Appendix F)

The mutual commitment and investment into learning and exploring each other's discipline showed respect and a genuine belief in the strength of this design and health collaboration from both disciplines. These activities facilitated crossdisciplinary knowledge flows and as they built a collective knowledge base further interest was incited, and a curiosity to explore the abilities of the collaboration. Each of these activities helped to sustain engagement and motivation for the progression of the project.

The following diagrams depict overviews of the mixed method approach as implemented in this research, these will be discussed in this chapter. These mixed methods continued to develop deeper and wider team relationships with built trust and knowledge.

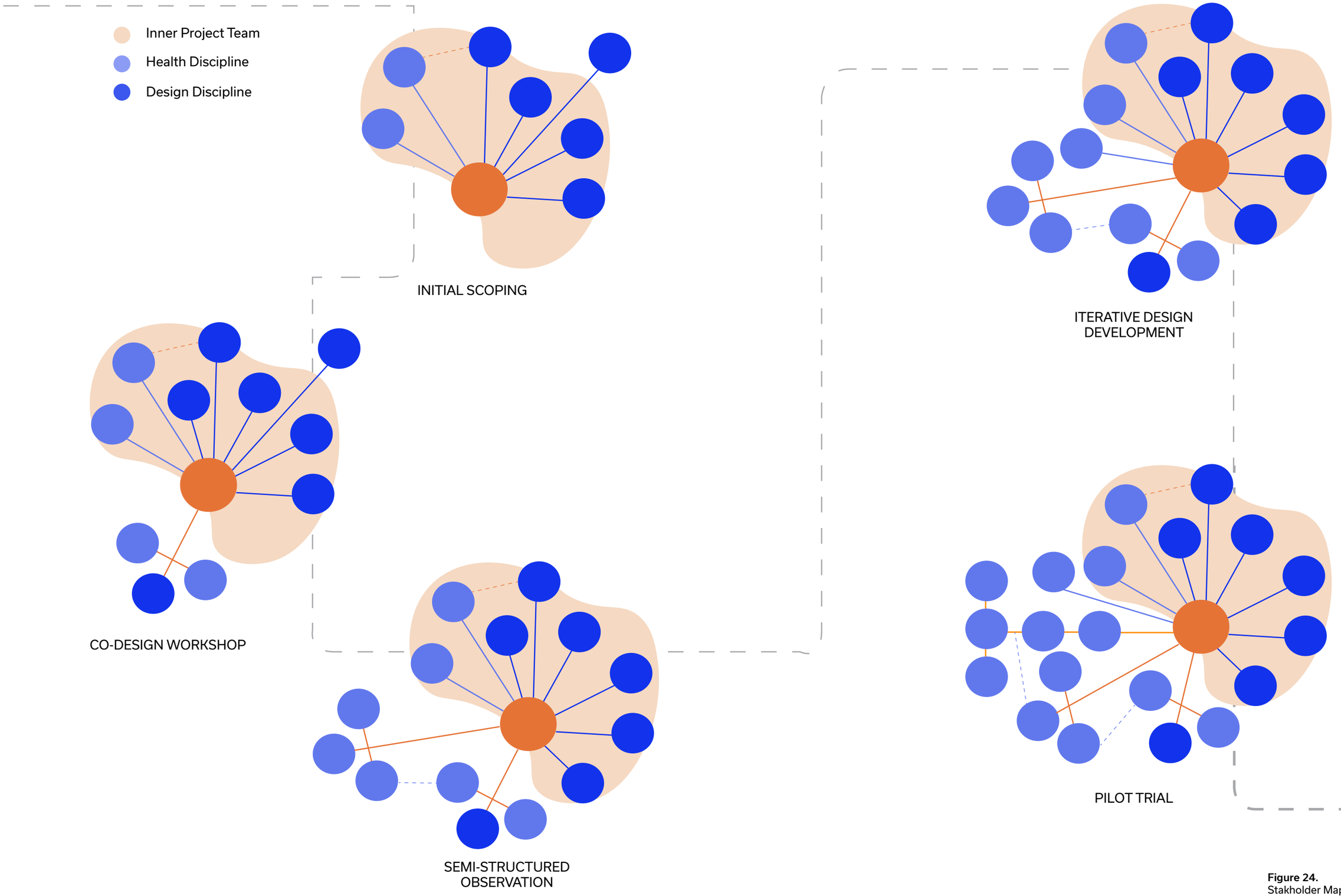


Figure 24.
Stakholder Map - Evolution

The Figure 25 depicts the methods implemented in this research, chronologically from left to right. Demonstrating how these methods built on eachother to generate extensive creative ideas and contribute to the design development. Notably, there are concepts generated that are beyond the scope of this research, it is anticipated that these will continue to be developed under the CCHV and CoCA collaboration.

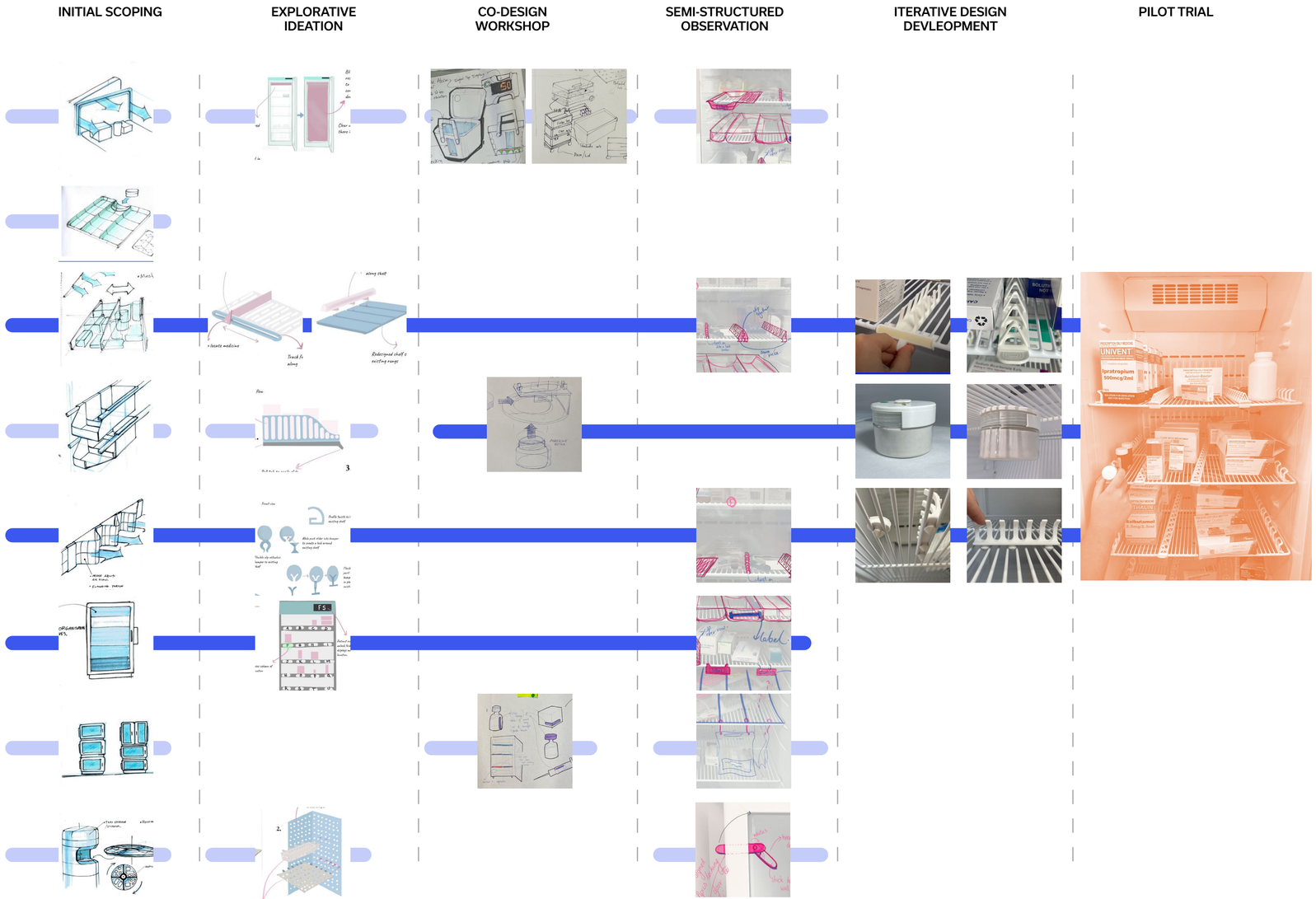
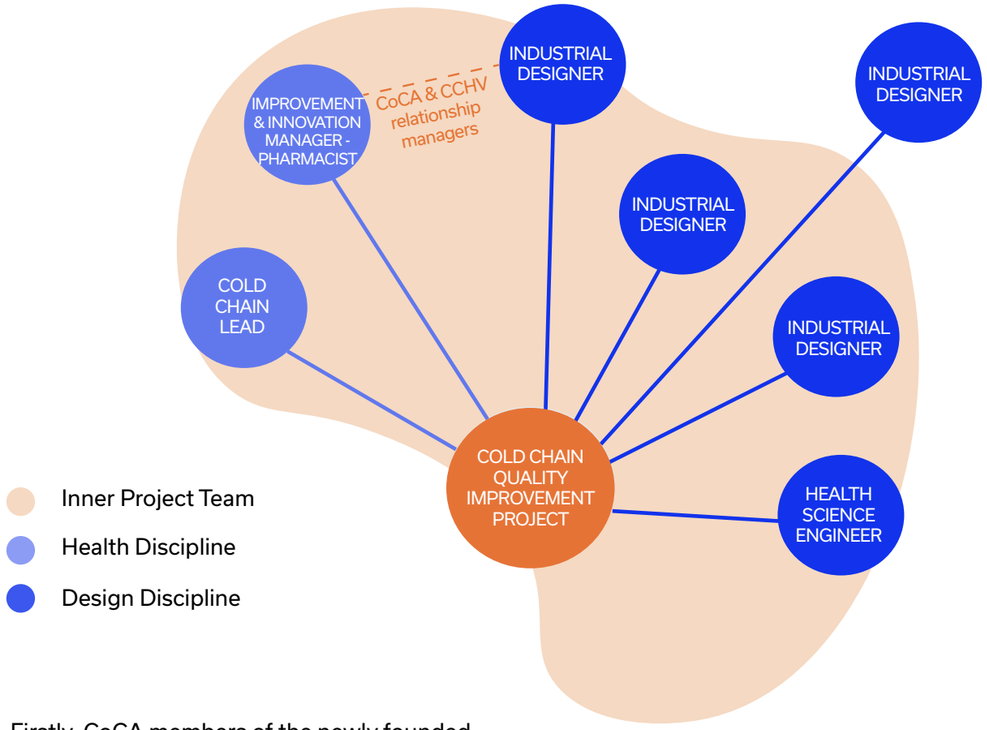


Figure 25.
Concept Development Map

4a INITIAL SCOPING

Prior to the commencement of this master of design research in the foundational stages of the collaboration between CoCA and CCHV an initial scoping phase was initiated. This phase served as an introduction as individuals and to each other's disciplines and organisations. Figure 26 shows the make-up of the foundational team.



Firstly, CoCA members of the newly founded team were taken on a tour of Wellington Regional Hospital's cold chain processes and systems. In the guided tour CCHV team members shared insights about best practice, current issues and contextual influences for cold chain.

Following the initial scoping, CoCA team members used these insights to produce a range of preliminary concept developments presented through sketching, CAD models, renders and prototypes. The preliminary concepts demonstrated the role of a designer in the Cold Chain – Quality Improvement project and the opportunities that arise from the collaboration (see Figure 27).

Figure 26.
Stakeholder Map – Initial Scoping

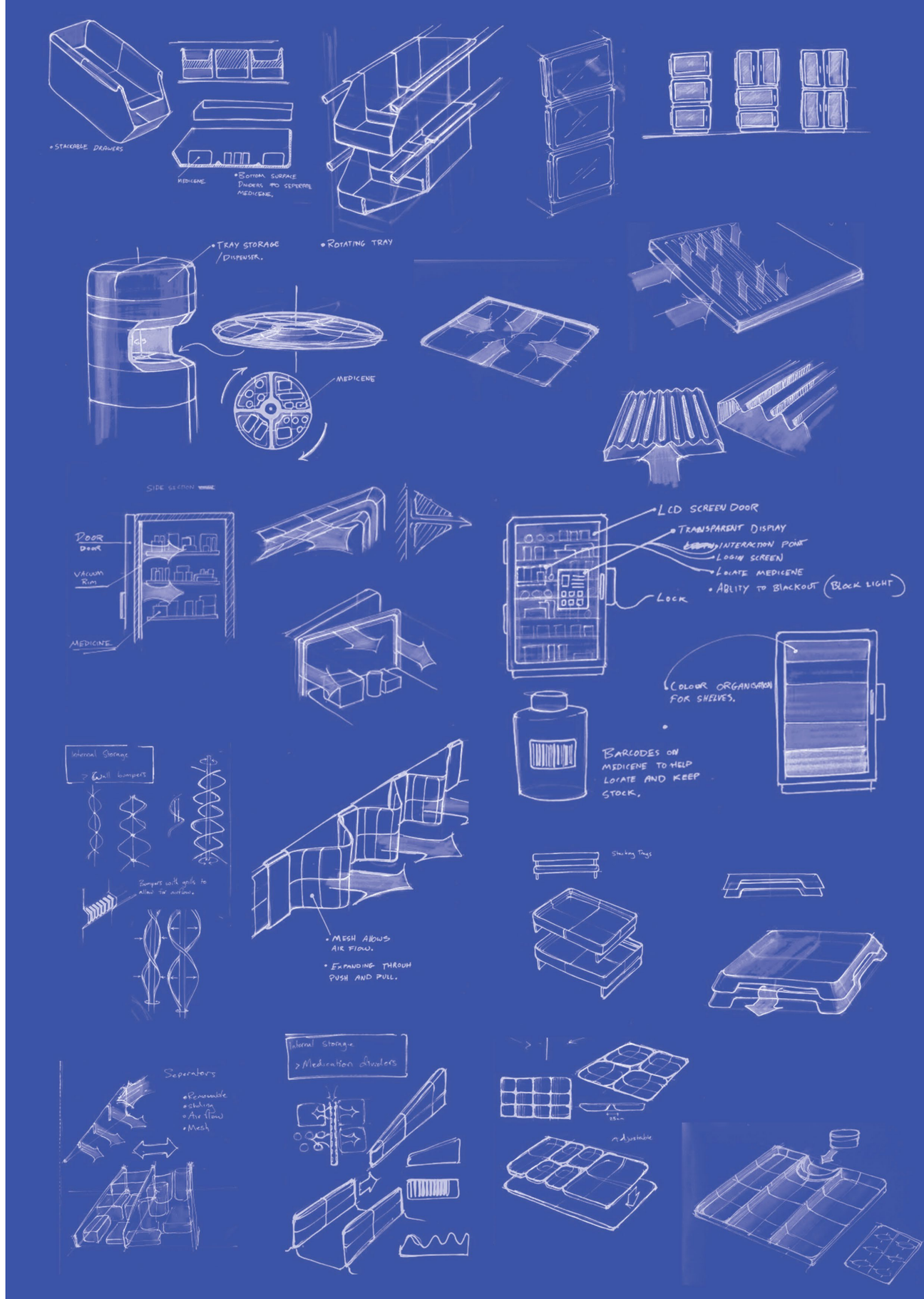
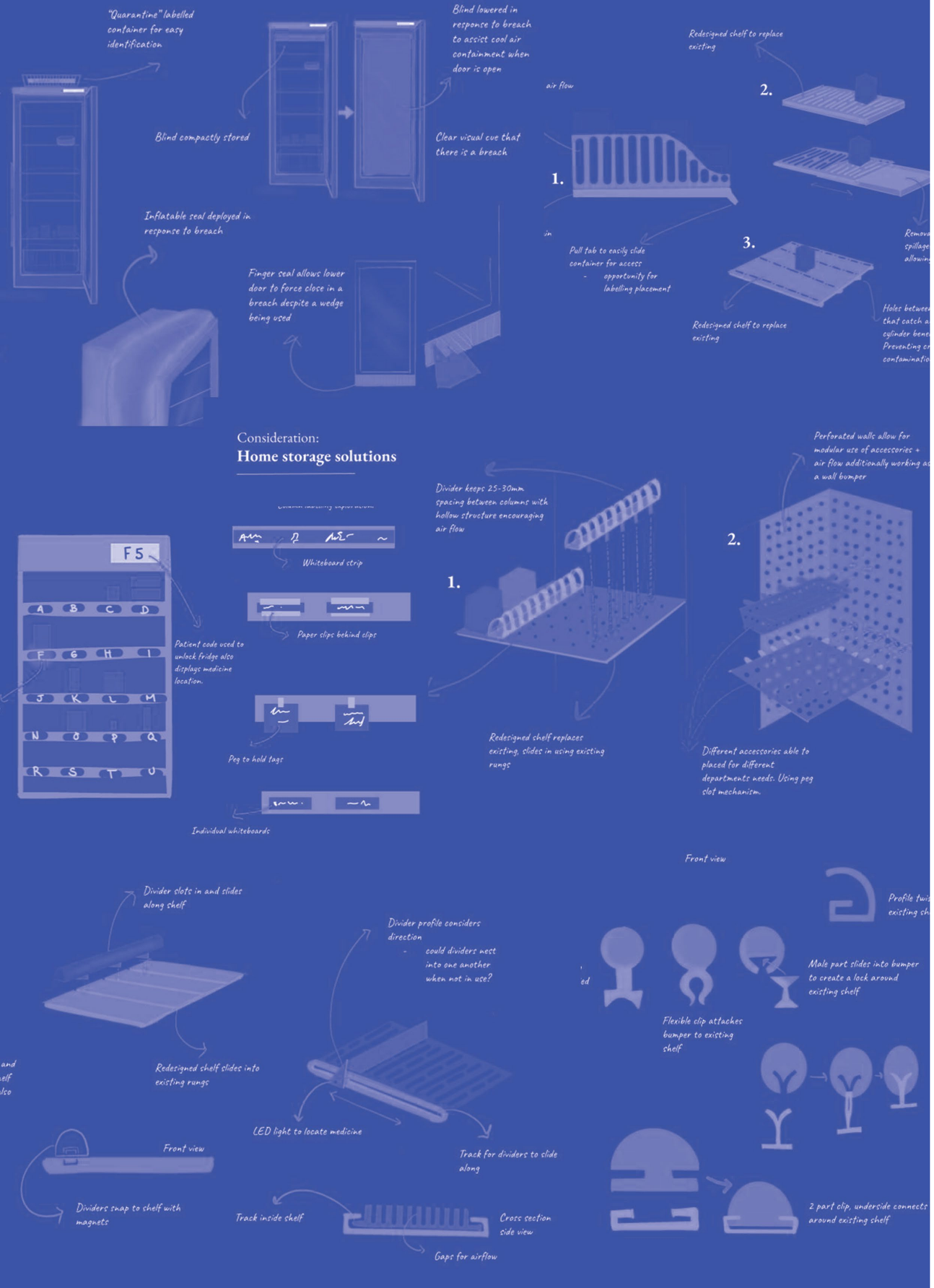


Figure 27.
Preliminary Concepts,

Note. Adapted from foundational CoCA team members, 2021



4b EXPLORATIVE IDEATION

At the commencement of this master of design study the researcher participated in the Immunisation Advisory Centre, New Zealand's (IMAC) vaccine storage and transport course to establish a thorough understanding of cold chain and best practice for TSP management.

Drawing on this the researcher analysed the preliminary concepts to extrapolate key themes, issues and ideas that had been identified prior and undertook an explorative ideation phase (see Figure 28). This served to familiarise the researcher with existing knowledge that had been built within the team. Additionally, the researcher added a new lens to broaden the concepts in the discovery phase of the Cold Chain – Quality Improvement project, through their positioning as an industrial designer and their completion of the IMAC course.

Figure 28.
Explorative Ideation

4c Co-Design Workshop

Figure 29.
Co-Design Workshop 01

Before

The Cold Chain – Quality Improvement project team prioritised two key goals to build upon the foundational knowledge developed in the initial scoping and explorative ideation phases. These were:

+ To build on existing relationships across disciplines and develop new ones

+ To facilitate knowledge flows between disciplines

    + By returning the disciplinary context introduction and showing CCHV team members a design studio environment and demonstrating design processes and prototyping capabilities

    + By mapping typical cold chain pharmaceutical refrigerator use cases and sharing lived experiences

A co-design workshop was selected because it provides an efficient and compelling means of sharing knowledge and building relationships between groups and individuals from different disciplines (Martin & Harrington, 2012).

A design workshop is an organised session typically attended by participants from various disciplines who work together to achieve a shared goal. Facilitated by designers, design workshops can consist of a variety of co-design activities and methods (Martin & Harrington, 2012).

Health specialists were recruited through purposive sampling. The selection criteria ensured that there was representation of a variety of health specialisations from Wellington Regional Hospital. This meant a range of experiences, values and beliefs around cold chain were collected.

The four health specialists were identified and approached through their working relationships with Cold Chain – Quality Improvement project team members from CCHV. A sample size of four was selected as it allowed researchers to collect thorough, in-depth insights from the participants producing direct and distilled information and data (Ames et al., 2019).

Consideration was also paid to the impacts and logistics on rostering if a larger sample of Wellington Regional Hospital healthcare professionals were removed from their practice to attend the workshop. The health specialisations of the participants were: a pharmacist, a nurse, a cold chain lead, and an associate clinical nurse manager.

Design specialists were also selected through purposive sampling. The selection criteria ensured they were able to support healthcare professionals to tease out their ideas and create visualisations. These specialists were recruited from current Massey University industrial design undergraduate and postgraduate students.

Informed consent was obtained before the commencement of the design workshop. Participants were contacted via email with a written invitation to attend and an attached document that outlined the research objectives and itinerary. Participants were thus informed of what the contribution required of them was.

During

The co-design workshop ran from 10am to 4pm, with a catered lunch break. The itinerary was divided into five sections: Introductions, use-case process, use-case problem, use-case opportunities, and concept development.

To commence the workshop a CoCA team member guided personal introductions to welcome everyone to the space, reiterated objectives and activities and outlined general house keeping.

Figure 30.
Co-Design Workshop 02

To start the planned activities participants were divided into four groups, each group consisted of a health specialist and two or three design specialists.

Informed by the expertise and experience of the health specialist each team selected a cold chain use-case scenario. The teams divided the scenarios into key touchpoints, each touchpoint was assigned to a blue post-it note and presented on an A1 poster.

Figure 31.
Co-Design Workshop 03

Examining each touchpoint teams identified any resulting pain points and added them to the poster on pink post-it notes.

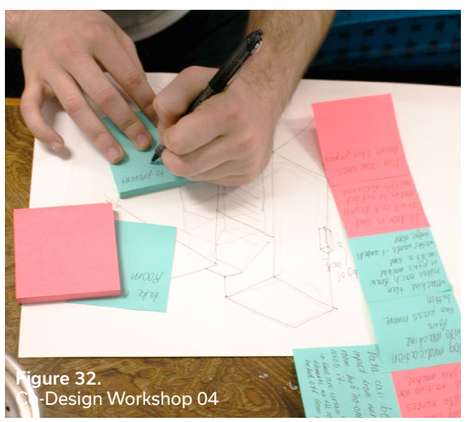


Figure 32.
Co-Design Workshop 04

To build on the experiential touchpoints and pain points teams were encouraged to adopt 'blue sky thinking' to develop possible improvements and solutions through a design sprint. Every 20 seconds for four minutes teams were required to add a new potential solution to the poster, this time on yellow post-it notes.

Further, teams were temporarily dissolved and participants were able to mingle and review other use-case scenario posters. The design sprint was repeated and individual participants added yellow opportunity post-it notes to any poster.

Figure 33.
Co-Design Workshop 02

Reviewing the complete posters participants began to create thematic clusters.

Figure 34.
Co-Design Workshop 03

Returning to the original groups, teams selected a thematic cluster informed by the expertise and experience of the health specialist. Groups began to flesh out concepts and create visualisations.

Figure 35.
Co-Design Workshop 04

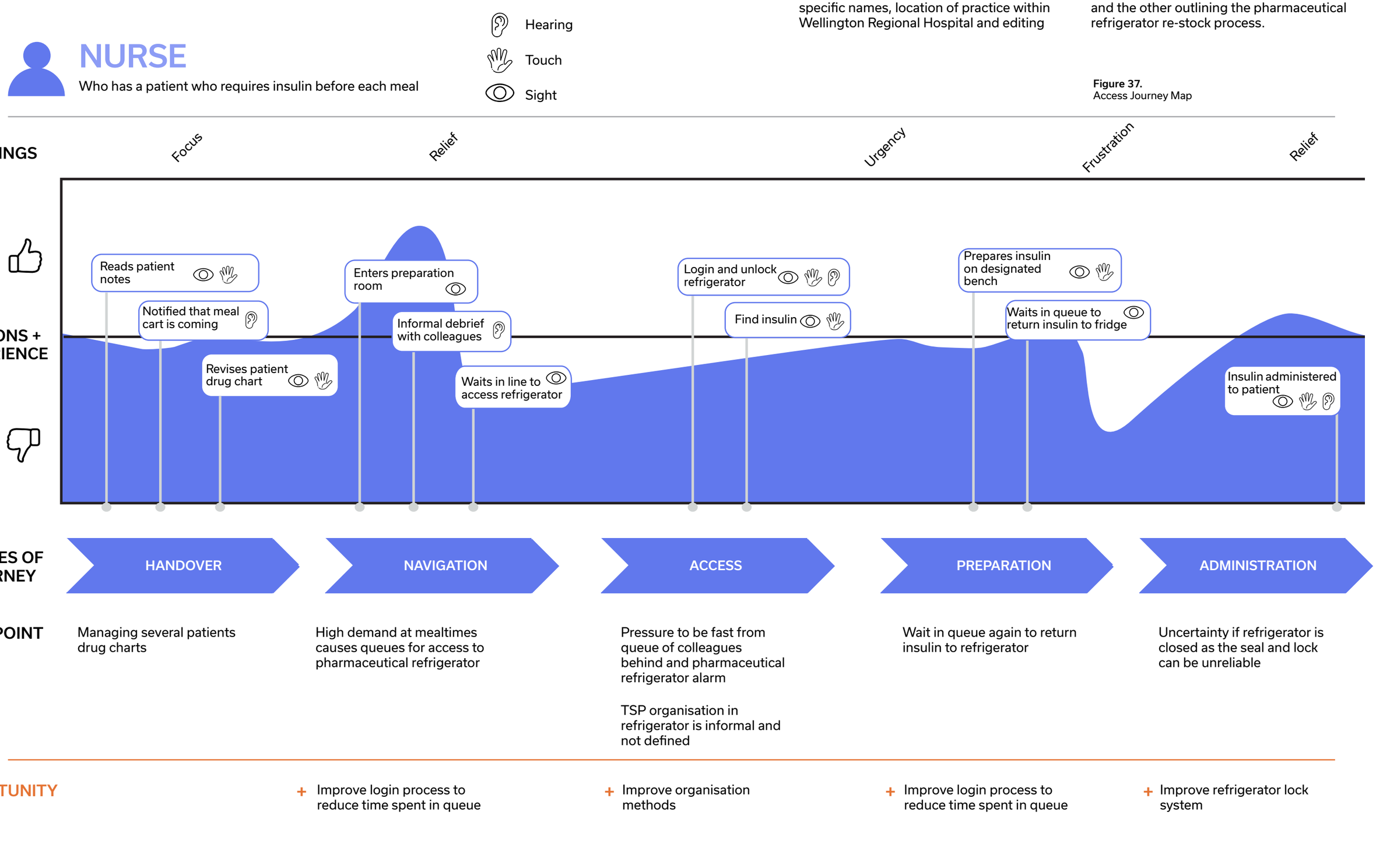
Groups presented their refined concepts back to the collective.

Figure 36.
Co-Design Workshop 04

After

After the co-design workshop the Cold Chain – Quality Improvement project team consolidated and analysed the notes, insights and concepts produced. Insights and data collected from this research was anonymised by non-use of identifying features such as specific names, location of practice within Wellington Regional Hospital and editing faces out of imagery. Participants are referred to through their professional practice specialisation.
The use-case scenarios were refined and digitised into two journey maps, one outlining accessing the pharmaceutical refrigerator and the other outlining the pharmaceutical refrigerator re-stock process.

Figure 37.
Access Journey Map

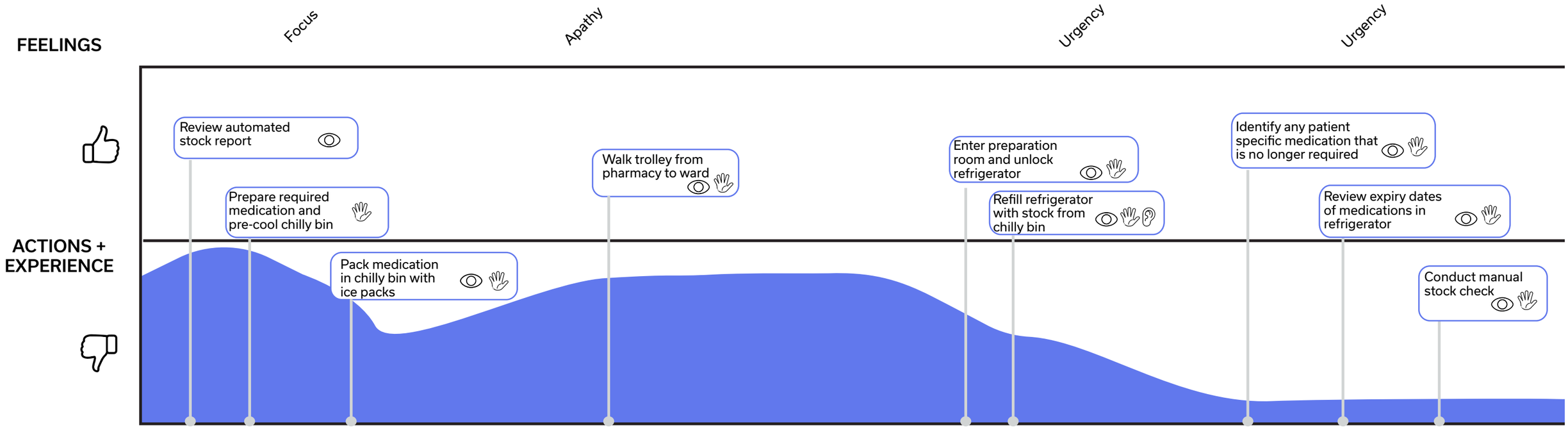


PHARMACY TECHNICIAN

Weekly refill of regular TSP stock for the ward

Hearing
Touch
Sight

Figure 38.
Restock Journey Map



PHASES OF JOURNEY	STOCK REVIEW	TRANSPORTATION	ACCESS	MANAGEMENT
PAIN POINT	Locating a chilly bin as they have not been returned to pharmacy Pharmacy is overstocked due to a public holiday Time consumption in chilly bin preparation	Unable to check chilly bin temperature is within range Large time investment	Pressure to be fast to avoid interrupting nurses and other specialists access to refrigerator Pressure to be fast to avoid a breach Resting door shut while preparing TSPs and door locks, requiring login again No consistency in how TSPs are organised in refrigerators	Manual review and stock check is time consuming due to lack of organisation Pressure to be fast to avoid interrupting nurses and other specialists access to refrigerator Pressure to be fast to avoid a breach
OPPORTUNITY	+ Improve chilly bin distribution and management system + Improve chilly bin design to maintain necessary temperature range and spacing	+ Add visible digital thermometer to chilly bin exterior + Improve TSP distribution methods	+ Improve refrigerator accessibility for restocking through compartmentilisation or rear entrance	+ Improve automated stock report + Improve organisation, accessibility and visibility of TSP's to ensure the oldest TSPs are being consumed first

These journey maps served to help designers develop an understanding of what the day-to-day cold storage processes and engagements are. Further, building a narrative helped designers to develop empathy and understanding of two key user communities in the cold storage journey and understand their unique perspective in the process.

Interestingly, there were two prominent recurring pain points identified in the journey maps: lack of TSP organisation in pharmaceutical refrigerators and time pressure to access TSPs from colleagues and the refrigerator timer.

The process of revising and reframing the journey maps produced in the co-design workshop was an opportunity to revise the material produced and insights gathered. This meant that concepts that were suggested but not further developed during the workshop were reintegrated into the concept development for inspiration.

Figure 39.
Co-Design Workshop Concept Development Posters

Reflection

In reflection the co-design workshop was successful in facilitating knowledge flows between disciplines. Primarily, as one of the foundational co-design methods in the Cold Chain – Quality Improvement project the closeness and intensity of the multiple disciplinary groups in the workshop helped to quickly forge an understanding of disciplinary language. Through the identification of key touchpoints, health specialists were able to present designers with discipline specific language and explain how it relates to the wider project. Similarly, the activities outlined in the co-design workshop may have introduced the health specialists to unfamiliar design terminology. I expect this will improve the quality of communication between disciplines in the project's continued development.

In extension, I suggest that this explanatory communication may have been beneficial for health specialists to think critically about cold chain and consider process intricacies that are usually taken for granted. Therefore, I think a strength of this process was utilising the limited cold chain knowledge possessed by the design participants prior to the workshop. This served as a prompt for health specialists to take a step back and critically analyse their routine practice.

I believe that hosting the workshop on-site at Massey University strengthened existing relationships across disciplines. This gesture reciprocated CoCA's commitment to the progression of the Cold Chain – Quality Improvement project demonstrated by CCHV team members in the guided tour, discussed in Chapter 4a - Initial Scoping. This therefore fostered a team culture of mutual trust.

Additionally, hosting health specialists in a design studio may have helped to build an understanding of a designer's psychosocial context and technical capabilities, serving to reduce the unfamiliarity of design practice.

The successful relationship building from the co-design workshop is represented in Figure 40, showing the further stakeholder engagement in the Cold Chain – Quality Improvement project.

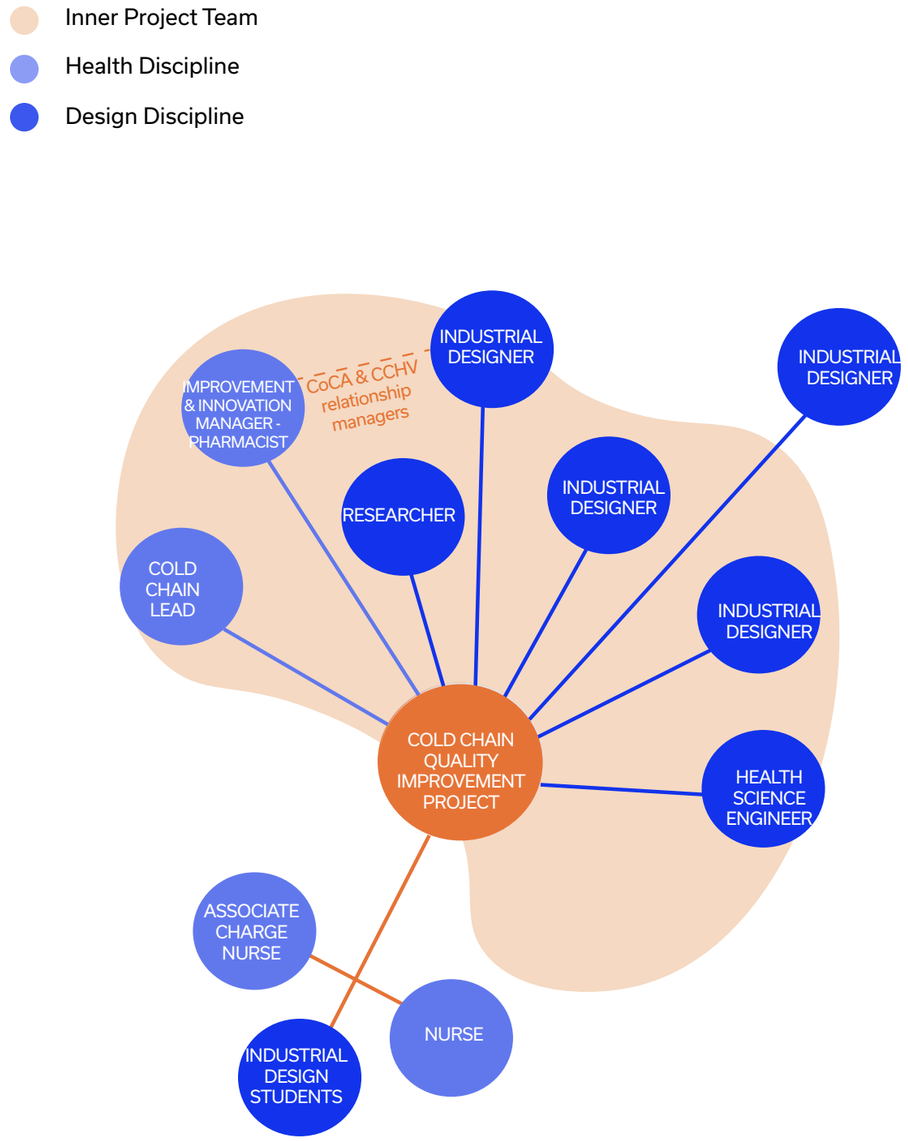


Figure 40.
Stakeholder Map – Co-Design Workshop

4d Semi-Structured Observation

Figure 41.
Semi-Structured Observation Site

Before

The experience-based insights collected from the sample of four health specialists in the co-design workshop provided an in-depth understanding of key cold chain touchpoints and pain points. To complement the information gathered, the Cold Chain – Quality Improvement team prioritised three key goals in the subsequent research method:

- To strengthen contextual and cultural understanding
- To observe user interactions with pharmaceutical refrigerators
- To build on existing relationships across disciplines and develop new ones

As a result, a semi-structured observation was selected to capture authentic representation of user interactions with pharmaceutical refrigerators on the wards and identify other interwoven systems or practices. This also provides the Cold Chain – Quality Improvement project team with a baseline to propose potential opportunities to improve usability, user satisfaction, product performance and improved cold chain compliance.

A semi-structured observation is an ethnographic method commonly used in the exploratory phase of the design process. The intention is for researchers to be immersed in their research context to collect baseline information. The semi-structured approach allows researchers to respond to unexpected events whilst still following a systematic documentation process (Martin & Hanington, 2012).

ETHICAL CONSIDERATIONS

The collaborative nature of the Cold Chain – Quality Improvement project required research to receive ethics approval from both CCHV and CoCA prior to commencement.

Careful attention was paid to ethical considerations for a semi-structured observation, and they were firstly documented in a low-risk ethics application and peer reviewed by staff at Massey University, Wellington.

This application was assessed as low-risk and the study was approved to proceed, see Appendix B.

Subsequently, the ethical considerations were submitted for approval in three documents to Wellington Regional Hospital's Research Office: the study protocol, the area sign off and the participant information and consent sheet (PICS).

This application was reviewed, and the study was approved to proceed.

Key ethical considerations outlined in the applications were:

- **CCHV on boarding:** CoCA team members undertaking research on-site at Wellington Regional Hospital completed CCHV on-boarding to ensure safe, professional and ethical practice. This includes completing the 3DHB Security Access Agreement Users Terms & Conditions, CCDHB Code of Conduct Form, reading the Wairarapa, Hutt Valley, Capital & Coast District Health Boards Code of Conduct, and complying with the COVID-19 Public Health Response (Vaccinations) Order 2021
- **Reducing conflict of interest:** The front facing researchers in this study were CoCA team members who do not have professional relationships with participants
- **Informed written consent** was obtained before the commencement of the observation
- **Non-disruptive to practice:** The semi-structured nature of the observation means the researcher will not interfere with staff workflows. Therefore, this study provides no risk to the pharmaceutical or nursing profession. There will be no physical risk, no known or anticipated psychological, emotional, or economic threat or risks to the participants
- **Anonymity:** All raw data collected through video, conversation or other means is only accessible to the lead researcher. This data was anonymised prior to further review by the Cold Chain – Quality Improvement project team, this includes the identities of participating staff and patient information.

OBSERVATION SITE SELECTION

This series of semi-structured observations was coordinated by the researcher who liaised with staff from the participating sites and conducted the observations. The semi-structured observation organisation was supported by health team members who provided a secondary tour of Wellington Regional Hospital for the researcher.

This tour outlined the various specialisations of wards and how this is likely to influence the use of the pharmaceutical refrigerator as well as confirming the use of the applicable pharmaceutical refrigerator. Three sites were selected.

Wards recruited for this study were selected through purposive sampling based on:

+ The use of a Rollex pharmaceutical refrigerator in the ward's preparation room to store TSPs
+ The specialty of the ward: general medicine, general surgery or paediatric
+ Staff who have participated in previous stages of the Cold Chain – Quality Improvement project
+ Historical temperature data collected from data loggers in each pharmaceutical refrigerator

Figure 42 maps the process that preceded the commencement of the semi-structured observations. This process took place over several weeks and was reviewed by multiple specialists before the study could begin. This diagram serves as a practical example of Ní Shé and Harrison's (2021) statement that co-design projects demand significant time to be spent behind the scenes.

After the Cold Chain – Quality Improvement project team had strategised how to further the research to gain meaningful insights an ethics application proposal was submitted to both parties, CCHV and CoCA, for approval as outlined in Ethical Considerations page 84. Following this, appropriate wards were selected as an observation site, as outlined in Observation Site Selection, and were approached by the researcher uniformly. Notably, the ward that provided immediate participation approval was one from which a health specialist had previously engaged with the Cold Chain - Quality Improvement project team during the Co-Design Workshop, see Chapter 4c. Subsequent to this clear depiction of the value of relationship building, the researcher visited each ward as a formal introduction.

Engagement and communication with each ward were nuanced and this is exemplified in Figure 42's 'staff notification' column, emphasising the necessity of adaptability for designers and researchers engaging in a hospital context.

Upon receiving confirmation and consent to be a site for the observational study, the lead researcher measured each site and constructed a floor plan (see Figure 43). This floor plan outlined the optimal location for the positioning of the recording equipment to collect meaningful observations and be non-disruptive to participants' workflows. It was decided that the researcher would be standing to ensure mobility and quick response to environmental changes.

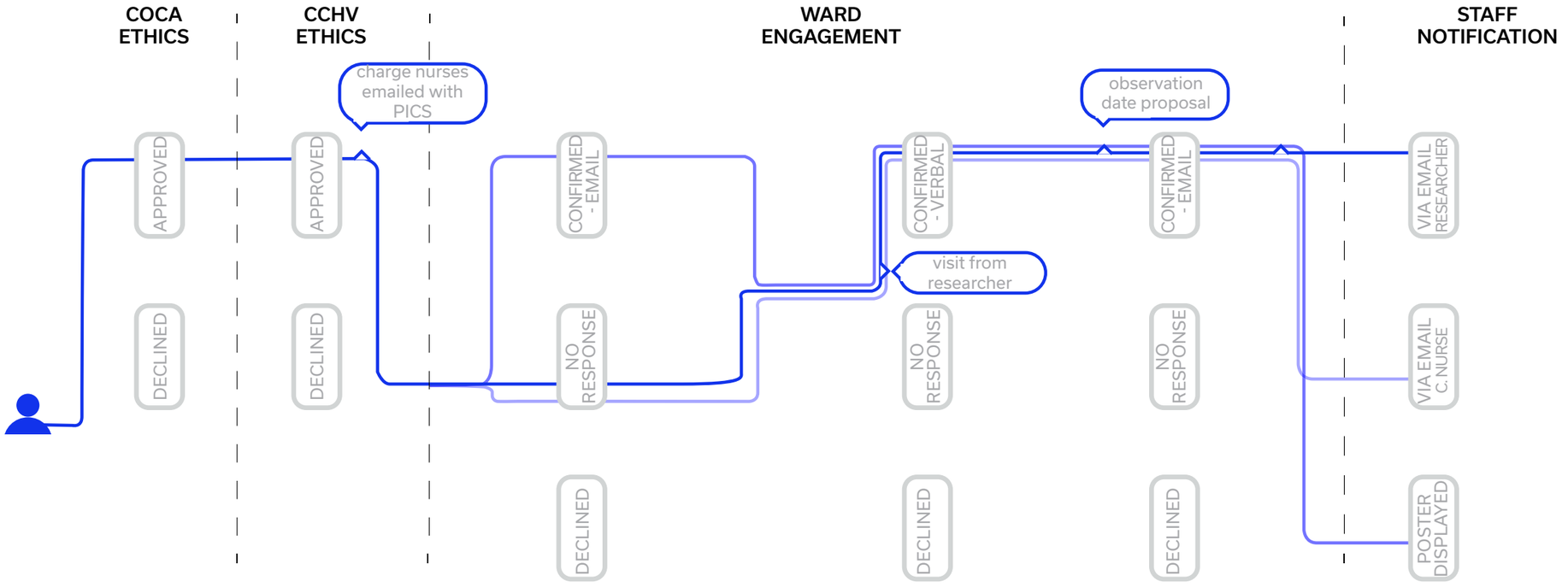


Figure 42.
Ward Engagement Map

Ward A

A 23 bedded Paediatric Surgical ward caring for patients from birth to 16, with additional specialties in ear nose and throat, orthopaedics, neurology, and an oncology day unit. The length of stay for these patients varies from days to months.

Ward B

A 37 bedded General Medicine ward with specialisations in gastroenterology, respiratory and infectious diseases. General medicine wards cater to a wide range of medical conditions and are staffed by a multi-disciplinary team constituted by a large number of registered and enrolled nurses, medical consultants, registrars and house surgeons as well as social workers, occupational therapists, physiotherapists, dietitians, pharmacists etc. The caseload has significant variation in terms of length of stay, care required etc.

Ward C

A 42 bedded General Surgical ward. Inpatients in this ward are typically there for a standard period of time in preparation or recovery from a surgery.

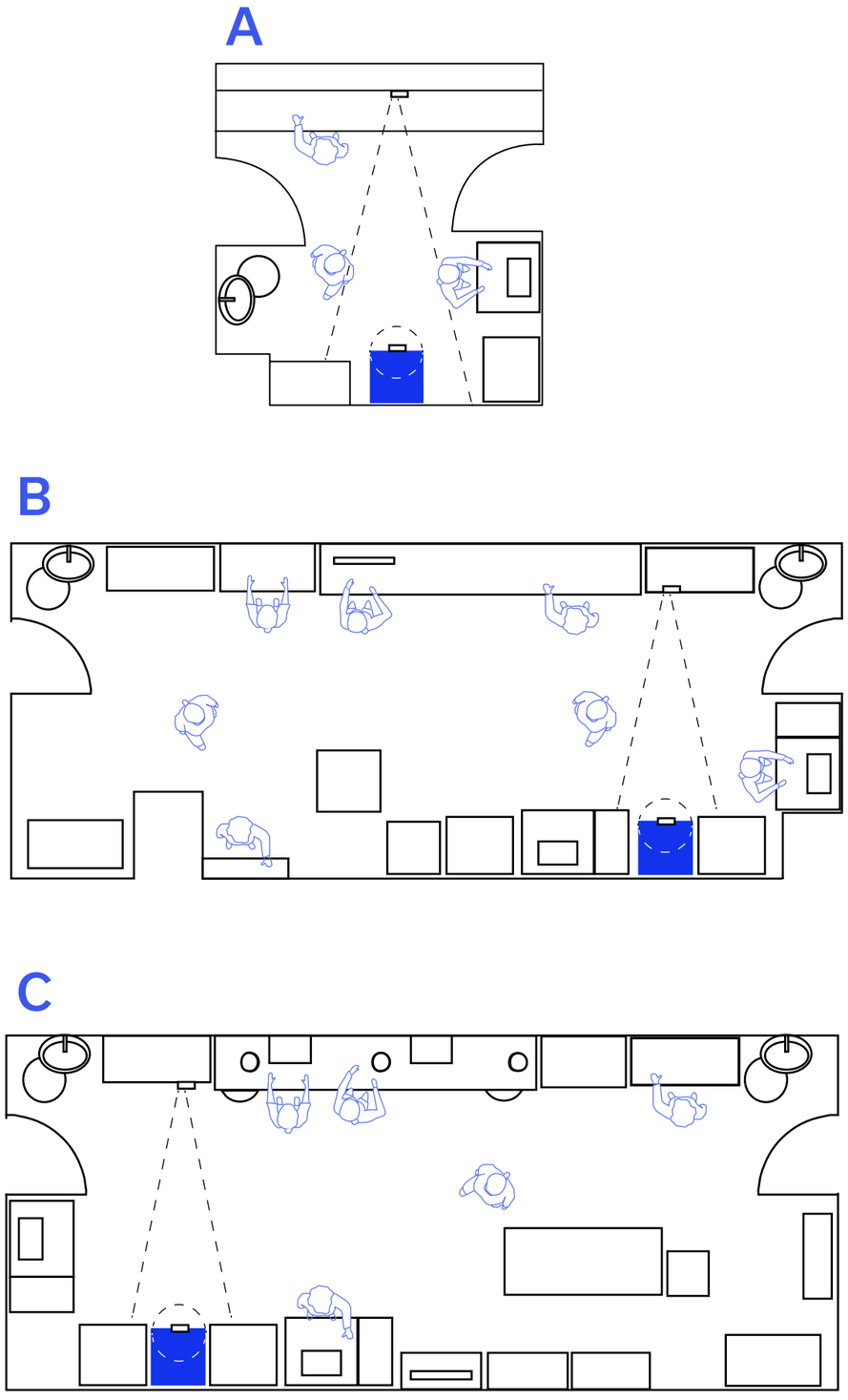


Figure 43.
Ward A,B,C Observation Site Floor Plan

During

The observations were conducted by the researcher and supported by photography and videography as a reference to ensure accurate representation and documentation.

At the commencement of each observation the researcher placed a “study in progress” poster accompanied by the PICS on both entrances to the preparation room to notify staff, see Figure 44. On the first observation in each site the PICS was taken to each pod on the ward to inform and discuss the study with staff members and gain their consent.

The researcher set up the videography, with one GoPro recording a plan view and the other an elevation view of the pharmaceutical refrigerator (Figure 45).

During the observation period the researcher documented points of interest and responded with sketch ideation and intermittently had discussions with participating staff members.

Each site was observed for one hour over a busy period and one hour over a quiet period over three days, totaling six hours of observation for each of the three sites. Quiet and busy periods were identified through analysis of historical temperature data collected from data loggers in each pharmaceutical refrigerator and confirmed by each ward’s charge nurse.

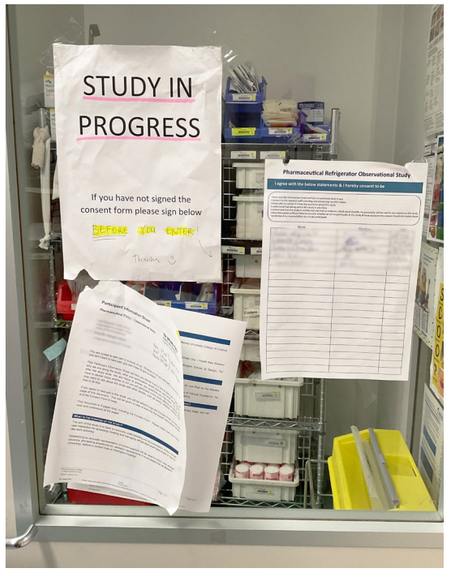


Figure 44.
Observation Site Set Up 01

Figure 45.
Observation Site Set Up 02

After

The lead researcher anonymised and consolidated the collected data to brief the wider Cold Chain – Quality Improvement project team on the findings. The insights were presented as a task analysis and artefact analysis, as follows:

TASK ANALYSIS

The lead researcher trimmed the eighteen hours of raw footage to extract the salient insights from twelve key user interactions. The collected data was then organised and synthesised through a series of constituent steps that segment the user engagement with the pharmaceutical refrigerator.

These steps were defined through cross referencing observation insights with the Pharmaceutical Refrigerator Access journey map produced in the Co-Design Workshop, see page 74.

As a result, the following six key steps were identified:

- **Unlock** – how the user accessed the refrigerator
- **Locate** – how the user located the required pharmaceutical
- **Pharmaceutical Type** – what pharmaceutical was being used
- **Door** – whether the user left it open or closed
- **Preparation Location** – where the user prepared the pharmaceuticals
- **Return** – how the user returned the pharmaceutical to the refrigerator (if required)

These six steps formed a framework to analyse and compare each unique user interaction, to provide the Cold Chain – Quality Improvement team with clear data demonstrating the differences, similarities and unexpected interactions shown in Figure 46.

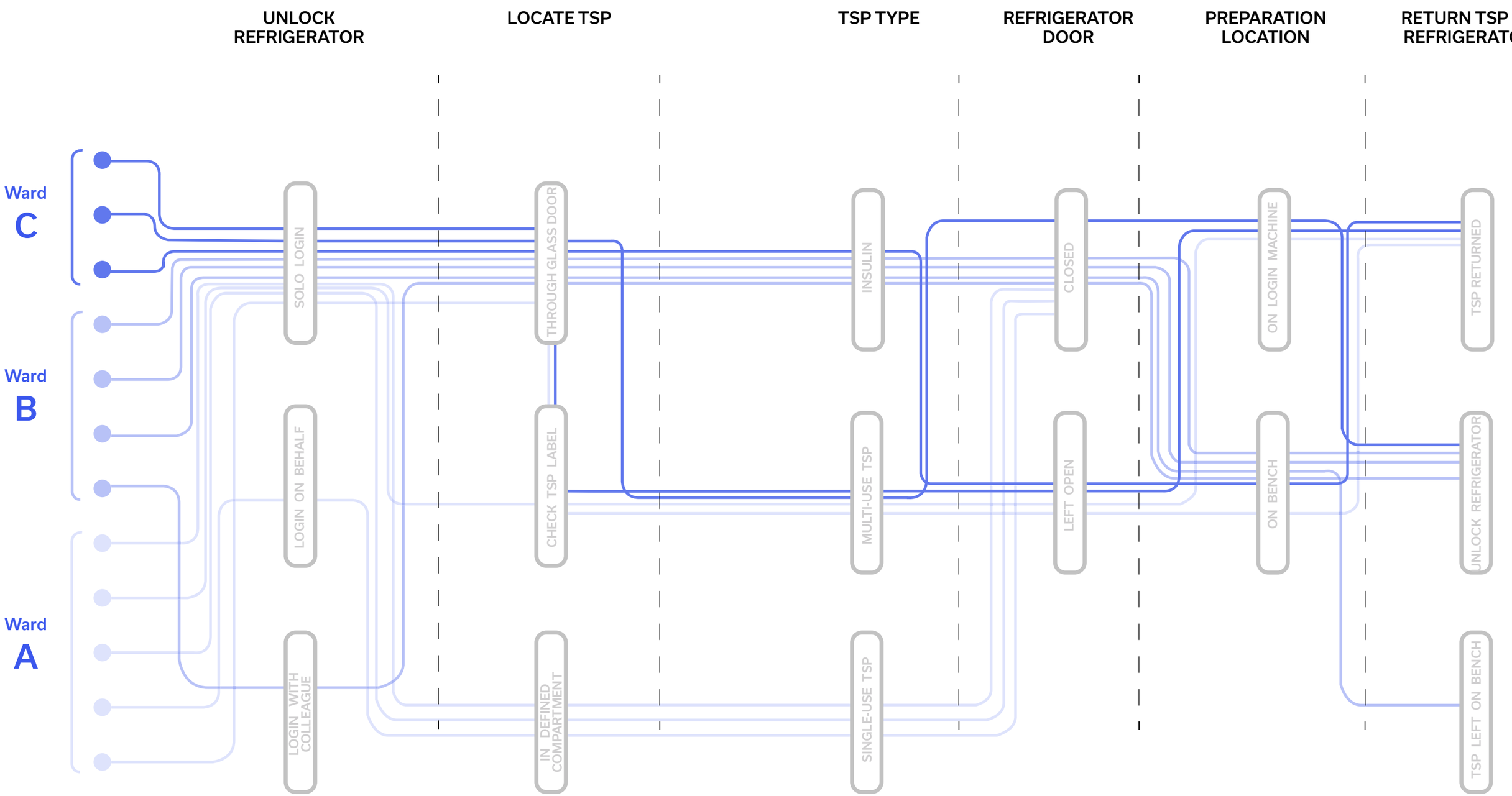


Figure 46.
Pharmaceutical Refrigerator Task Analysis

This task analysis synthesises the twelve observed pharmaceutical refrigerator interactions. Figure 46 is designed to maintain the integrity of the individual interaction as well as clearly visualise trends, common and correlated behaviours through the touchpoint columns. The use of observation sites as identification allows the project team to begin to analyse how ward specialty may influence the data collected, for example Figure 46 shows that each ward had a different type of TSP that was most frequently accessed.

75% of users used the glass door to locate the medicine required before opening the pharmaceutical refrigerator. This shows good cold chain compliance and an understanding of the need to limit the amount of time the refrigerator is open for. However, the frequency of this also suggests that the internal management of the refrigerator and location of TSPs is unreliable, requiring staff to invest time in locating a TSP.

Additionally, 25% of users left the pharmaceutical refrigerator open whilst preparing the TSPs for administration; the degree in which the door was left open varied from resting on the seal to wide open. This only occurred on occasions when TSPs that are stored in bulk were needed (multi-use TSPs), requiring staff to remove a dose and return it to the pharmaceutical refrigerator. The motivation for this behaviour appears to be time conservation to avoid repeating the login and unlock process.

Another time conservation behaviour was TSP preparation location; interestingly it was observed that 75% of users who left the pharmaceutical refrigerator open prepared TSPs on the login machine as opposed to the defined bench space. It is suggested the motivation for this is the proximity of the login machine to the pharmaceutical refrigerator (approximately 500mm) as opposed to the bench (approximately 2000mm).

These user interactions and behaviours provided the research team with contextual insights to understand the efficiency and urgency of staff working in this environment, highlighting to the research team that to best serve these users the design intervention needed to facilitate efficient and reliable practice.

ARTEFACT ANALYSIS

The focus of this exploration was to identify and analyse the characteristics of artefacts currently in use to manage cold chain compliance, with consideration to materiality, functionality, and potential user motivations (Martin & Hanington, 2012).

The analysis highlighted two key areas:

+ Data logger placement
+ TSP organisation

The ‘purpose’ of the examined artefacts was defined through observation and interviews with health specialists.

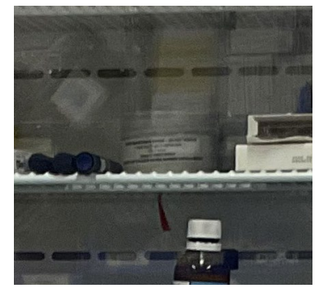
Data Logger Placement

The unifying purpose of these three artefacts is to ensure the integrity of the automated data outputs from the data loggers by fixing or indicating the correct positioning. Notably, all three artefacts utilise an ad hoc application of affordable and accessible supplies; electrical tape and wire. Of particular interest are artefacts 01 and 03, these electrical tape artefacts suggest that there is a significant issue with movement of data loggers. However, the materiality of these artefacts is a limitation, as depicted in artefact 01 the electrical tape has been stretched out of place as the data logger was moved.

Figure 47.
Artefact 01 – Data Logger Container with Electrical Tape Fixture

Figure 48.
Artefact 02 – Data Logger Suspended by Wire

Figure 49.
Artefact 03 – Electrical Tape Indicator for Data Logger



TSP Organisation

The unifying purpose of these five artefacts is to maintain organisation of TSPs in the pharmaceutical refrigerator. Typically, readily accessible items in the preparation room are used to define a zone to cluster like TSPs. For example Figure 52 shows the repurposing of a container typically used for non-refrigerated storage (see Figure 55). To create a visual divide between the differential zones on the refrigerator shelves methods such as stacking shown in Figure 54 and pushing TSPs to the outer walls, Figure 51, 53 and 54, are employed.

These artefacts show that pharmaceutical refrigerator users desire organisation to quickly and reliably access TSPs but lack the means to achieve this uniformly. The resourceful use of these repurposed artefacts often conflict with cold chain protocol, as exemplified firstly in Figures 50 to 53 where a solid structure surrounds the TSP restricting airflow and secondly in Figures 51, 53 and 54 which are in direct contact with internal walls of the pharmaceutical refrigerator. This suggests that a key motivation for the users is quick and reliable access to TSPs.

Figure 50.
Artefact 04 – Designated Insulin Storage Container

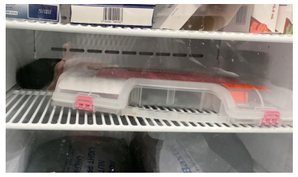


Figure 51.
Artefact 05 – Patient Specific TSPs Isolated with Resealable Bags

Figure 52.
Artefact 06 –Like TSPs Stored Together Using Repurposed Containers

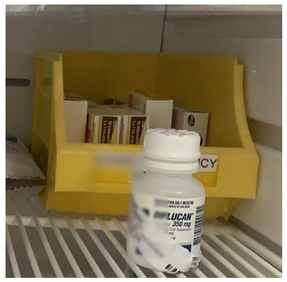


Figure 53.
Artefact 07 –Like TSPs Stored Together in Original Film Packaging

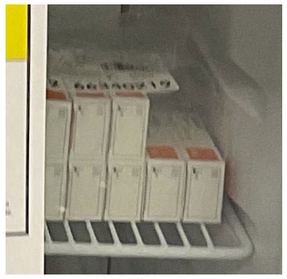


Figure 54.
Artefact 08 –Like TSPs Stored Together

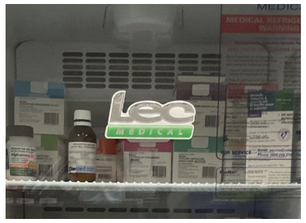


Figure 55.
Preparation Room Shelving

Figure 56.
Observation Concept Ideation

Reflection

As the first research method conducted at Wellington Regional Hospital, it was an invaluable opportunity to further learn about the similarities and differences in disciplinary and organisational culture between CoCA and CCHV. This primarily occurred through navigating the ethics application process for both parties and secondly through experiencing the nuances of research recruitment and engagement with a variety of stakeholder and user communities. As outlined earlier in this chapter, each of these factors required a tailored approach and significant time-investment to navigate.

The value of multiple disciplinary collaboration was evident in this experience as the Cold Chain – Quality Improvement team utilised health and design disciplinary, organisational, cultural, and contextual expertise to efficiently circumnavigate any potential hurdles.

In reflection, I believe a strength of this research was the positioning of a design researcher in a health context. This was valuable because it provided an opportunity for the researcher to familiarise themselves with hospital processes that are routine to health specialists. For example, understanding hospital navigation and the make-up of a ward both architecturally and professionally. Integration and exposure to the wider project context helped to reduce the disciplinary divide and built confidence in being a designer in a hospital environment. Interestingly, my profession was often met with surprise during interviews with users in the observation.

Further, being situated in the preparation room facilitated a clear observation of the engagements with the pharmaceutical refrigerator but also demonstrated how external influences such as patient load, colleagues in the preparation room and call bells can impact these engagements.

When designing this research, locations and timeframes were selected with the intention that the insights collected would be representative of interactions across the hospital. However, during the 18 hours of observation only twelve interactions were observed. This number is too few to extrapolate to represent Wellington Hospital. However, this quantity of data does allow for in-depth analysis of each engagement.

A significant learning was of the unpredictability of pharmaceutical refrigerator use, as it is directly dependent on the needs of the current inpatients. I propose it may be beneficial in future observations to have a motion sensor recording setup for an extended period of time unsupervised, supported by intermittent on-site observations conducted by the researcher. This would also be useful to identify how the presence of a researcher influences user interactions.

This research was successful in expanding the research team's relationships across stakeholders and user communities as outlined in Figure 57, and built upon connections made in the co-design workshop.

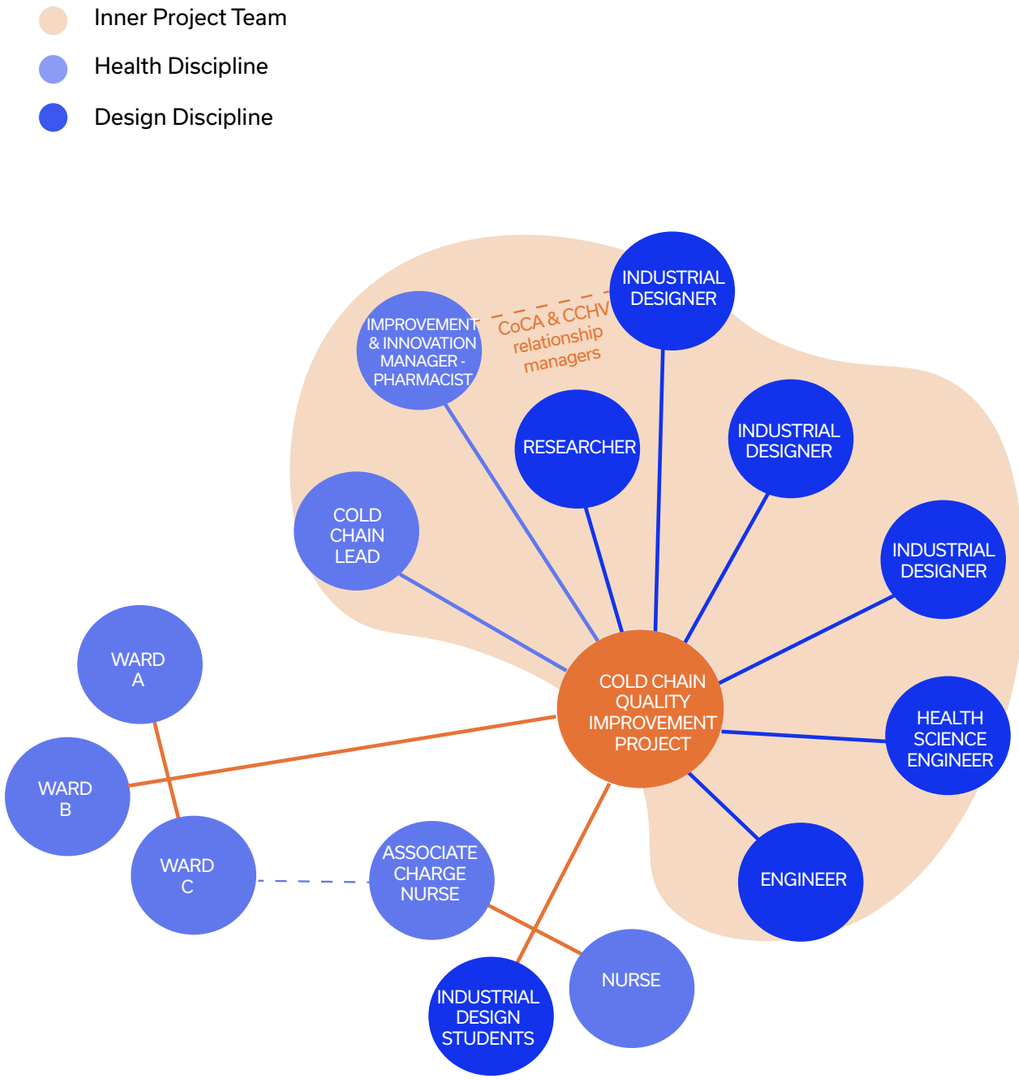


Figure 57.
Stakeholder Map – Semi-Structured Observation

4e Iterative Design Development

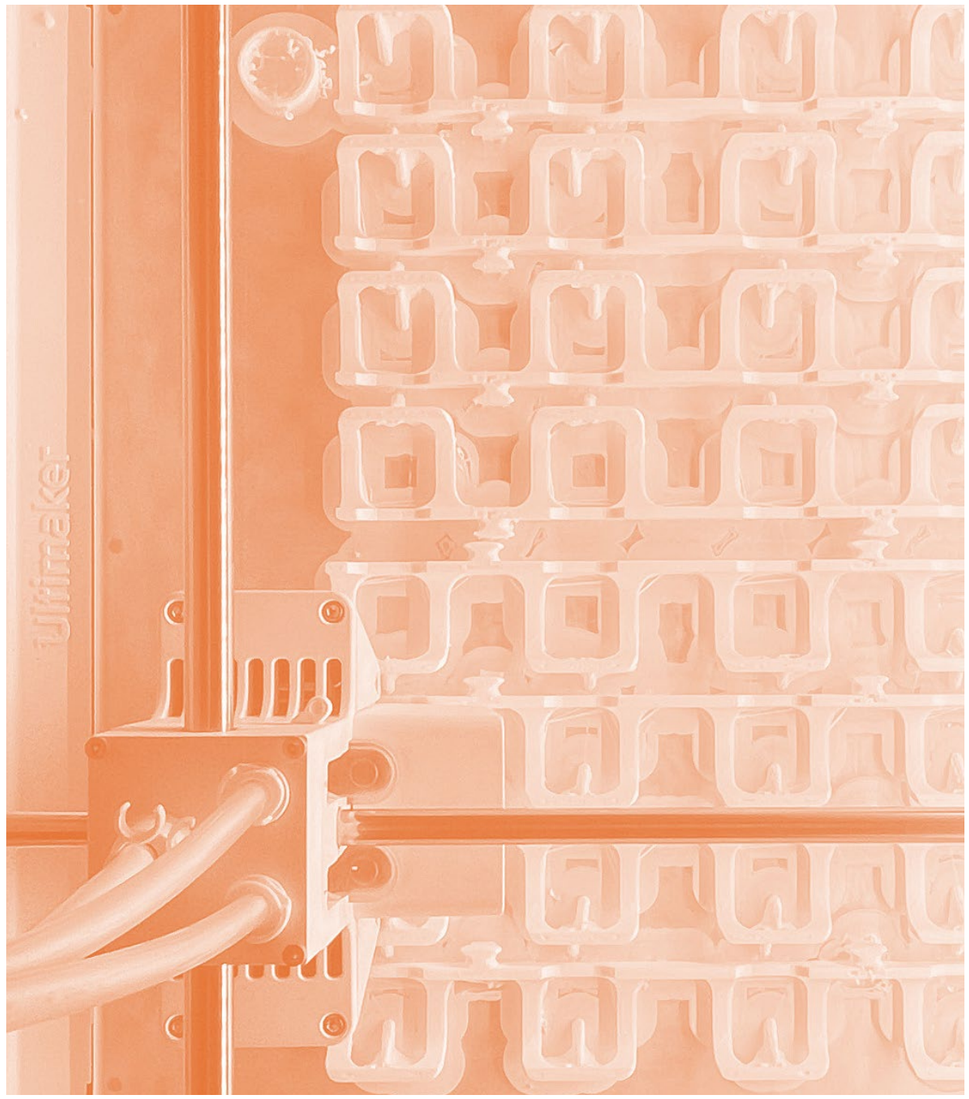


Figure 58.
3D Printing of Bumper Component

Before

The semi-structured observations and co-design workshop provided the Cold Chain – Quality Improvement project team with a rich contextual and ethnographic understanding of cold chain. This highlighted several opportunities for design intervention to improve cold chain compliance. To synthesise this knowledge the Cold Chain – Quality Improvement team prioritised three key goals in the subsequent research method:

+ To facilitate knowledge flows between disciplines by creatively engaging a variety of stakeholders in the design development
+ To develop concepts that will meaningfully impact and improve cold chain compliance and are achievable within the defined financial and time restraints

Consequently, an iterative design development (IDD) process was implemented to synthesise the learnings thus far and explore how they manifest as a design. Additionally, this aimed to integrate and familiarise health specialists with the design process, clearly showing how their contribution can influence a design solution.

Iterative design development is the refining of an idea or concept by running it through a repetitive cycle (The Interaction Design Foundation, 2021). The cycle is outlined in Figure 59. Whereby each implentation of this cycle builds on the previous to meaningfuly shape the design development, Figure 60.

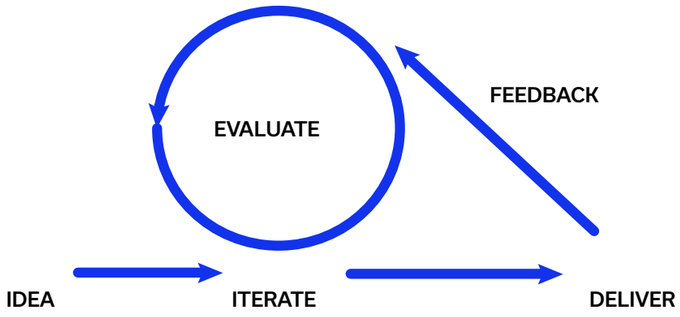


Figure 59.
Agile Project Management: Iteration

Note. Adapted from Design iteration brings powerful results. Interaction Design Foundation.
Copyright Holder Planbox. CC BY-SA 3.0

Figure 60.
3D Iterative Design Development

A review of the complete range of concepts generated throughout the process was undertaken by CoCA and CCHV team members to define a focus for the design development. Two objectives were prioritised within the scope of this research due to their prevalence throughout the process:

+ To facilitate TSP organisation in alignment with cold chain protocol
+ To maintain correct data logger placement

Beyond the scope of this project, other opportunities with elevated levels of technological sophistication and complexity have been identified to be developed and addressed under the CoCA and CCHV partnership. This shows the value of the generative methods implemented in this process beyond this project's scope, for further application in cold chain improvement and TSP management.

During

The researcher conducted a series of design workshops hosted at Wellington Regional Hospital and Massey University; these involved various team members and stakeholders from the Cold Chain – Quality Improvement project. Through the synthesis and integration of participants' insights the aforementioned objectives were developed through various mediums including, sketching, CAD and 3D printing. Figure 61 depicts how the series of design workshops built on one another to clarify and strengthen the design outcome. The insights illustrated are non-exhaustive but exemplify key moments in defining the design.

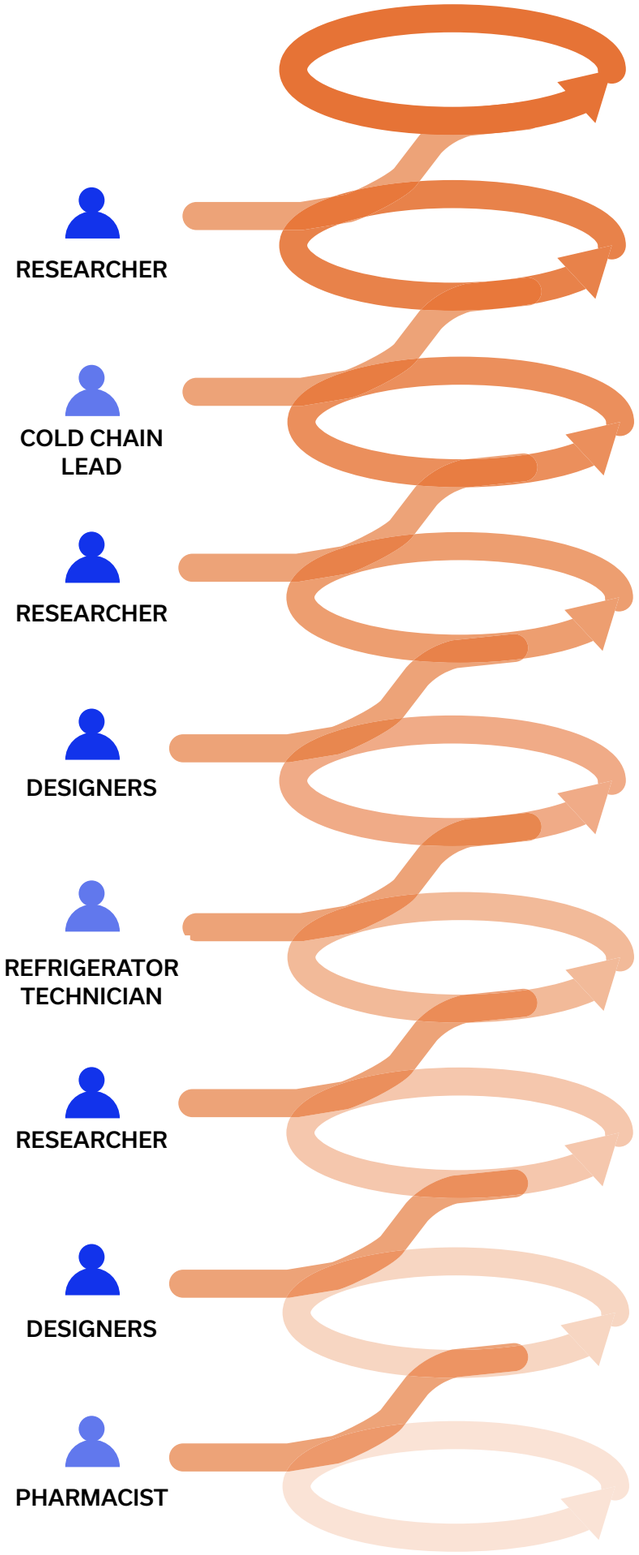
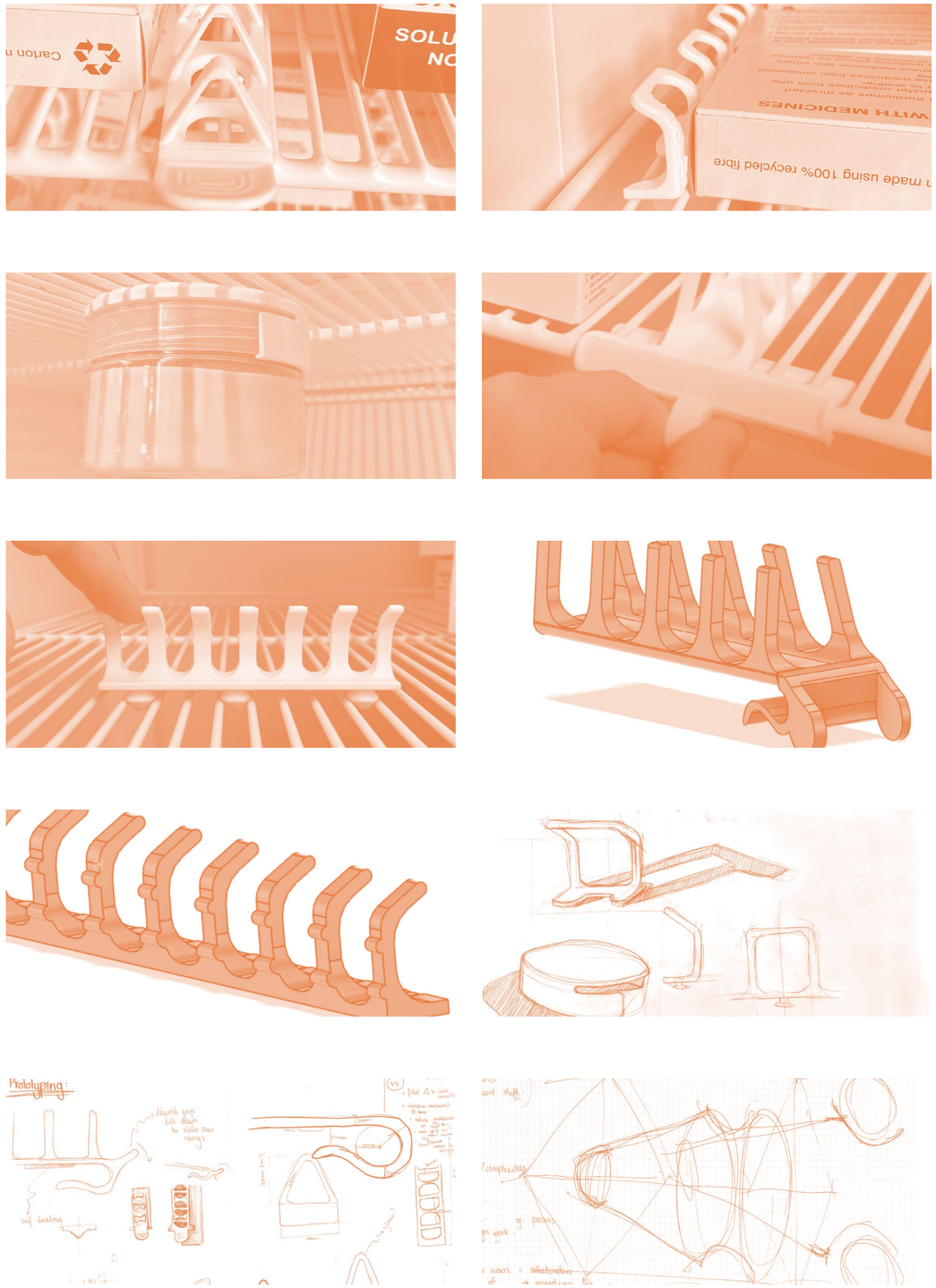


Figure 61.
3D Iterative Design Development in Practice



After

This multiple disciplinary collaboration between CCHV and CoCA on the Cold Chain – Quality Improvement project followed a co-design process to facilitate effective communication and creative practice. The final design from this process is a three-part system that includes bumpers, spacers and a clip, which can be retro fitted into existing cold chain architecture. The bumpers and spacers are designed to facilitate TSP management and organisation and the clip to manage data logger placement.

As a co-design process several designers were involved to varying degrees across the Cold Chain – Quality Improvement project. My design contribution was principally to the development of components one and two: bumpers and spacers. However, my role within the project team meant that I contributed to the design of component three: clip through gathering feedback and insights from key stakeholders and users during the IDD, as well as through conducting and observing the subsequent pilot trial.

COMPONENT ONE

Bumpers
+Single Tier

The bumper component is designed to ensure a 25mm gap in maintained between TSPs and pharmaceutical refrigerator walls, as outlined in the Cold Chain Annual Report guidelines.

This requirement is in place to maximise air circulation around TSPs and to avoid thermal bridging. Thermal bridging can occur when the temperature of a TSP is changed by maintaining contact with another object of a differing temperature. The surface of the refrigerator walls tend to be cooler than +2°C because of the cool air vents. Therefore, if TSPs maintain contact with the wall it can create a thermal bridge, shown in Figure 62, and reduce the TSP's temperature below the optimal +2°C to +8°C window, increasing the likelihood of reduced TSP efficacy.

In current practice, maintaining the 25mm gap is the responsibility of pharmaceutical refrigerator users to inspect and verify the spacing simultaneously to conducting their regular tasks.

However, through the co-design workshop and the semi-structured observations it was identified that this spacing was often compromised due to the need to efficiently access TSPs. For example, to create zones for like TSP's to be stored together users maximised shelf space by pushing TSPs to the shelf's edge. This also occurred to access a TSP located at the back of the shelf, as depicted in Figure 63, below.

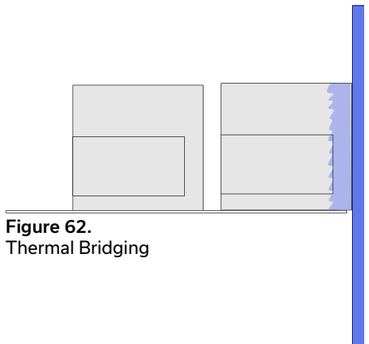


Figure 62.
Thermal Bridging

Figure 63.
Thermal Bridging in Pharmaceutical Refrigerator

In response to these insights the bumper provides a 25mm boundary around each refrigerator shelves perimeter to passively reduce the likelihood of thermal bridging, shown in Figure 64, removing the responsibility from users. The structure of the bumper utilises solid and hollow space to act as a barrier and facilitate air circulation.

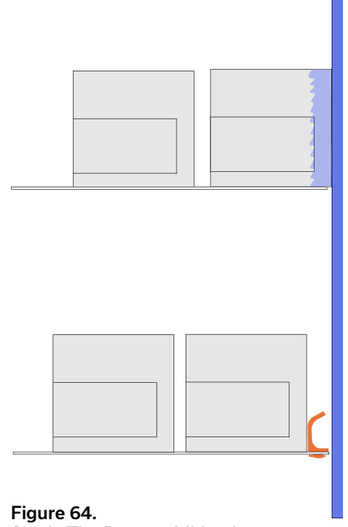


Figure 64.
Single-Tier Bumper Mitigating Thermal Bridge

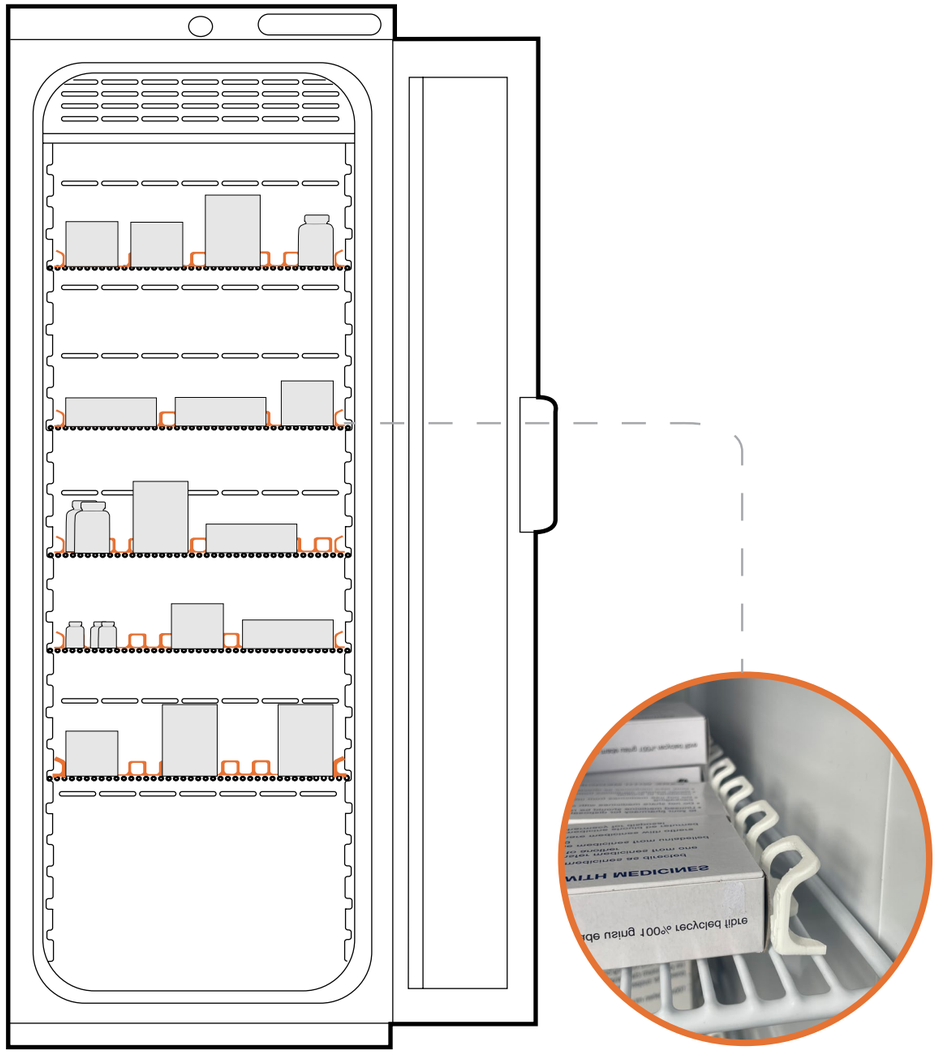


Figure 65.
Single-Tier Bumper Contextual Visualisation

Figure 66 demonstrates the bumper's key design features.

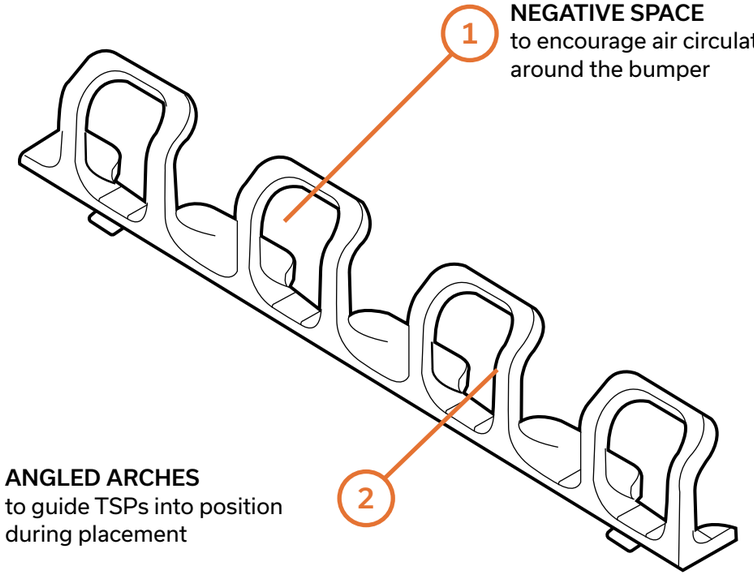


Figure 66.
Single-Tier Bumper Design Details

Bumpers
+ Two Tier

Similarly, the two-tier bumper ensures a 25mm gap is maintained around the shelf perimeter, however, it builds on this by additionally addressing 'stacking' of like TSPs shown in Figure 67.

Figure 67.
Stacking in Pharmaceutical Refrigerator

This latent need was identified by the Cold Chain Lead during a review of the single-tier bumper prototype and it's functionality in relation to the shelf and TSPs in the IDD process. It was noted by a team member that commonly like TSPs are stacked at the back of the shelf for visibility and space maximisation and regular use of the pharmaceutical refrigerator can cause TSPs to be pushed against the refrigerator's back wall. As visibility is limited at this part of the refrigerator it is challenging for staff to ensure 25mm spacing is being achieved, therefore, increasing the likelihood of thermal bridging.

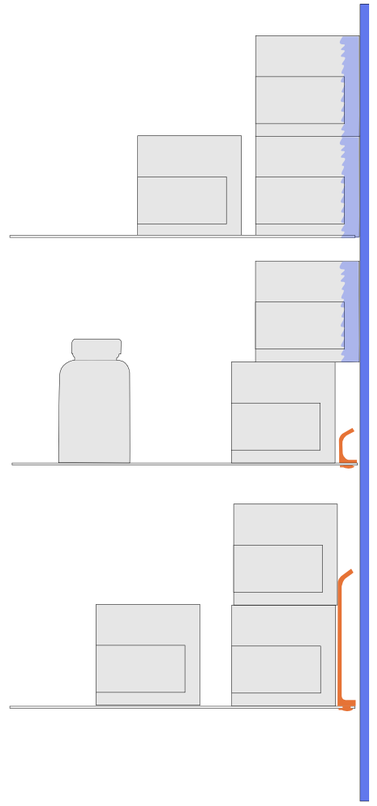


Figure 68.
Bumpers Mitigating Thermal Bridging

The two-tier bumper was designed to work in conjunction with the single tier model for application at the rear of the refrigerator shelf as depicted in Figure 69.

Having two variations of the bumper allows pharmaceutical refrigerator management to be tailored to the unique needs of each ward. The single tier bumpers are preferred on the sides of the shelves to for accessibility to TSPs, as this is a higher use area of the shelf than the back. The lower height provides a clear channel along the side of the TSPs for easy removal.

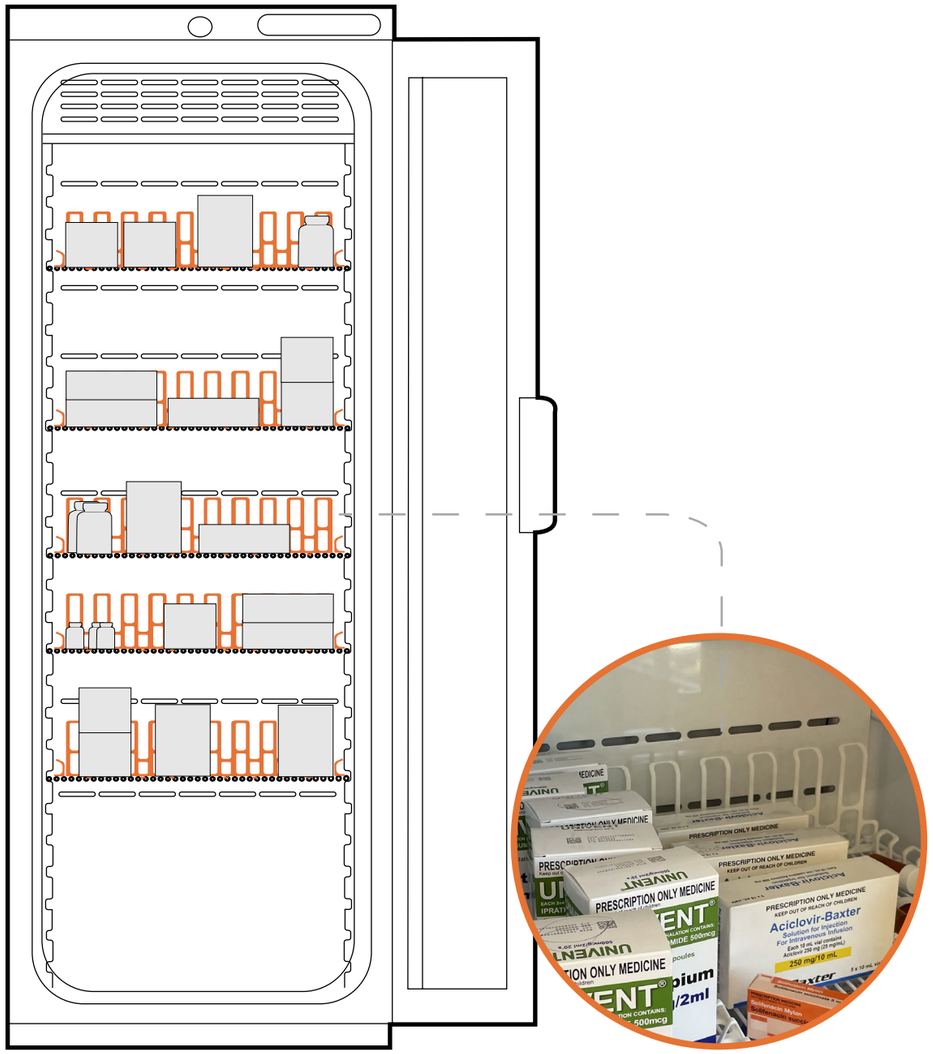
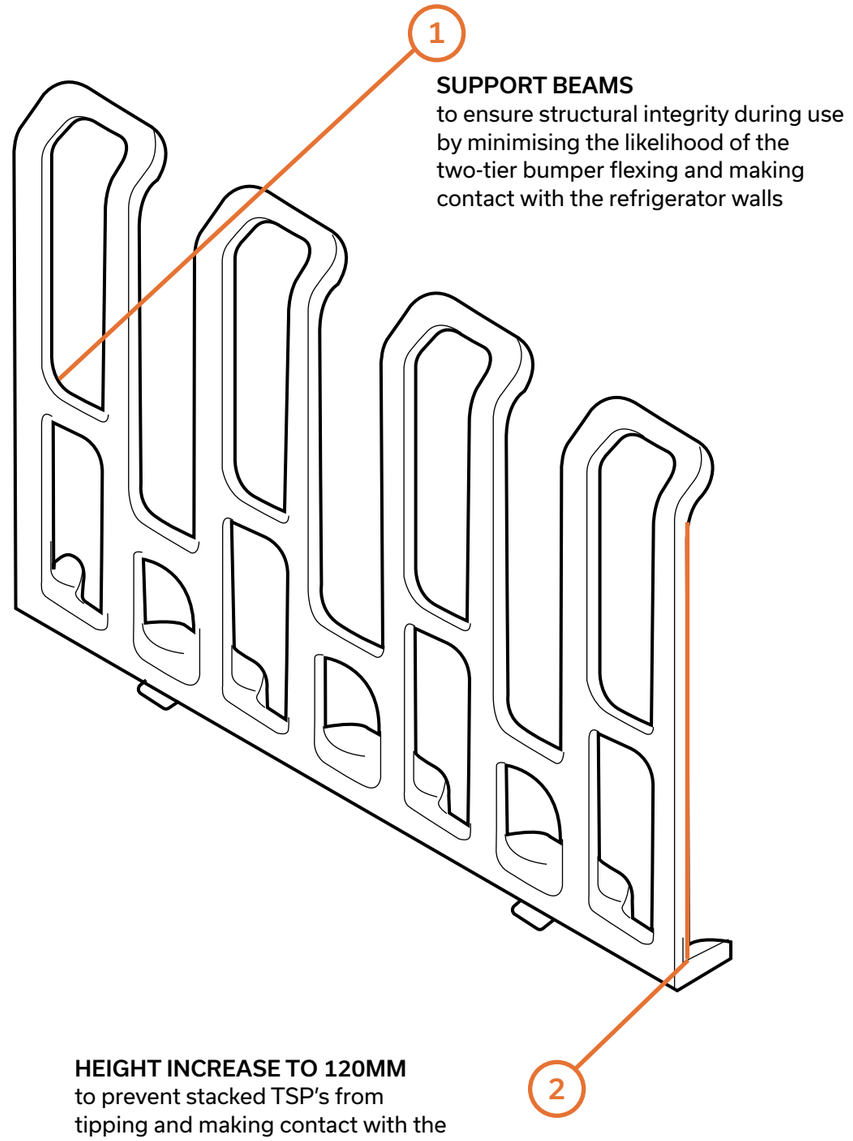


Figure 69.
Two-Tier Bumper Contextual Visualisation

The additional design features are highlighted in Figure 70.



SUPPORT BEAMS
to ensure structural integrity during use by minimising the likelihood of the two-tier bumper flexing and making contact with the refrigerator walls

HEIGHT INCREASE TO 120MM
to prevent stacked TSP's from tipping and making contact with the pharmaceutical refrigerator's back plate (see Figure 68).

Figure 70.
Two-Tier Bumper Design Details

Spacer

Through the co-design workshop, semi-structured observations and team discussions, it was identified that maintaining TSP organisation is a priority for users as it increases the efficiency of the interaction. This is exemplified in Figure 71 and further in the Artefact Analysis, page 95, demonstrating the techniques and resourceful repurposing of artefacts to achieve organisation.

However, these solutions are typically characterised by a dense collection of like TSPs which does not adhere to cold chain management requirements (see Figure 71). If TSPs are stored densely without air circulation it is incredibly difficult to know the temperature they're maintaining.

Figure 71.
Existing TSP Organisation Techniques

The spacer component of the three-part system addresses the practical aspects of assuring consistent spacing between TSPs and aims to avoid time consuming individual appraisals of distance. Creating defined columns on the shelves for TSP storage the spacers serve as a tool to maintain organisation as well as a channel for airflow.

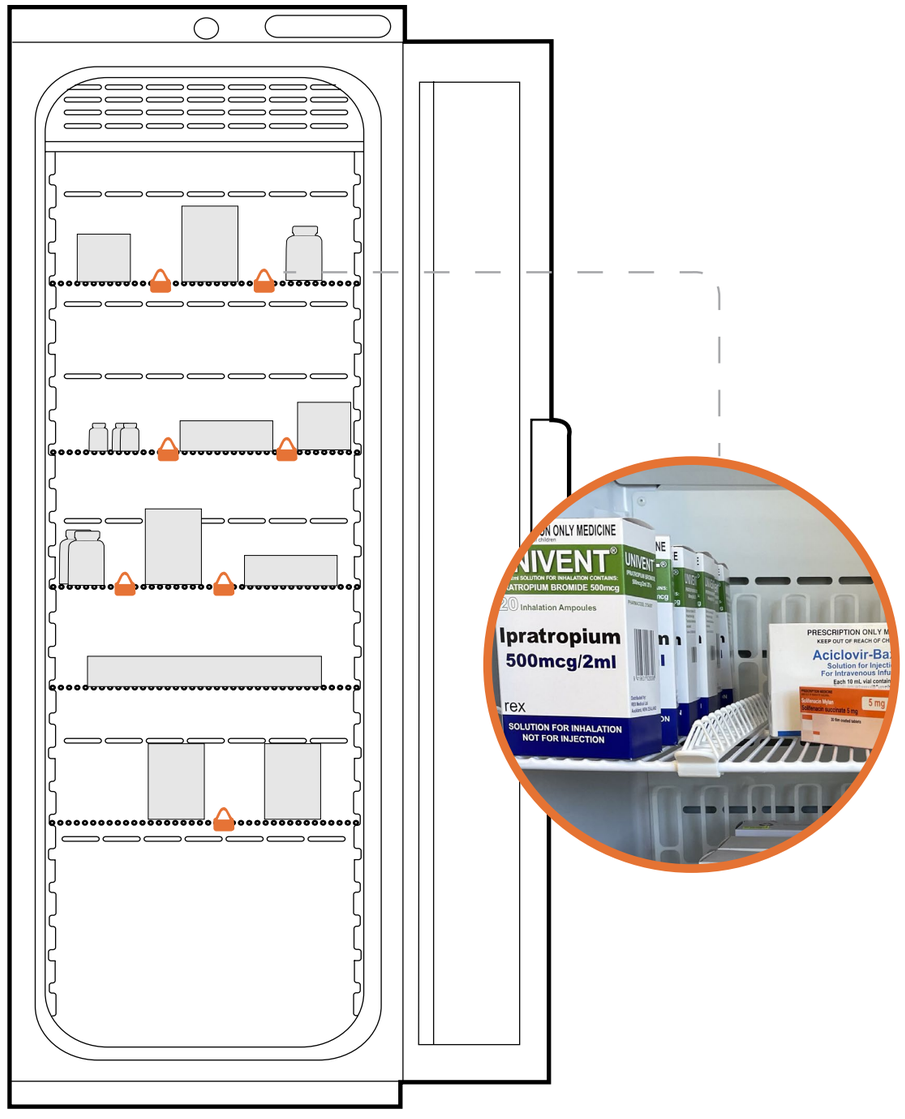


Figure 72.
Spacer Component Contextual Visualisation

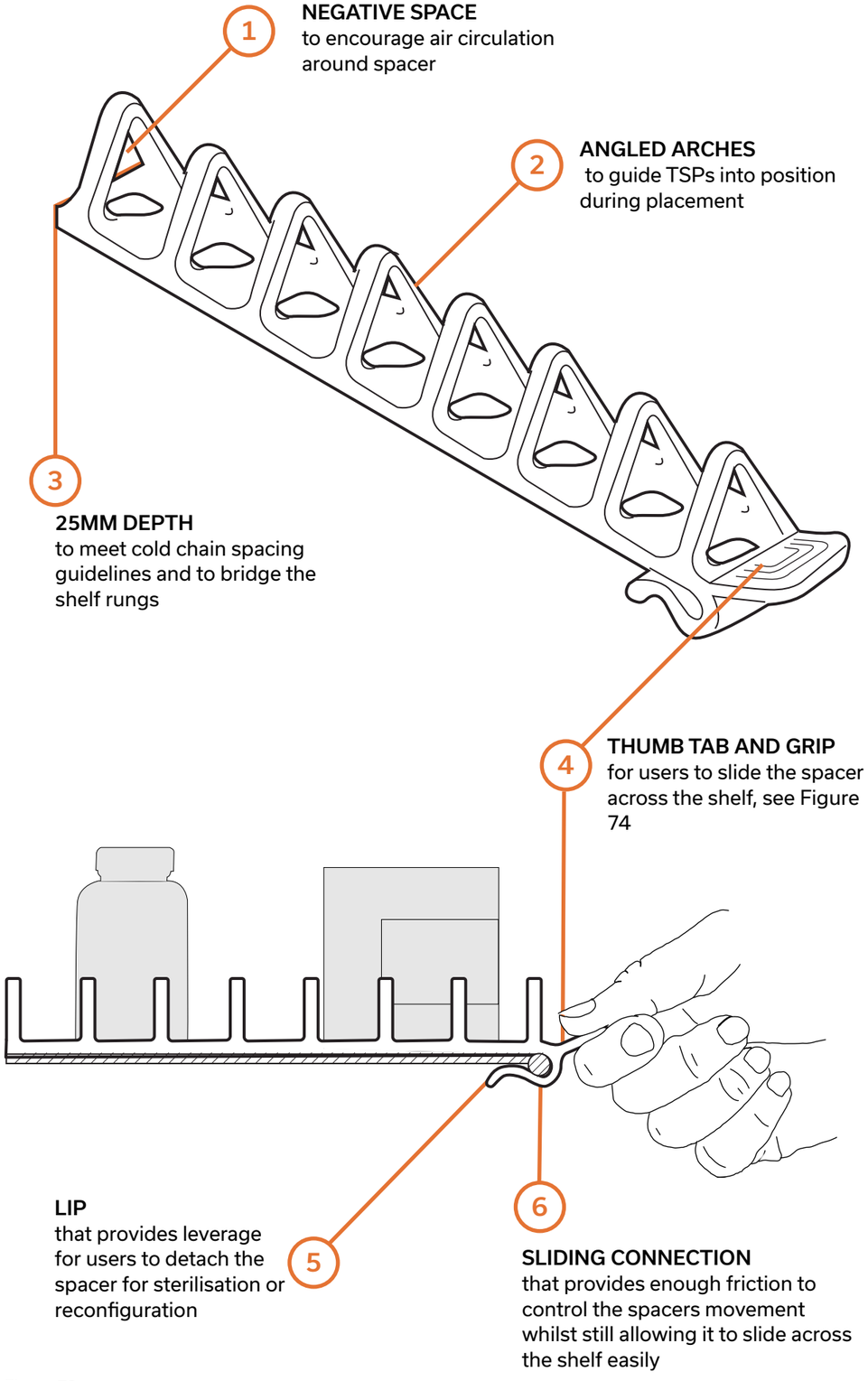


Figure 73.
Spacer Design Details

The connection of the spacer to the front of the shelf allows it to slide horizontally to assist in efficiently repositioning TSPs (Figure 74).

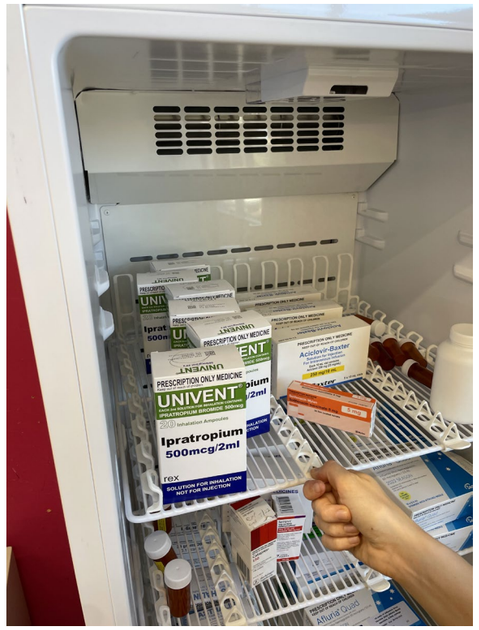


Figure 74.
Spacer Sliding Function

Clip

The third component: clip, was designed by Cold Chain – Quality Improvement team member Daniel Harmsworth.

The clip is designed in response to quantitative data collected from the data loggers that were introduced at the end of the quality improvement project conducted within CCHV prior to engaging with CoCA. In current practice the data logger tags are contained in a substrate to replicate the temperature sensitivity of TSPs, shown in Figure 75. They record and send the internal refrigerator temperature at set time intervals.

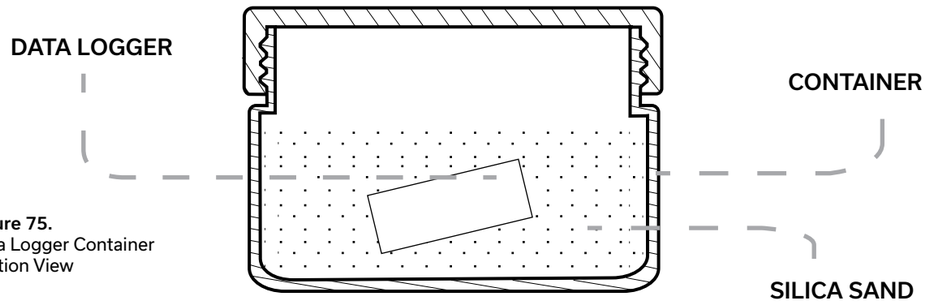


Figure 75.
Data Logger Container Section View

CCHV team members identified a pattern that linked the introduction of data loggers to occasional abnormally low temperature recordings and identified user behaviours as a likely cause. The data loggers were being accidentally moved from their designated central position to make contact with the refrigerator walls, causing the temperature readings to fall below +2°C. As depicted in Figure 76.

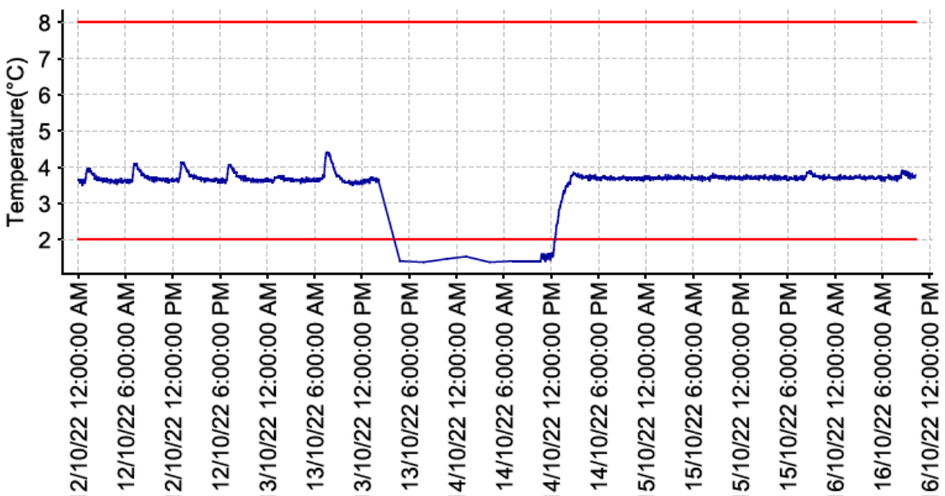


Figure 76.
Graph of Skewed Data Logger Readings

Note. **Produced by Richie Perry, 2022**

Figure 77 shows an example of existing techniques to reduce the mobility of data logger containers, these are further outlined in Artefact Analysis, page 95.

The clip component of the three-part system was designed to address this 'human-factor' by mounting the contained data logger to a fixed location within the pharmaceutical refrigerator.

Figure 77.
Data Logger Movement

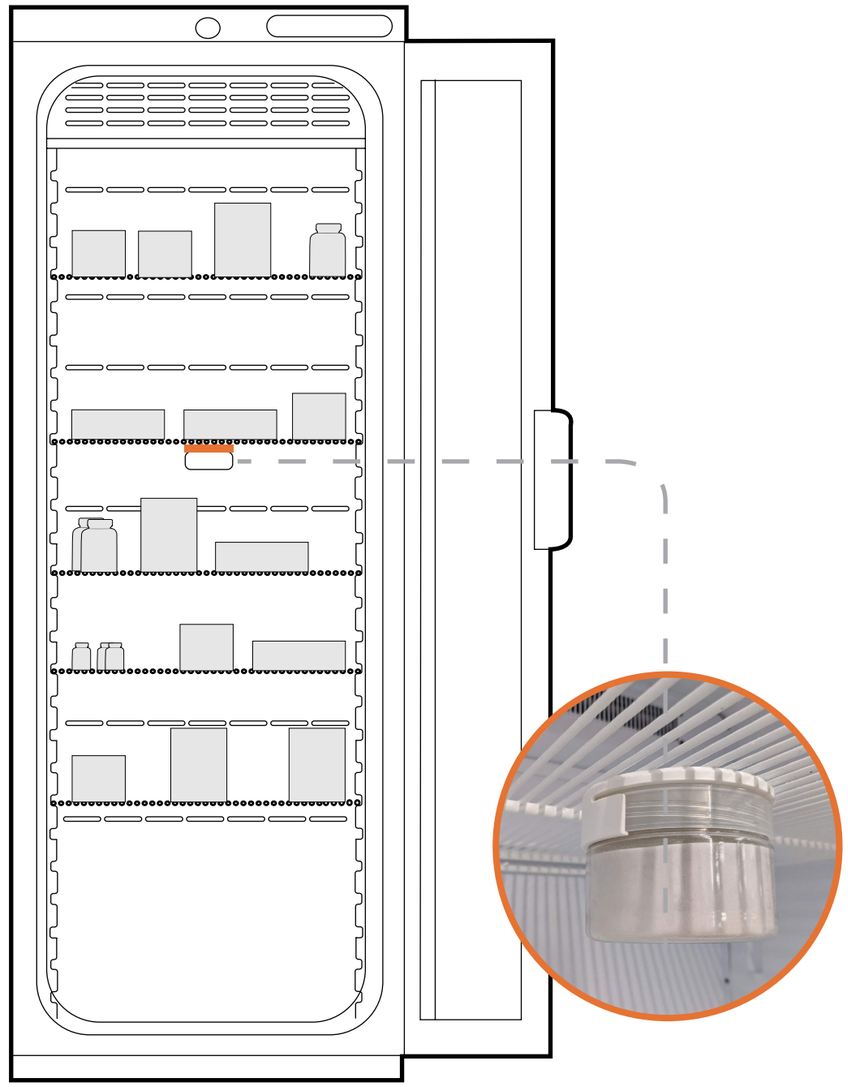


Figure 78.
Clip Component Contextual Visualisation

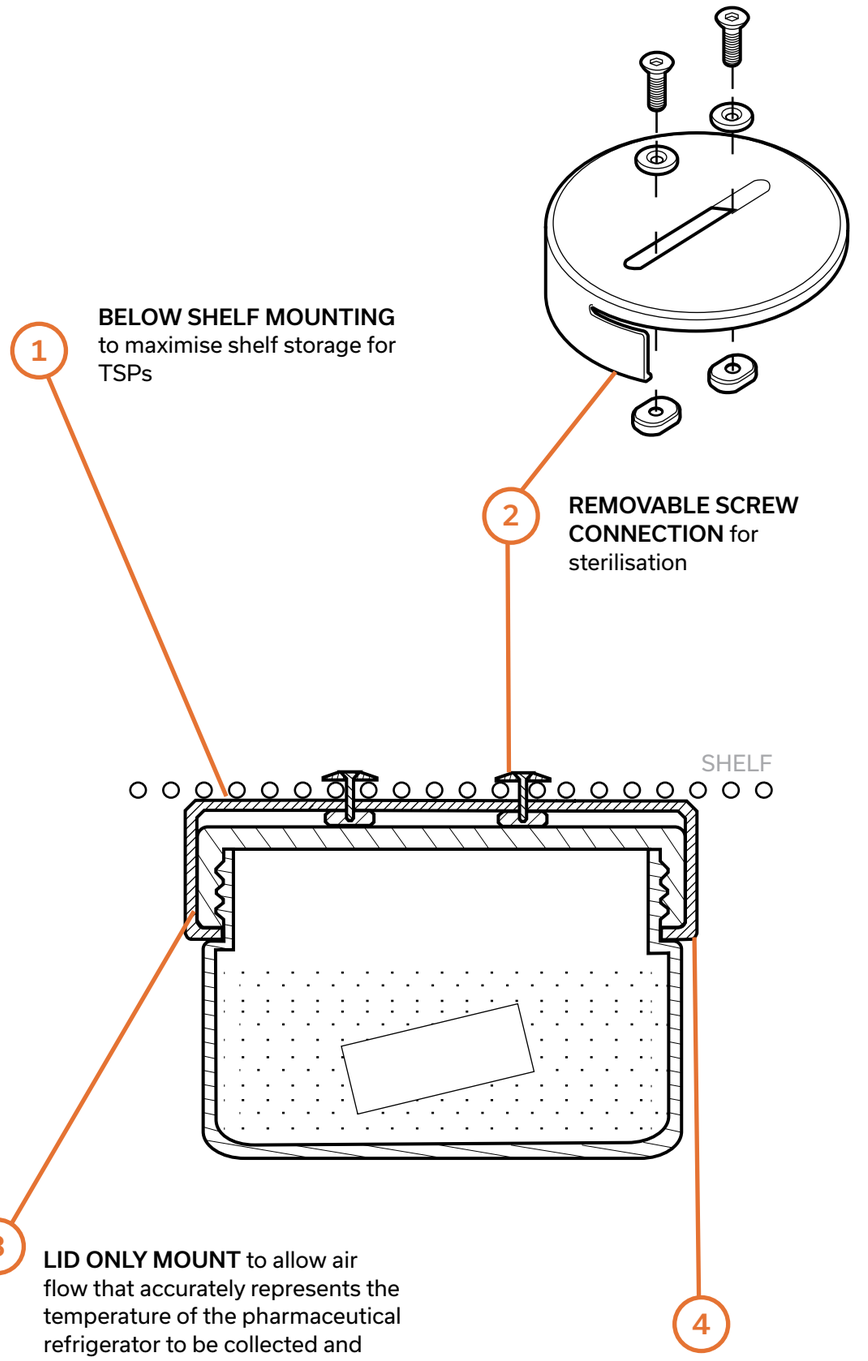


Figure 79.
Clip Design Details

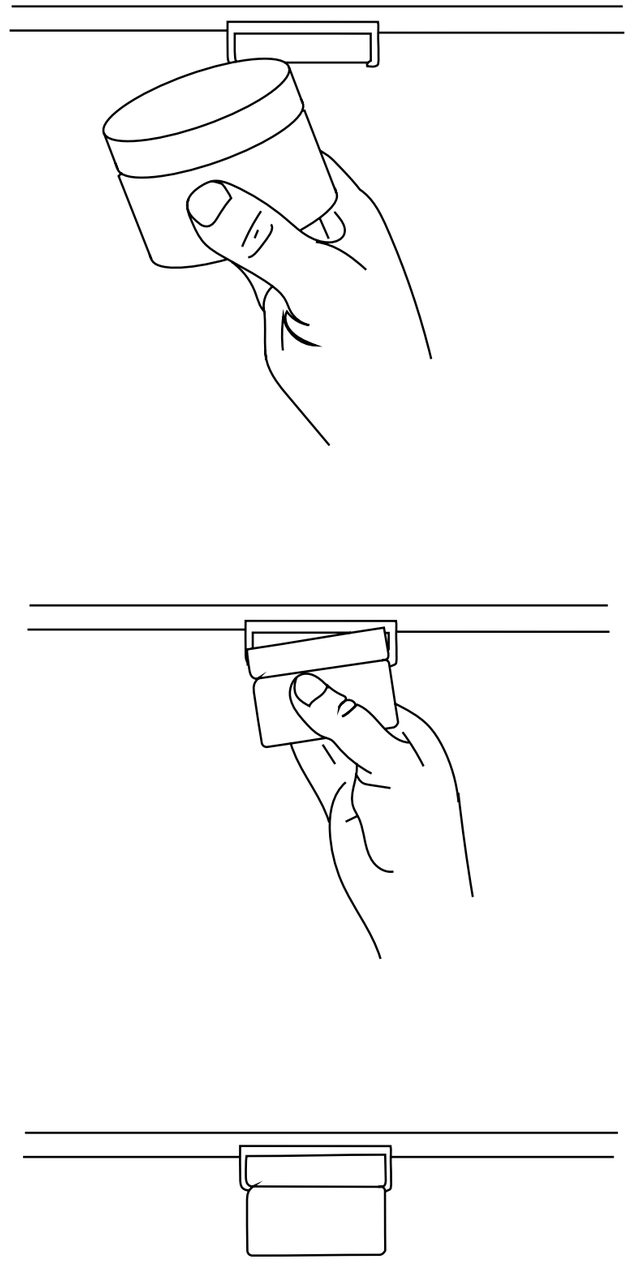


Figure 80.
Data Logger Placement into Clip

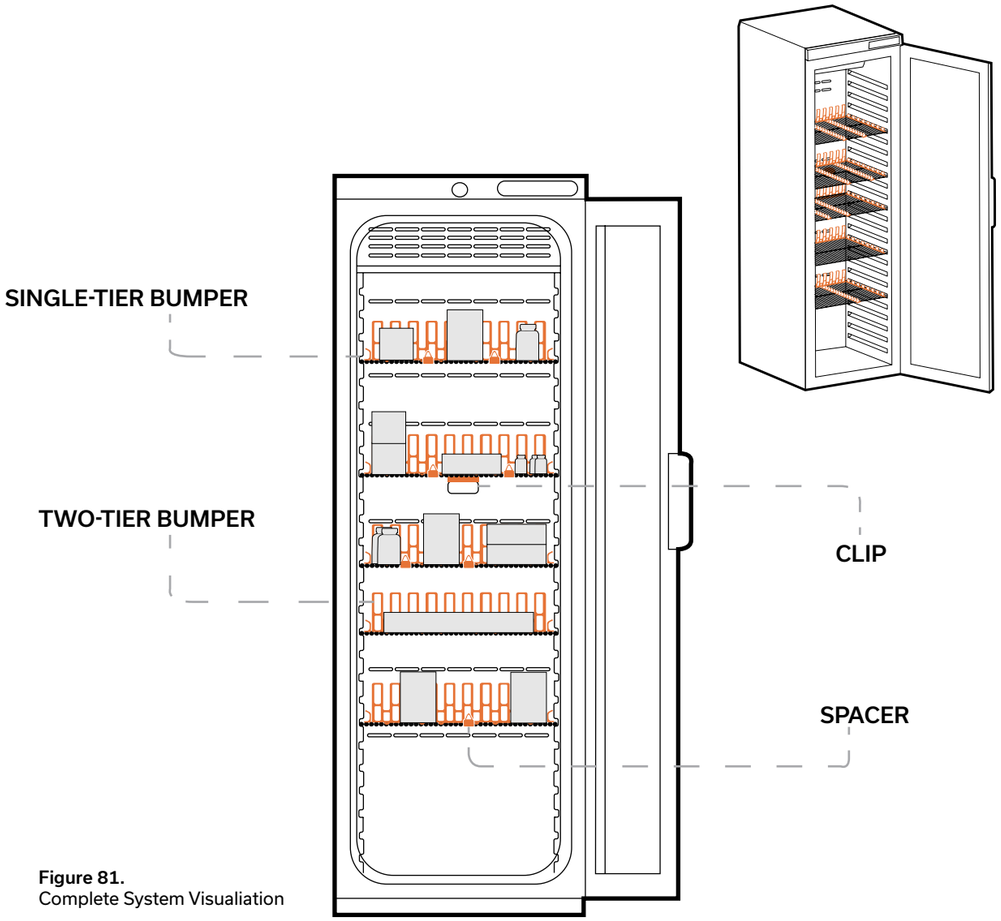


Figure 81.
Complete System Visualiation

Together the complete system improves the accuracy of data collected from data loggers and facilitates TSP storage in compliance with cold chain regulations. The system is considerate of the unique TSP stock held on each ward and consequently the unique organisation habits and therefore is modular. Modularity is presented through the ability of spacers to move across the shelves and be detached as well as the choice of either a two-tier or single-tier bumper on the back plate. The integration of this three-part system within existing cold chain architecture aims to reduce the workload of staff by passively ensuring TSP storage regulations are met. In addition, it requires minimal changes to current practice for staff, reducing the burden of change.

Figure 82.
Complete System in Empty Pharmaceutical Refrigerator

Figure 83.
Complete System in Use

Reflection

In reflection, the repetitive nature of the iterative design process was reminiscent of the PDSA cycles, an improvement and innovation methodology prominently used in healthcare environments, see Chapter 2.4a, Frameworks page 34.

I suggest that implementing an iterative design process may have served as a bridge across disciplinary boundaries, highlighting the shared value of an iterative process and demystifying disciplinary practice.

The fast-paced nature of iterative design allowed ideas and concepts to be quickly materialised and critiqued by the project team. The low resolution and partial prototypes were a useful tool to clearly demonstrate that the design wasn't static, it was malleable, and that critique and feedback would further craft it. Drawing on Heiss and Kokshagina's (2021) discussion of externalisation, the tangible prototypes removed the individual from the critique and aided transparent and genuine communication to resolve the design.

Additionally, conducting the workshops and prototyping across sites deepened the sense of shared ownership between CoCA and CCHV, aligning this research with Britton's (2017) definition of co-design. In turn, this showed both disciplines were valued and continued to build trust.

Further, the collaborative approach to iterative design development was mutually beneficial to both health and design disciplines. The production of tangible designs informed by previous collaborative research was an important moment that demonstrated and realised how the previous research has helped shape the design outcome. This demonstrated how non-design specific knowledge and expertise directly influences the development of design.

For designers, the critique with health team members considerably shaped the refinement of the design outcome and provided confidence that the designs would have genuine and meaningful impact for users. I believe, the honestly and constructive nature of the discussion in the iterative design development exemplified the strength of the relationships built across disciplines.

Part of my role was to organise and conduct the series of concept critiques with key stakeholders for designs produced by other team Cold Chain – Quality Improvement team members and myself to then inform further ideation and refinement. The ability for health perspectives and information to be constructively relayed to other design team members demonstrates the growth of confidence and competency in health disciplinary discussion between designers. This signifying the movement further along the spectrum of collaboration.

This method showed the tangible impact of the invested time and effort from both disciplines. It increased excitement for future opportunities within the CCHV and CoCA collaboration and continued to expand the reach of project contributors, shown in Figure 84.

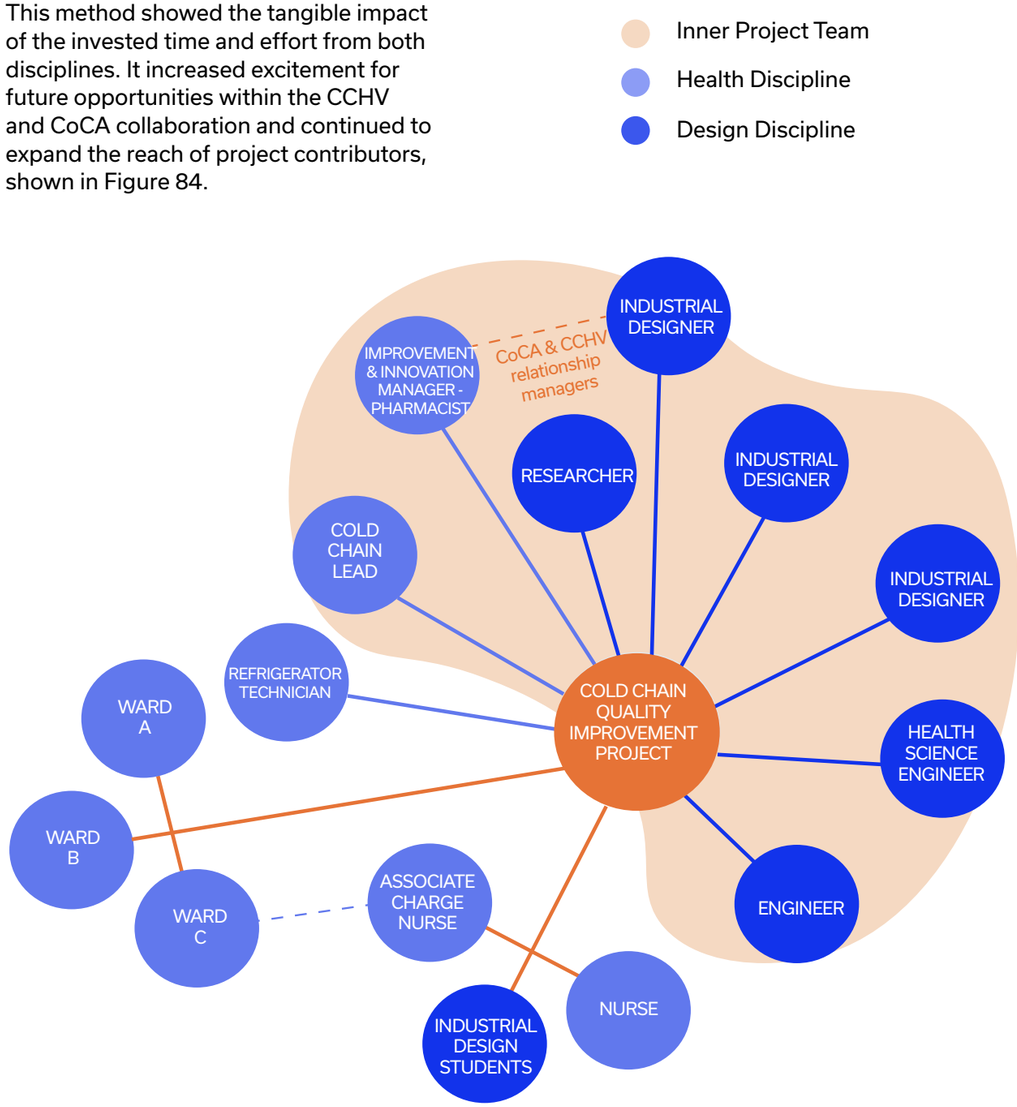


Figure 84.
Stakeholder Map - Iterative Design Development

4f Pilot Trial

Figure 85.
Pilot Trial Prototypes in Use

Before

Following the iterative design process the final designs were delivered to a wider and varied sample of stakeholders and users. Three key goals were prioritised:

- To evaluate the functionality and user experience of the final design
- To build on existing relationships across disciplines and develop new ones
- To expand awareness of Cold Chain – Quality Improvement project

To achieve this a pilot trial was selected to examine and identify any issues or limitations with the designs at a small scale to minimise risk. Commonly used in clinical research, a pilot trial also allows the Cold Chain – Quality Improvement team to examine the trial process to ensure meaningful data and insights are collected to inform further design development (Leon et al., 2011).

ETHICAL CONSIDERATIONS

The collaborative nature of the Cold Chain – Quality Improvement project required research to receive ethics approval from both CCHV and CoCA prior to commencement.

Careful attention was paid to ethical considerations for a pilot trial and they were firstly documented in a low-risk ethics application and peer reviewed by staff at Massey University, Wellington.

This application was assessed as low-risk and the study was approved to proceed. Subsequently, the ethical considerations were submitted for approval in three documents to Wellington Regional Hospital's Research Office: the study protocol, the area sign off and the participant information and consent sheet (PICS).

This application was reviewed, and the study was approved to proceed, see Appendix B.

Key ethical considerations were:

- **CCHV on boarding:** CoCA team members undertaking research on-site at Wellington Regional Hospital completed CCHV on-boarding to ensure safe, professional and ethical practice. This includes completing the 3DHB Security Access Agreement Users Terms & Conditions, CCDHB Code of Conduct Form, reading the Wairarapa, Hutt Valley, Capital & Coast District Health Boards Code of Conduct, and complying with the COVID-19 Public Health Response (Vaccinations) Order 2021.
- **Reducing conflict of interest:** The front facing researchers in this study were CoCA team members who do not have professional relationships participants.
- **Risk Aversion:** The prototypes and trial design were developed with cold chain experts to ensure there was no physical risk, no known or anticipated psychological, emotional or economic threat or risks for participants.
- **Informed consent** was obtained by the site's charge nurse before the commencement of the pilot trial.
- **Materiality:** Material safety data sheets were reviewed to inform the selection of polymer used in the prototypes trialled. Material qualities considered were poor thermal conductivity to minimise the impact of thermal bridging and a high chemical resistance to withstand hospital grade cleaning.
- **Anonymity:** All raw data collected through video, conversation or other means is only accessible to the lead researcher. This data was anonymised prior to further review by the Cold Chain – Quality Improvement project team, this includes the identities of participating staff and patient information.

PILOT TRIAL SITE SELECTION

The site for the pilot trial was selected due to the relationship built between the researcher and charge nurse during the semi-structured observation. At the completion of the observation series the charge nurse expressed interest in being involved in future development of the Cold Chain – Quality Improvement project.

The charge nurse was contacted via email and in-person by the researcher and provided with a copy of the PICS and study protocol before consenting to participating in the trial. Prototypes were demonstrated and a suitable time frame was confirmed.

The researcher liaised with the charge nurse via email and in-person to outline the objectives of the pilot trial, share the study protocol and PICS and answer any questions or concerns. Prototypes and renderings were presented to the charge nurse to clarify what was involved in the trial and how it may impact staff.

Figure 86.
Pilot Trial Site

During

The pilot trial was conducted over seven days. At the commencement, a banner was fixed to the pharmaceutical refrigerator door informing users a trial was taking place and referring them to the study documentation located on the side of the refrigerator for further information. It also provided users with contact details for the lead researcher for further comments or queries. Further, feedback forms were available throughout the trial alongside a deposit box (see Appendix D).

The prototypes were installed into the pharmaceutical refrigerator with access and supervision provided by nursing staff. This was followed by a one-hour observation period to ensure there were no significant issues.

Over the following seven days intermittent observations were conducted by the researcher and two health team members. These observations served to ensure durability and functionality of prototypes were maintained, observe user engagement and as an opportunity for users to provide verbal feedback.

After

After the seven-day trial period was over, the prototypes were removed from the pharmaceutical refrigerator with access and supervision provided by nursing staff.

To gather feedback the researcher attended a handover to open a discussion on the prototypes and trial with the site nursing staff. It was considered important to acknowledge the contributions by providing the nurses with a thank you gift and a researcher note with contact details for further comments or questions.

Newly identified stakeholders were contacted via email and invited to be involved in the further development of the Cold Chain – Quality Improvement project.

Feedback collected through various methods was consolidated and synthesised into the following diagram.

Figure 87.
Pilot Trial Feedback

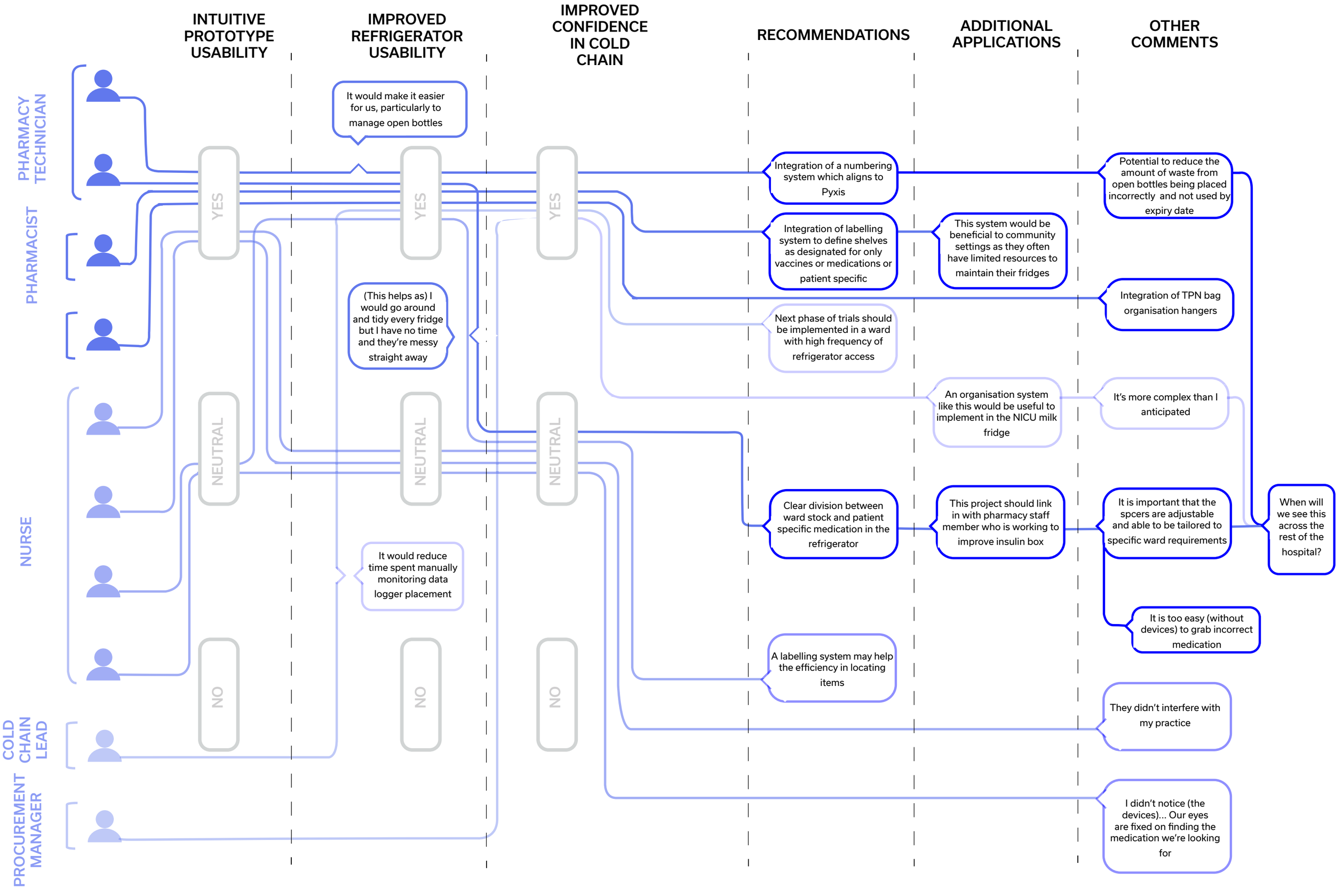


Figure 87 synthesises the analysis of the feedback collected by maintaining the integrity of the individual user experience but also allowing the Cold Chain – Quality Improvement team to identify and extrapolate shared experiences and opinions across users. The use of health specialisation as identification allows the project team to analyse the differences and similarities in how different specialties engage with the prototypes and perceive the value of the design intervention.

The success of the pilot trial is exemplified through three aspects depicted in Figure 87. Firstly, 75% of feedback providers indicated an improved experience when engaging with the pharmaceutical refrigerators. The remaining 25% stating there was no impact to their practice, demonstrating that the design development was effective in considering and integrating the task analysis insights.

Secondly, 50% of feedback providers experienced improved confidence that cold chain compliance was being maintained. Finally, it is suggested that the feedback providers see longevity and value in this design outcome and the Cold Chain – Quality Improvement project through the facilitation of building connections, suggestion of alternate applications and interest in future stages of the project.

Figure 88 depicts the expansion of the Cold Chain – Quality Improvement stakeholder map through the pilot trial.

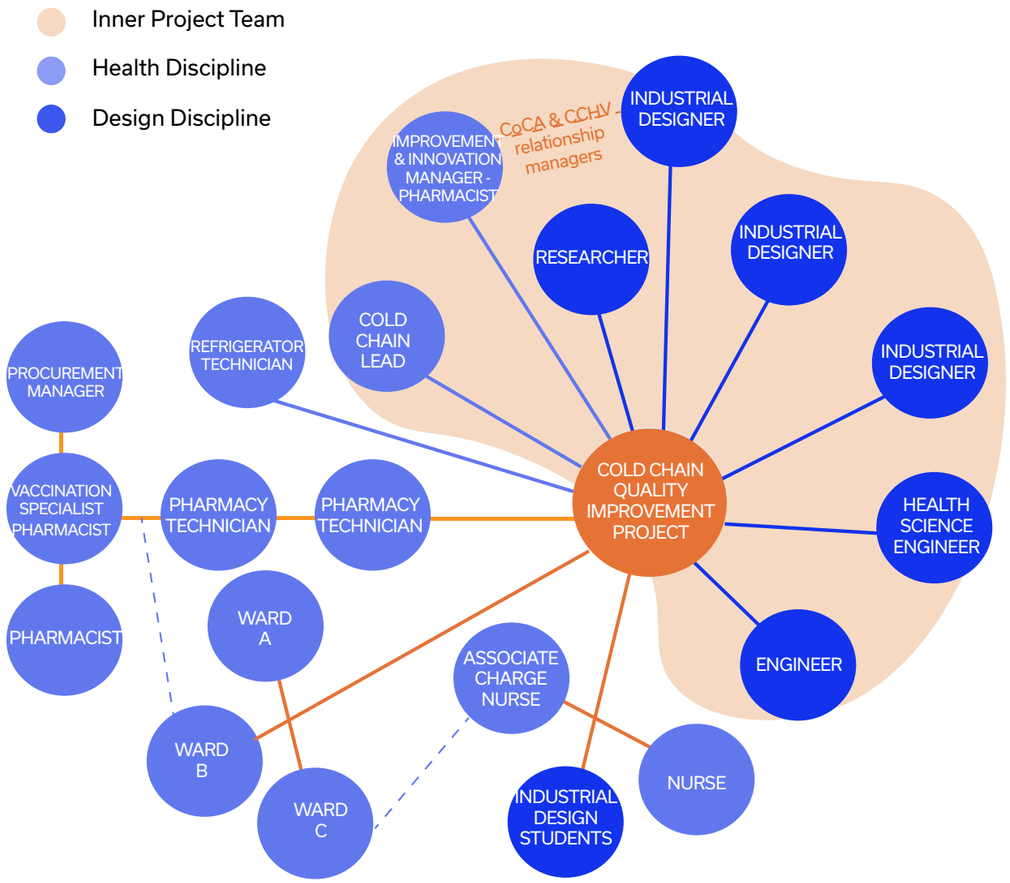


Figure 88.
Stakeholder Map - Piot Trial

Reflection

The pilot trial had notable success in expanding the awareness of the Cold Chain – Quality Improvement project and engaging stakeholders, primarily through word of mouth. During the seven-day trial period CCHV Cold Chain – Quality Improvement project team members invited colleagues to visit the pilot site to observe and review the prototypes.

This led to increased engagement during intermittent observation periods and provided an opportunity for the researcher to engage in semi-structured interviews. I suggest that the quality and scope of the discussion during these interviews was rich due to the context. Being positioned on-site with the prototypes in use allowed for salient and productive feedback to be collected.

In my experience, I found that participants were more forthcoming with verbal feedback. Therefore, feedback collection was heavily dependent on the researcher being on-site conducting observations. This contrasts starkly to the semi-structured observations, where staff members were reluctant to engage with the researcher. Although it is difficult to assign a definitive cause for the increased engagement, the following is proposed;

+ Increased familiarity with the researcher from previous research
+ The reciprocity of the researcher presenting their work and observing the participants.
+ The tangibility of the prototypes causing genuine interest and engagement from participants

05

RECOMMENDATIONS

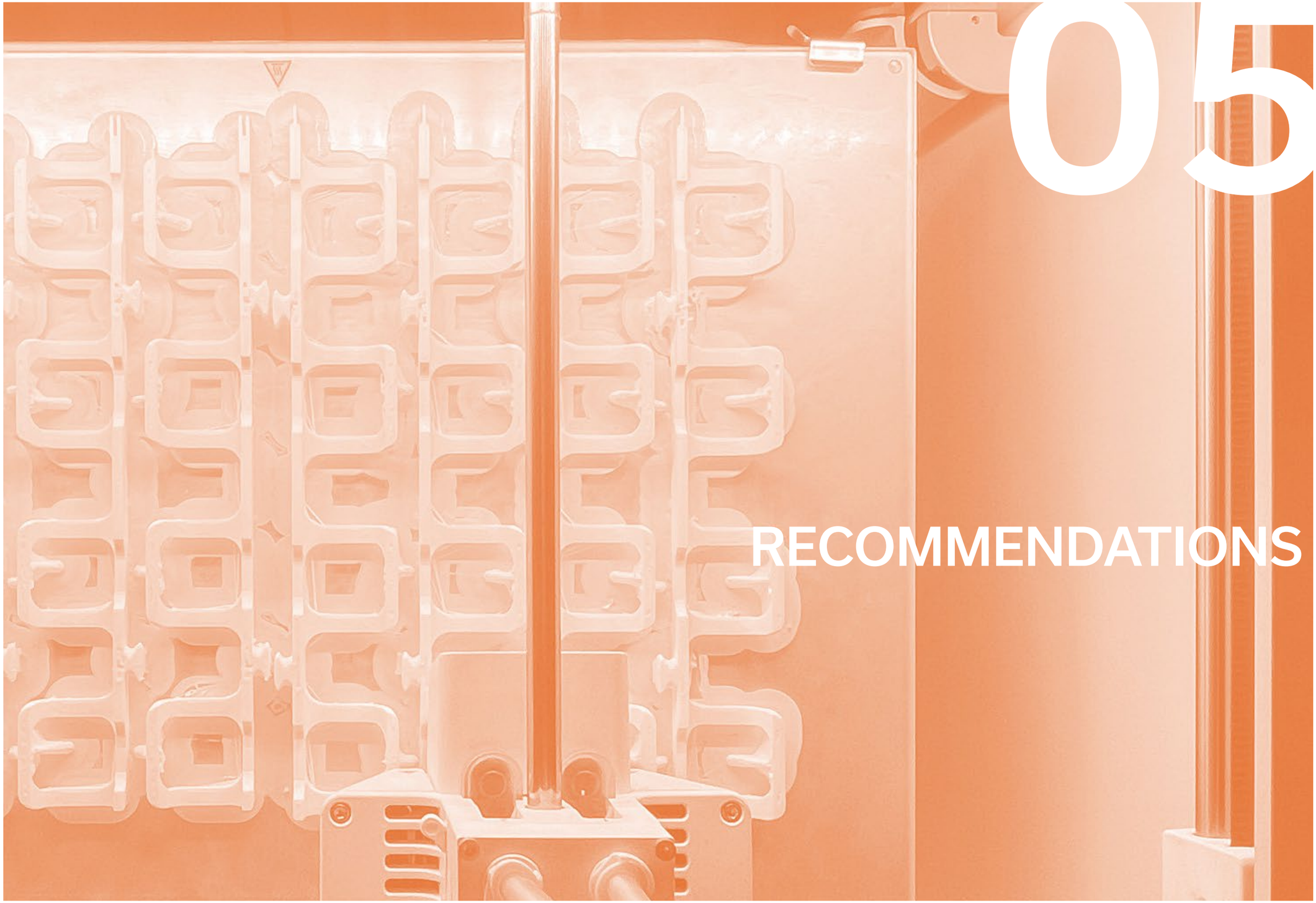


Figure 89.
3D Printing 03

The feedback and observations gathered from this pilot trial have been used to inform the following design recommendations for the continued development of the three-part system. Primarily it is recommended that a design review is undertaken in collaboration with the project team for each of the three components: bumper, spacer and clip to assess functional performance and usability. The following are the author's contributions to the design review and it is recommended that the identified features are addressed and refined.

Bumpers
+ Single-Tier

The bumper had significant success preventing TSPs from making contact with the internal refrigerator walls on the sides on the shelves and was able to withstand applied pressure from day-to-day tasks without dislocating. An example of this is shown in Figure 90.

Figure 90.
Bumper Pressure Resistance

However, further design refinement should be applied to the bumper's insert for mounting on the side of a shelf.

During the design development phase, it was identified that on some sections of the refrigerator's shelves the rungs had a distribution variation of up to 6mm, shown in Figure 91, across different refrigerators of the same model. This is likely a result of the welding and powder coating tolerance in manufacture.

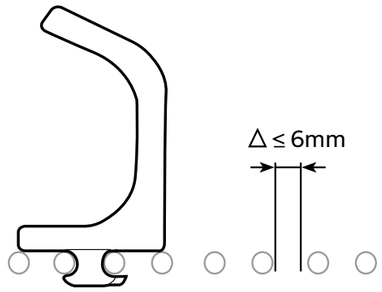


Figure 91.
Rung Distribution Variation

The prototypes used in the pilot trial were designed to fit the measurements of the trial site's refrigerator. Therefore, further development should be conducted to enable side bumpers to reliably function in a variety of fridges despite this variation.

Figure 91 shows potential avenues for further development.

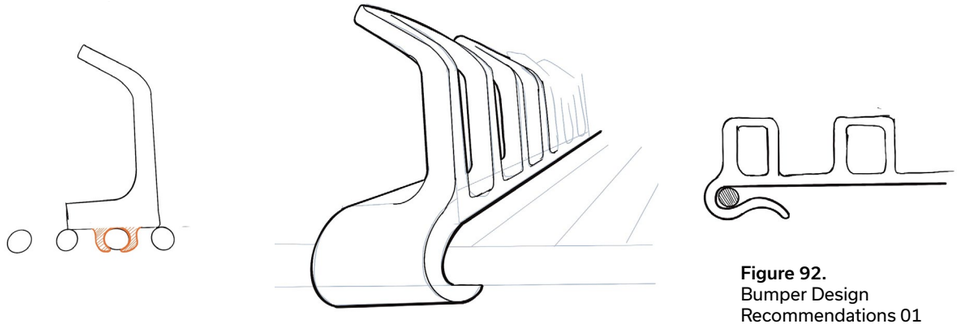


Figure 92.
Bumper Design Recommendations 01

Bumpers
+ Single-Tier
+Two-Tier

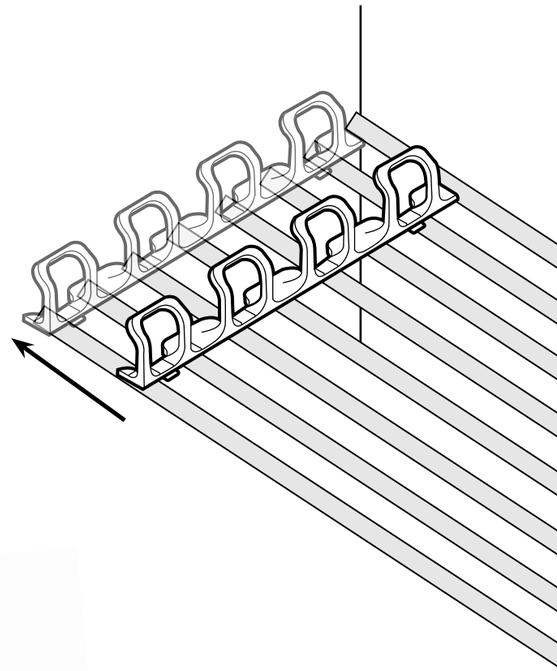
The rung distribution variation also effects bumpers mounted on the rear of the refrigerator shelf. The current bumper design has the bumper spanning the rear of the shelf with inserts protruding between the shelf rungs at set distances. However, the insert protrusions may not align with all distribution variations. It is recommended that other methods of connection are explored for rear shelf mounted bumpers.

Additionally, during the pilot trial it was observed that when mounted at the back of the refrigerator shelf the bumpers were able to be pushed along the shelf rungs toward the rear refrigerator wall (Figure 93). This may cause thermal bridging. It is also recommended that the connection point between the bumpers and refrigerator shelves is refined to limit sliding.

Finally, it is suggested to explore further structural strengthening. Although there were no incidents that suggest this as an issue from the pilot trial it is recommended that the structure is reinforced to ensure durability and decent product life span.

An exploration of how this may be achieved is illustrated in Figure 94.

Figure 93.
Bumper Sliding



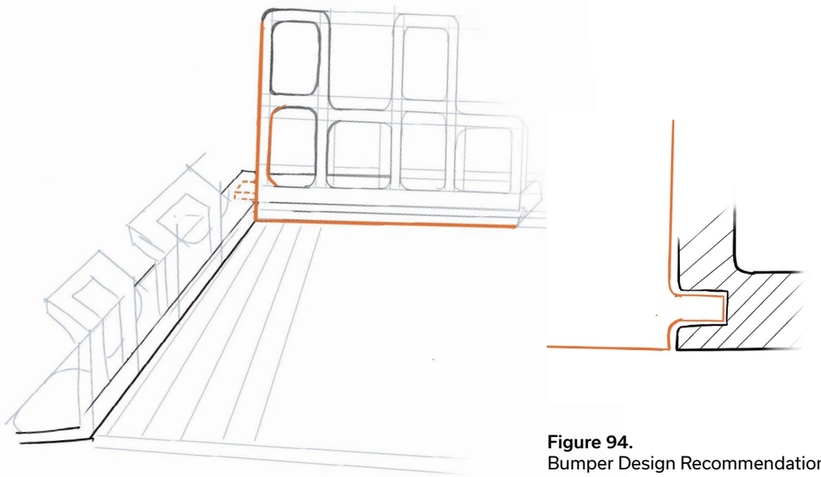


Figure 94.
Bumper Design Recommendations 02

Spacer

The spacer is the component that is interacted with most by the users and therefore required careful consideration so that their usability was intuitive and non-disruptive to daily tasks. The pilot trial feedback stated that they did not interfere with day-to-day tasks and that they positively improved the organisation of the pharmaceutical refrigerator. During the intermittent observations it was observed that the thumb tabs are intuitive to use as one user correctly gripped and slid the spacer to access a TSP located toward the back of the refrigerator.

Figure 95.
Spacer Grip

Similarly to the bumpers the variation in tolerances in the manufacturing of the refrigerator shelves impacts the spacers connection point and needs further consideration in future developments.

It is also recommended to consider the control of the slider to avoid tailing and to ensure it has the ability to move the weight of a variety of TSPs when it is slid.

An exploration of how this may be achieved is illustrated in Figure 95.

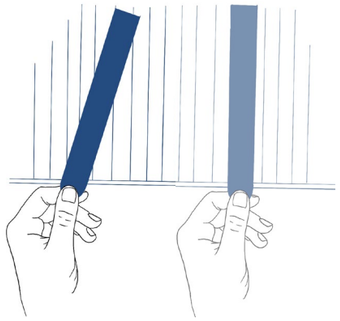


Figure 96.
Spacer Tailing

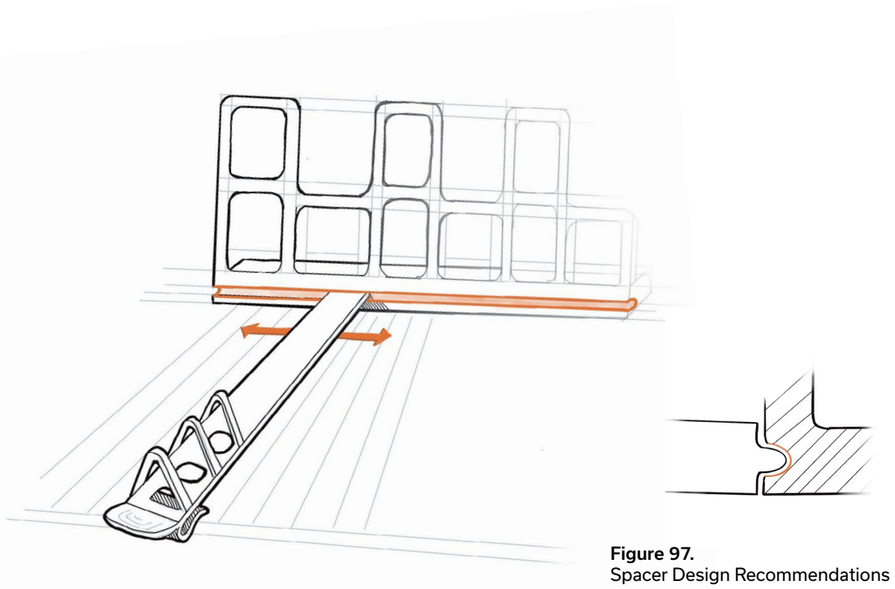


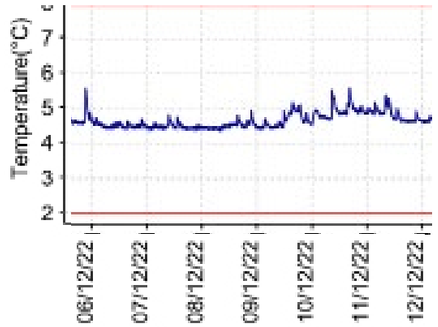
Figure 97.
Spacer Design Recommendations

Clip

In the pilot trial feedback, the clip was praised for creating more usable space for TSPs on the refrigerator shelves by mounting the data logger container beneath the shelf. During the seven-day pilot trial the data logger mounted in the clip produced consistent readings within the +2°C to +8°C window, indicating that the clip can aide reliable collection of data from data loggers. The recorded data was collected by a health team member and is shown in Figure 98.

Figure 98.
Pilot Trial Temperature Graph

Note. Produced by Richie Perry, 2022



Another feature to consider is the connection of the clip to the shelf. The nut and allen head screw fixture in the current design allow for appropriate tension to lock the clip in the correct location and prevent the clip from sliding along the rungs, which is necessary to the success of this design. However, this method requires seven separate parts and an allen key, it is recommended to consider if there are other methods that require less componentry, to avoid parts going missing (into the refrigerator) and to improve reliability and robustness of the component and its performance.

This connection also takes a considerable amount of time to insert, so can be difficult if inserting in an operating pharmaceutical refrigerator as the window of access is very limited, as it would be packed with TSP's. The intention of this design is that it would be installed in pharmaceutical refrigerators by the technician prior to installation on the wards, so time requirement is less of an issue. However, this will require careful coordination in future trials. Further, if alternative connection designs are explored it's important to consider the height at which the connection feature protrudes above the shelf so as not to interfere with other components in the system, such as spacers which must freely slide over them.

Finally, future design development should consider integrating a feature on the clip that indicates the correct orientation of the data logger within the clip, to ensure the orange 'calibration' sticker is visible through the glass door.

An exploration of how this may be achieved is illustrated in Figure 99.

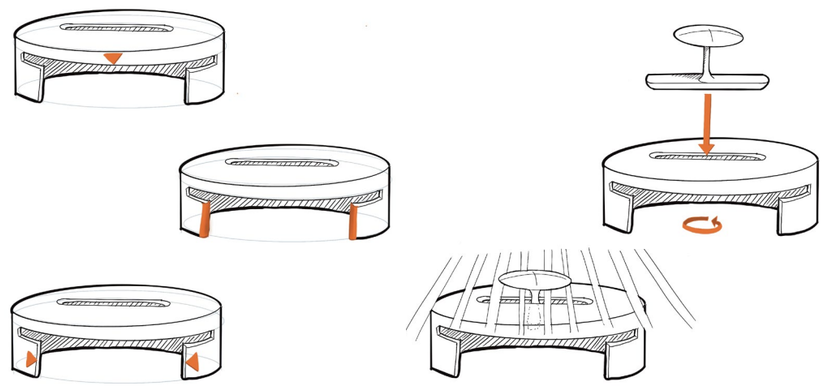


Figure 99.
Clip Design Recommendations

COMPLETE SYSTEM

Overwhelmingly the feedback on the complete system collected from the pilot trial was positive and stated that there was no negative interference with the current practice of staff across nursing and pharmacy professions.

It is recommended that further research should be conducted to explore the integration of labels on bumpers and spacers. In the pilot trial feedback, it was suggested that these may be numbered to existing codes attached to TSPs or may be alphabetical by TSP name. This may pose the opportunity to further facilitate improved organisation within the refrigerators, but it is important that the labelling method selected is intuitive to all user groups.

An exploration of how this may be achieved is illustrated in Figure 100.

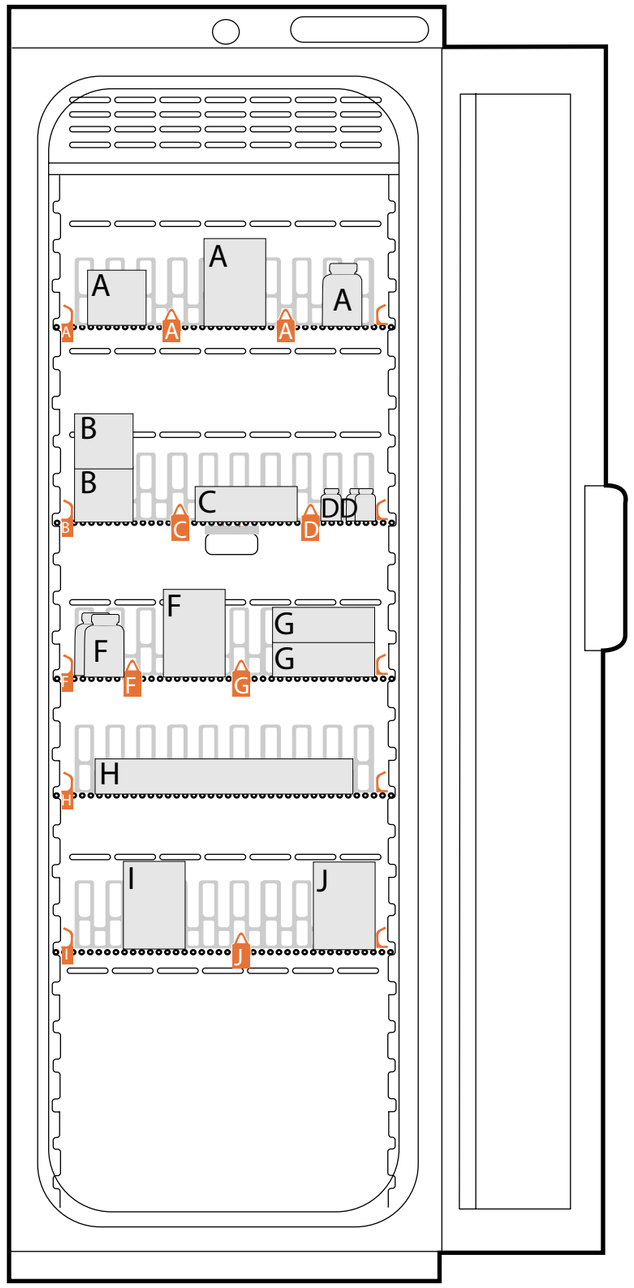


Figure 100.
Label Design Recommendations

I suggest there may be value in implementing another co-design workshop. This would provide an opportunity to build on relationships and integrate insights of stakeholders and collaborators who have become involved in the project since the first workshop. I expect this will provide an in-depth, productive discussion as the scope of the project has significantly narrowed since the first co-design workshop and there is increased representation from a variety of health disciplines.

Informed by the pilot trial the next steps of the design research were discussed and agreed upon by the Cold Chain – Quality Improvement team to include a secondary trial across 20% of Wellington Regional Hospital's pharmaceutical refrigerators and in a selection of wards with a variety of specialties to stress test product performance.
It is vital that researchers strategise effective and efficient feedback collection methods with staff at each observation site, to ensure the collection is thorough and insights are meaningful.

Concurrent with the development of the secondary trial, design for manufacturability should be considered and alignment with a specific manufacturing process will be required. Significant influencers on the manufacturing process are likely to be pricing and manufacturing methods that work with medical grade materials.

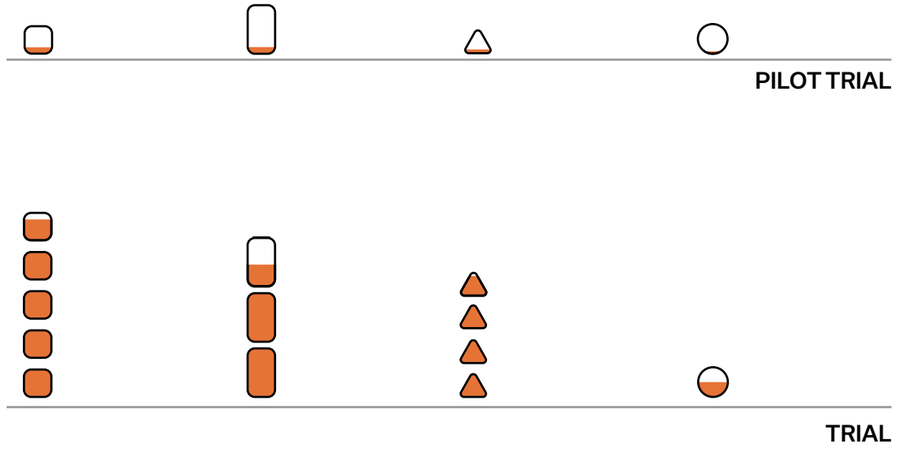
As an example of the potential demand from a single hospital Wellington Hospital has approximately 150 pharmaceutical refrigerators dedicated to cold storage of TSPs. To fit out these refrigerators with the complete three-part system it would require the production of an estimated:

150 aero-scout clips
1,200 spacers
1,500 side bumpers
750 back bumpers

Figure 100 visualises the number of components required for the pilot trial, 20% trial and hospital wide introduction, whereby each shape

(This calculation is based on the estimation that each pharmaceutical refrigerator has 5 internal shelves)

Figure 101.
Scale of Production



The exploration of manufacturing methods should consider production at this scale and, due to the centralisation of Te Whatu Ora, the scalability of production for the possibility of application across other New Zealand hospitals.

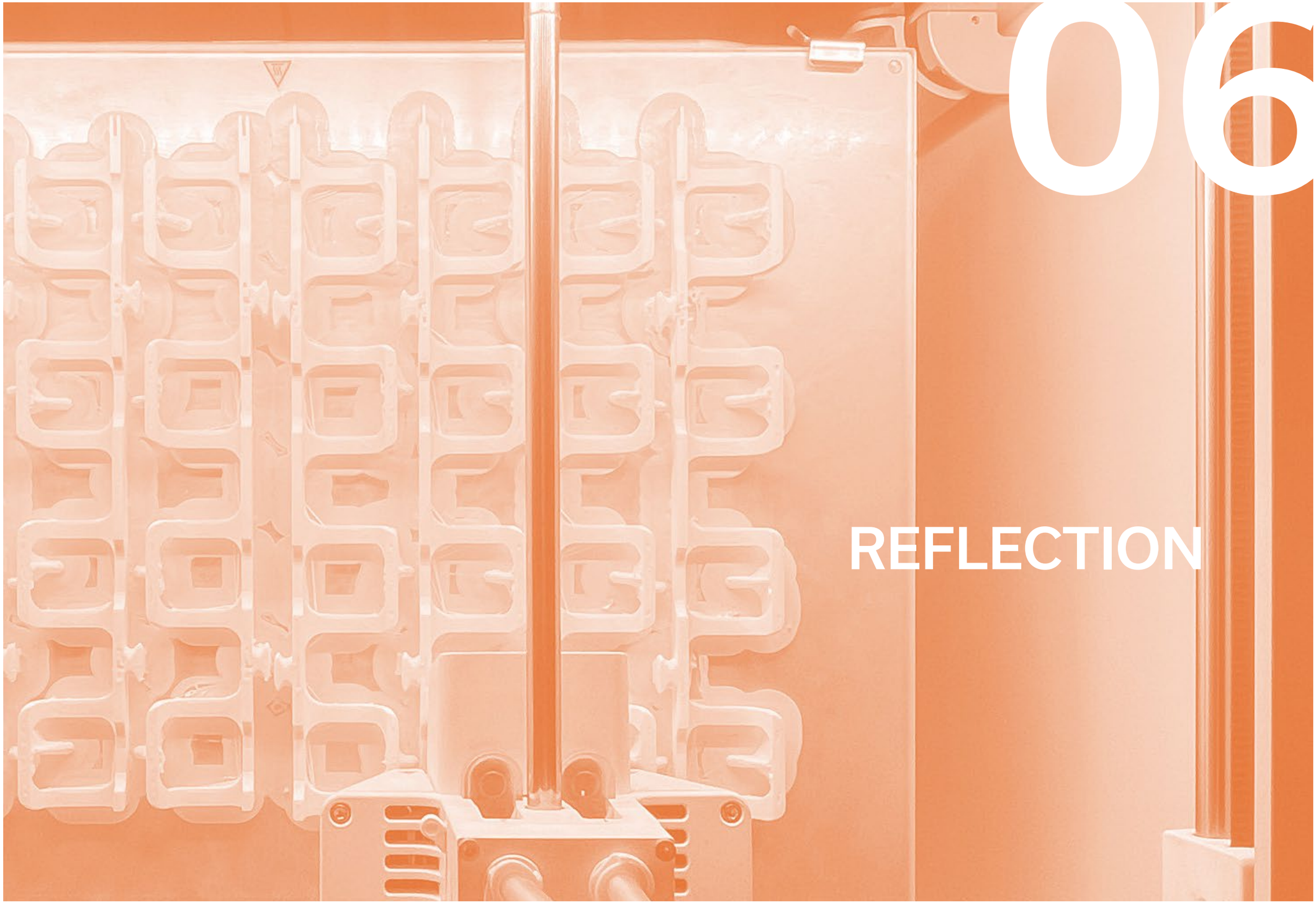


Figure 102.
3D Printing 04

Through the implementation and critical reflection of a co-design process conducted in the progression of the Cold Chain – Quality Improvement project this design research has developed expertise in explorative design research methods and their applicability to design teams and stakeholders operating in a hospital environment.

This process aligns with the New Zealand Health Strategy: Future Direction (2016) and New Zealand Health Research Strategy 2017-2027 (2017) through its prioritisation of creativity, collaboration, and lateral thinking to create a design outcome that improves cold chain compliance in pharmaceutical refrigerators. Further, the partnership between CoCA and CCHV established under the Individual Access Agreement demonstrates a commitment to the integration of design thinking into quality improvement projects to shape the future of New Zealand's health care system.

To reflect on this process meaningfully, it was important that the voices of team members from design and health disciplines were expressed. As such this section weaves together the researcher's reflection of the collaborative design process with the reflection of the inner project team members: two industrial designers, a cold chain lead and an improvement and innovation manager/pharmacist. To achieve this, the researcher distributed a digital survey to the inner Cold Chain Project team upon the conclusion of the pilot trial de-briefing. The survey was a combination of multiple choice and open-ended questions that prompted team members to reflect on and present their individual experiences in this project (see Appendix E).

This critical reflection is a qualitative contribution to furthering the understanding of the value, challenges, strengths and opportunities of co-design in a hospital context.

This project has trialled and explored the application of a co-design process in a hospital context. Reflecting upon the Cold Chain – Quality Improvement project 100% of the survey respondents see significant value in multiple disciplinary collaboration in hospital environments. This demonstrates the benefits of this co-design process and positions this research in alignment with Blomkamp (2018) and Eisenhardt et al.'s (2016) (as cited in Heiss and Kokshagina, 2021) proposition that complex problems within complex systems are addressed more effectively by teams with a variety of disciplinary representation. In my experience with co-design this argument is valid as the nature of the collaboration enriched my understanding of two key areas: contextual understanding and stakeholder engagement.

CONTEXTUAL UNDERSTANDING

The multiple disciplinary approach to the Cold Chain – Quality Improvement project provided a pathway for team members to engage in environments and contexts beyond those typical of their disciplines. Relationships between health and design specialists built through the co-design process facilitated effective and informed engagement in unfamiliar contexts through open dialogue and knowledge sharing.

O'Leary et al. (2021) theorise that designers tend to underestimate the complexity of hospital environments. This research is not positioned to endorse or negate this theory however I can contribute my experiences as a designer in a hospital context to the discussion and reflect on how co-design facilitated the development of a meaningful contextual understanding.

In the Cold Chain – Quality Improvement project I was positioned both as a Massey University, CoCA master of design student and as a part-time employee at CCHV; consequently my time was divided between sites. Through the supported immersion into a health environment, I was able to develop a comprehensive picture of the complexity of hospital environments, as I navigated my own agenda and observed those of my colleagues.

It is not to say that I 'underestimated' the complexity of the hospital but rather that there are many nuances and unique protocols to the environment that I would not have been able to identify, learn and navigate without immersion and support from health specialists. Summarised by a survey respondent that "we are stronger as a research team than working... in isolation". Through collaborating and engaging with health specialists in a health context I was able to develop an understanding of the social and physical paths that network the hospital formally and informally, and how these can act as both facilitators and limiters.

In this time, I also became increasingly aware of the significance of relationship building across the hospital as a tool to help navigate the nuances in processes and practices in varying areas. This helped me to understand that hospital staff are continuously working with multiple disciplines within the hospital context.

STAKEHOLDER ENGAGEMENT

As an employee of CCHV, I found I was able to position myself within this network and expand connections across the hospital as the Cold Chain – Quality Improvement project developed. As new stakeholders were introduced and involved in the project their insights were utilised to inform the subsequent steps of the research. This manifestation of stakeholder mapping references Britton's (2017) definition of co-design demonstrating how co-design isn't connected to a defined phase of a process but to the 'shared agency or collaboration' (p.36) in a project's continuous evolution.

MANAGING QUALITY COMMUNICATION ACROSS DISCIPLINES

As a designer, engaging with a range of stakeholders and users from various health disciplines brought with it some unique challenges that co-design tools helped to navigate. These co-design tools include: Empathetic innovation, object aided communication, lead user engagement, designer facilitation and relationship building.

EMPATHETIC INNOVATION

Through discussion with my colleagues, I was introduced to the concept of 'change fatigue' and its prevalence and impact on hospital staff. Brown et al. (2018) describe change fatigue as an "overwhelming feeling of stress, exhaustion, and burnout associated with rapid and continuous change in the workplace " (p. 307).

Quality improvement projects and design are implemented to make changes to a product or service, ultimately to improve its usability and functionality. Therefore, with the irrefutable presence of change fatigue for hospital staff it is the responsibility of the research team to take an empathetic approach and pay careful consideration to the management and engagement of these users and stakeholders throughout all phases of a project. This will likely require the research team to apply adaptable and tailored approaches which I suggest will be most impactful and valuable if they're grounded in relationships between the research team and key stakeholders.

For example, the coordination of the observational study (Chapter 4d) required liaising with three wards of varying specialties. It was a priority during the preparation phase that I built a rapport with the charge nurse of each ward as "relationship building with clinical staff is critical" (survey respondent, 2022). In the digital and in-person conversations prior to the commencement of the observation we were able to strategise engagement methods that would integrate best with each ward's unique preferences. This gave each collaborator the autonomy to shape their engagement.

Taking an empathetic approach to innovation helped to improve the quality of insights collected in this research by facilitating consistent engagement with users and stakeholders (Donetto et al., 2015). This is exemplified in repeated stakeholder engagement throughout the Cold Chain – Quality Improvement project. Furthermore, I propose that adaptability in practice serves as a tool to navigate the unpredictability of hospital environments and minimises the negative impact Reay et al. (2017) argue waiting for the perfect research conditions can have on a design process. Reiterating van der Bijl-Brouwer's (2019) position that co-design requires adaptability.

One of the key design criteria was that the design outcomes do not interfere with the existing practice for staff. Methods adhering to this criteria were explored in the semi-structured observation and pilot trial conducted on-site at Wellington Regional Hospital, providing the team with an authentic understanding of day-to-day practice. As a result of this criterion the research and pilot trial required participating staff to make very little change to their regular practice. This may have been a contributing factor to the consistent growth in project stakeholders.

OBJECT AIDED COMMUNICATION

As a co-design project it was essential that communication between individuals and disciplines was clear and informative to build a strong shared knowledge and ability to meaningfully utilise expertise and insights. During the iterative design development I recognised that providing a tangible object significantly improved the quality of communication between stakeholders.

For example, design and health specialists used empty TSP boxes and CoCA's pharmaceutical refrigerator to quickly demonstrate issues and opportunities within current cold chain practice. By visually demonstrating the relationship between objects ideas were efficiently and effectively exchanged between disciplines.

Additionally, during the IDD the presentation of a physical prototype to stakeholders and users helped to manage the scope of the conversation by guiding the critical discussion to examine key details and functions of the prototype. As a result of this learning, I carried the complete collection of 3D printed iterative design development and a pharmaceutical refrigerator shelf with me to each design refinement workshop with health stakeholders. This also helped to exemplify how non-design expertise enriches an IDD process.

Drawing on principles from the co-design toolkit case studies (Chapter 2.6a) the co-design workshop, iterative design development and the pilot trial conducted in this research employ externalisation. In reflection both tangibility and externalisation served as a buffer, by moving the ownership of an idea away from the individual and to the collective. I suggest this strengthened the quality of communication within the team and across disciplines by creating a safe space to think experimentally and creatively therefore providing a deep and broad exploration to draw from for design development.

LEAD USER ENGAGEMENT

Further, in my experience I perceived the presentation of tangible prototypes to generate an increased interest and investment in the ongoing project. For example, during the pilot trial, some staff members voluntarily provided feedback and others saw value in the project so recommended additional cold storage experts to collaborate with to further the research, adopting a 'champion' role within their department or discipline.

This invested the study with input from high value and motivated 'lead users'. According to von Hippel (1986), these types of users are particularly useful sources of information as they are often able to articulate their emerging needs, due to their extended experience with the existing system. Further, they have an in-depth understanding and consequently can appraise how new product benefits and innovations would be received into that system.

DESIGNER FACILITATION

In reflection, I agree with Chamberlain and Craig's (2017) statement that often a designer's role is to facilitate creative engagement by building the scaffolds for other disciplines to express their creativity. The methods discussed above demonstrate how as a designer I have strove to construct an environment that allows key stakeholders to comfortably and meaningfully contribute to the design development. However, in my experience this did not serve as a limitation for my ability to contribute to the design development with the team, as experienced in the case study of the Neo Project (Gustavsson & Andersson, 2019).

RELATIONSHIP BUILDING

My experience in this process also supports Ní Shé and Harrison's (2021) position that most of the work and time investment in co-design projects is spent behind the scenes. This was particularly true in the earlier phases as I was learning how to navigate the hospital environment physically, culturally, and linguistically. I invested time with my health disciplinary colleagues learning appropriate and productive ways to communicate and expand my network, over time becoming familiar with the health disciplinary jargon. Sharing an office with hospital-based team members was a key driver of building authentic and genuine relationships and knowledge flows, as our communication wasn't limited by time constraints or agendas (Heiss & Kokshagina, 2021). These behind-the-scenes actions, I believe, are where the value of co-design is added; in the ability to communicate honestly, respectfully, meaningfully.

Heiss and Kokshagina (2021) state that co-design requires participants to reframe their understanding of 'work' and 'practice' away from individualised expertise towards knowledge flows. As a result of this throughout the Cold Chain – Quality Improvement project I aimed to balance a mind-set that presented confidence in my design disciplinary expertise with knowledge that this expertise is malleable and adaptable.

COMPLEMENTARY DISCIPLINES OF DESIGN AND HEALTH

Through this research I learnt the strengths and limitations of my practice, realising the driving focus of my work was qualitative insights of how users experience a product or system. This project has helped me to understand how these insights can be complemented with quantitative research methods to strengthen the complete understanding of a product or system in which I'm designing for. A strength in this project team was the comfortability with the unknown and the ability to lean on one another to suggest how to address unknown factors. This was illustrated from the outset by the collaboration between CCHV and CoCA to understand the human factors that cause patterns or anomalies in data collection.

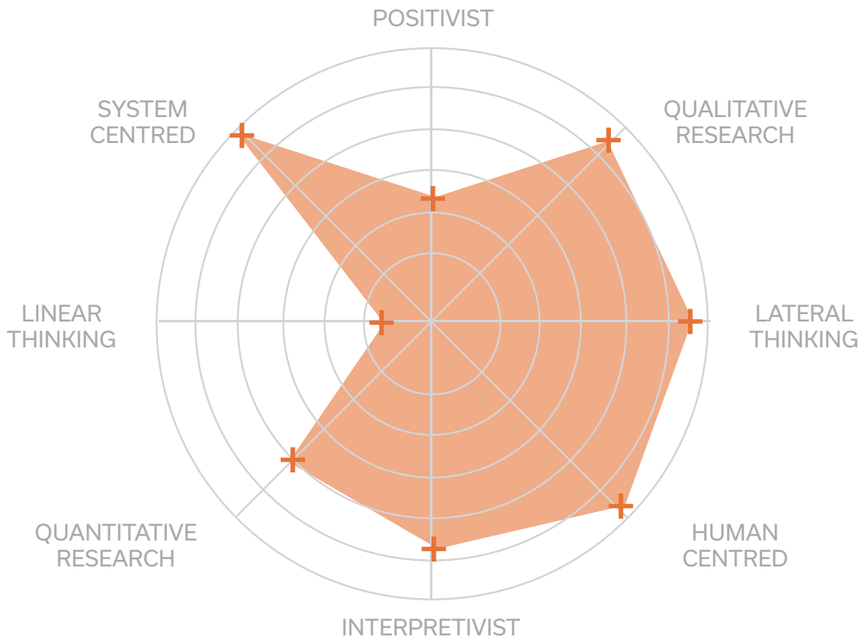


Figure 103 is the author's interpretation of the diversity in the range of methods implemented in the Cold Chain - Quality Improvement project in the scope of this master of design research.

I, alongside other inner project team members, believe that the strength of this process was the team's ability to engage and utilise individual and disciplinary expertise to advance the project further, realising the potential benefits of a health and design collaboration. For myself, and a survey respondent, it solidified the unifying characteristics of design and health disciplines. The inner project team, unanimously believe that the insights and knowledge gained from the Cold Chain – Quality Improvement project process will influence future projects in our practice with regards to informing engagement and communication strategies.

Figure 103.
Project Polar Chart

> **... importantly it shows a path to a sustainable research platform that does not disappear or loose relevance at the end of a specific project. It continues to open doors and build capacities and benefits for the health and wellbeing of our communities.**
>
> Cold Chain – Quality Improvement project team member, survey feedback, 2023

07

CONCLUSION

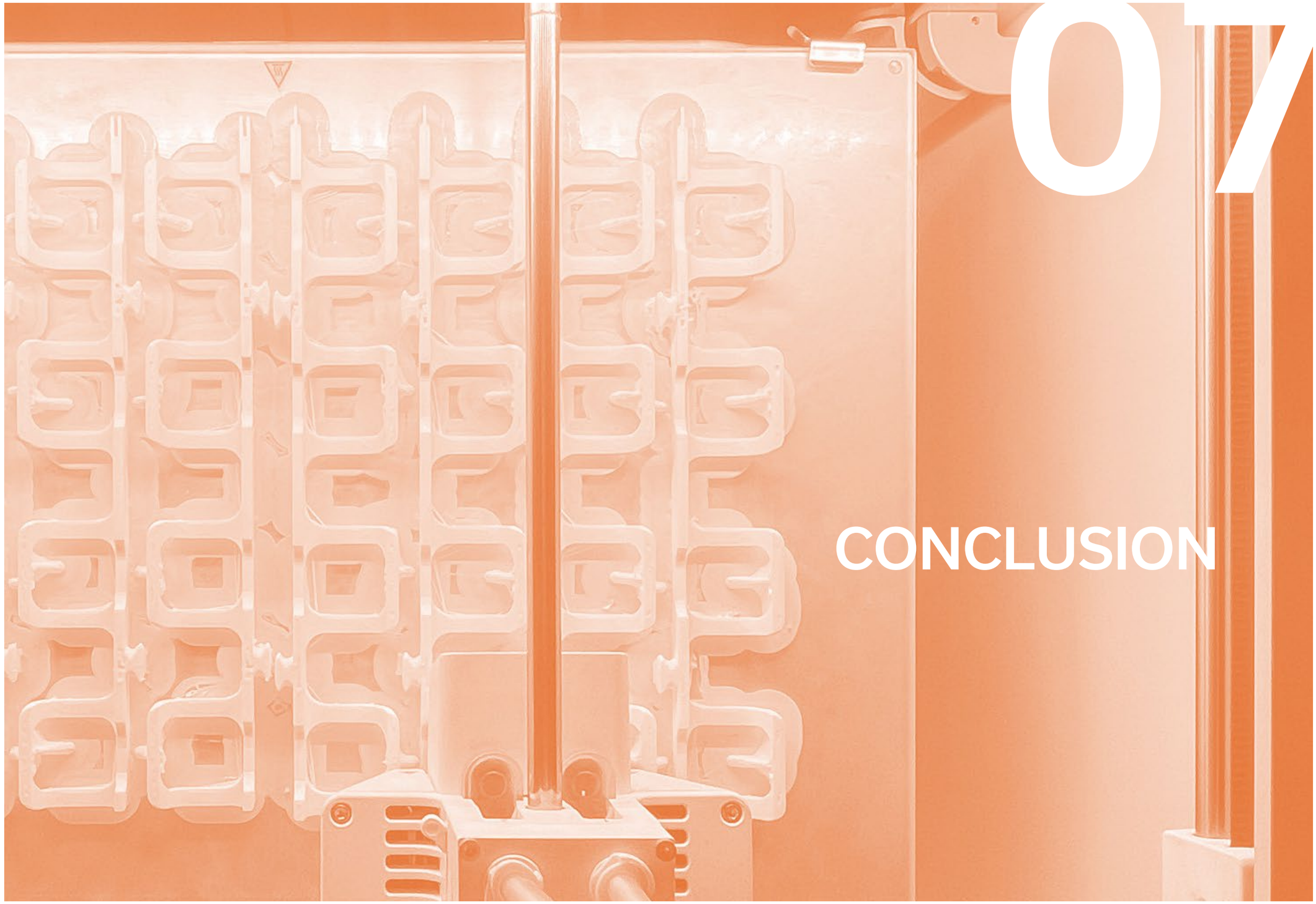


Figure 104.
3D Printing 05

In illustrating the collaborative process conducted in the progression of the Cold Chain – Quality Improvement project we have aimed to provide an example of how to synthesise health and design disciplinary expertise to strategise valuable innovation in health environments.

The reflective analysis of the range of design methods implemented has demonstrated the irrefutable contribution of relationship building to collaboration across disciplines, serving as a facilitator to strategise quality communication and understand stakeholder contributions. This was exemplified through the effective and responsible research in complex health environments and the considered navigation of ethics applications. A demonstrated commitment to the project knowledge flows ensured meaningful insights were collected from the research and creative methods were utilised to build upon early ideation.

This master of design research has application to both design and health disciplines by illustrating the successes and limitations of conducting co-design workshops, semi-structured observations, concept and prototyping critiques, semi-structured interviews, and pilot trials to inform collaborative practice in hospital environments. Demonstrating how a range of design research methods can facilitate a multiple disciplinary team's progression through the spectrum of collaboration toward transdisciplinarity. Furthermore, this research has advanced design innovation that meaningfully affects the quality, delivery and management of temperature sensitive pharmaceuticals responsive to lead users and end users' requirements, and processes and procedures of cold chain management.

Through this research we have continued to learn and identify areas that need further investigation. In the next steps of this project, the team will conduct a temperature analysis study of the pharmaceutical refrigerators. This study will centre on collecting quantitative data to deepen the team's understanding of how temperature is maintained and distributed throughout the pharmaceutical refrigerator with and without human interaction. The particular focus will be on generating data that shows clear differentiation of the impact on TSPs when they are and aren't in contact with the internal walls of the pharmaceutical refrigerator.

Evidence of the success of this collaboration is illustrated in the following quote which represents the general sentiment of future ambitions expressed in the Cold Chain – Quality Improvement project team reflection survey.

> **"... we are at the stage that we can move to having a portfolio of projects underway... a range that addresses a variety of agendas... we can do this through the trust and understanding established through the journey to date."**
>
> Cold Chain – Quality Improvement project team member, survey feedback, 2023

This is reinforced by the re-advertisement of the position at CCHV, which has been filled by a design graduate. This shows the health team sees value in the continued integration of design processes and expertise in their sector and provides an opportunity to continue to build on the in-house design capabilities at Wellington Regional Hospital. The next steps for this project remain supported by both CCHV and CoCA to apply for the next rounds of funding.

This explorative and reflective design process has application to the ongoing larger project, and other emerging projects from the collaboration between CoCA and CCHV that seek approaches to enrich design research suitable for a hospital context.

It is clear that collaboration between design and health disciplines produces valuable human-centred innovation. The integration of designers and design thinking into health innovation projects and contexts is recommended to shape the future of New Zealand's health system.

Glossary

CONSUMER
Person receiving healthcare

COCA
Massey University College of Creative Arts - Toi Rauwharangi

CCHV
Te Whatu Ora – Health New Zealand, Improvement & Innovation, Capital, Coast and Hutt Valley

DESIGN DISCIPLINE
The professional practice of designers based on formal training and experience

DATA LOGGER
A sensor that digitally monitors and records the temperature at set time intervals

DATA LOGGER CONTAINER
A container filled with silica sand that houses a data logger

HEALTH DISCIPLINE
The professional practice of those who provide healthcare treatment and/or advice based on formal training and experience

IDD
Iterative design development

IMAC
The Immuisation Advisory Centre, New Zealand

MULTI-USE PHARMACEUTICALS
Bulk-sored pharmaceuticals whereby a portion is extracted before consumer administration

TPN
Total Parenteral Nutrition- method for intravenous feeding

PICS
Participant Information and Consent Sheet

PREPARATION ROOM
A limited access room within a ward which holds pharmaceuticals and professional equipment

TPN
Total parenteral nutrition- method for intravenous feeding

TSP
Temperature sensitive pharmaceuticals

List of Figures

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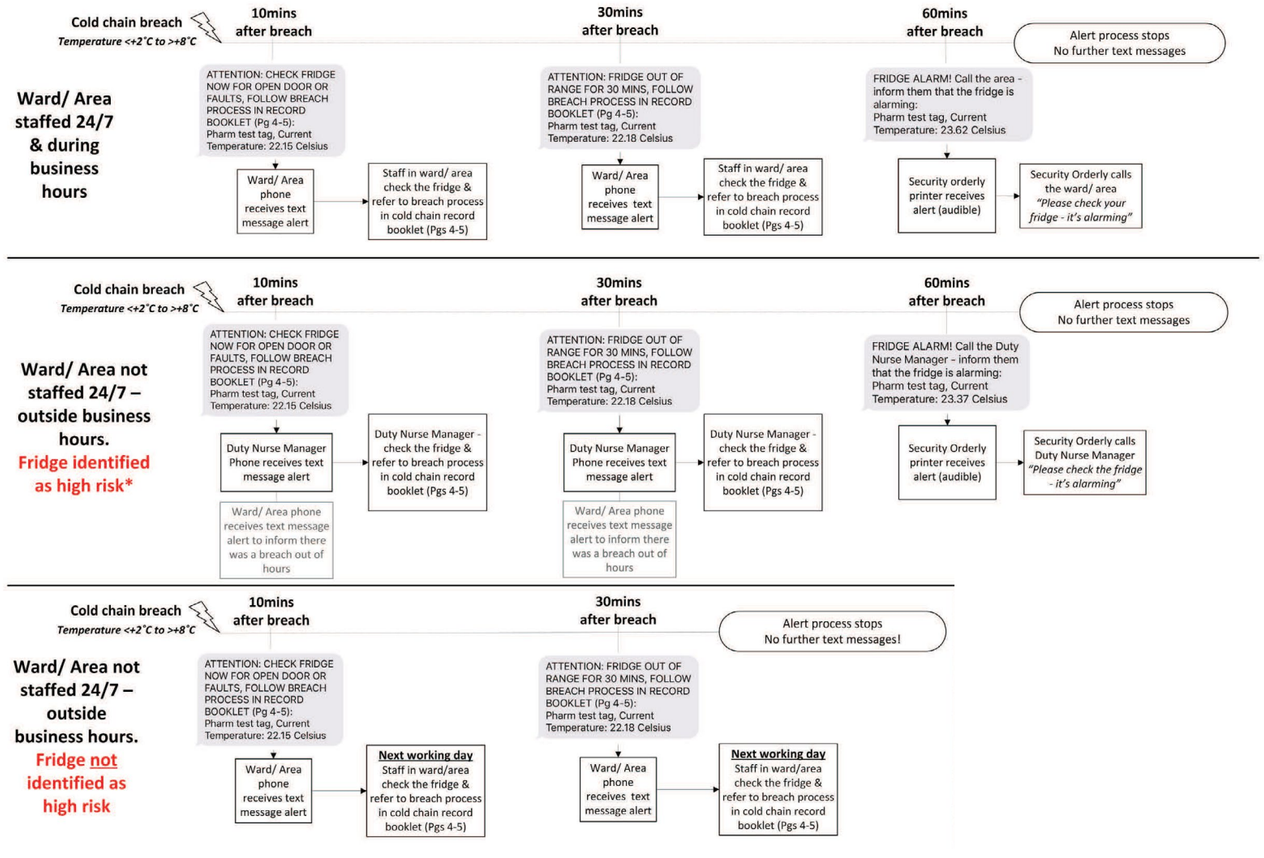
Cold chain breach - online refrigerator temperature monitoring alert process and management



Appendix A

The following checks must be completed when storing pharmaceuticals (medicines and/or vaccines) in a refrigerator.

Daily checks

- Record the refrigerator's minimum and maximum daily temperatures at the same time every day (that the service is open) using the digital thermometer on the refrigerator door.
- Reset the digital thermometer every day.
- The person recording the temperatures should initial in the space provided on the recording chart, see example.
- Any temperatures outside the +2˚C to +8˚C range must be followed up according to the flow diagram on pages 4 & 5.
- All actions and responses must be documented in the cold chain history on page 20.

Weekly checks

- Every Monday the area will receive an emailed temperature history report (from MobileView) with the previous weeks' refrigerator temperatures. Review this report in conjunction with the daily maximum/minimum temperature recordings.
- Any temperatures outside the +2˚C to +8˚C range must be followed up according to the flow diagram on pages 4 & 5.
- All actions and responses must be documented in the cold chain history on page 20.

Monthly checks

At the end of every month, complete the monthly checklist. When further documentation is required add this to the cold chain history section in the record.

Six monthly (page 12) and Annual checks (page 19) need to be completed.

Example

Daily minimum/maximum refrigerator temperature recordings — Month: January

Record the temperatures at the same time each day & reset the digital thermometer

	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	18th	19th	20th	21st	22nd	23rd	24th	25th	26th	27th	28th	29th	30th	31st
13˚C																															
12˚C																															
11˚C											Alert - act quickly																				
10˚C											10.4																				
9˚C																															
8˚C																															
7˚C			7												7															7	
6˚C	6.2	6.5		6.3	6.9	6.8	6.2	6.7	6.3	6.1		6.3	6.7	6		6.2	6.3	6.8	6.2	6.7	6.3	6.3	6.9	6.8	6.1	6.3	6.9	6.8	6.1		6.1
5˚C																															
4˚C	4	4.3	4.1	4.2	4	4.4	4	4.3	4.1	4.2		4.4	4	4.3	4.1	4.2	4	4	4.3	4.1	4.2	4.4	4	4	4.3	4.1	4.2	4.4	4	4.6	4
3˚C											3.9																				
2˚C																															
1˚C																															
0˚C																															
-1˚C											Quarantine all of your medicines/vaccines and ring pharmacy (ext. 5853)																				
-2˚C																															
Reset min/max	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Initials	RP	RP	RP	RP	LC	LC	LC	LC	RP	RP	RP	RP	LC	LC	LC	LC	RP	RP	RP	RP	LC	LC	LC	LC	RP	RP	RP	RP	LC	LC	LC

Weekly Check: Compare weekly emailed temperature history report to daily minimum and maximum recordings.

Comments: 11 January: Stocktake completed temperature up, data logger showed max temperature 10.4 degrees C for 15mins

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

21/06/2022

Dear: A/Pro Rodney Adank

Re: Low Risk Notification - 4000026117 - Cold Chain - Quality Improvement

Thank you for your notification which you have assessed as Low Risk.

Your project has been recorded in our database for inclusion in the Annual Report of the Massey University Human Ethics Committee.

The low risk notification for this project is valid for a maximum of three years.

If situations subsequently occur which cause you to reconsider your ethical analysis, please contact a Research Ethics Administrator.

Please note that travel undertaken by students must be approved by the supervisor and the relevant Pro Vice-Chancellor and be in accordance with the Policy and Procedures for Course-Related Student Travel Overseas. In addition, the supervisor must advise the University's Insurance Officer.

A reminder to include the following statement on all public documents:

"This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named in this document are responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you want to raise with someone other than the researcher(s), please contact Professor Craig Johnson, Director - Ethics, telephone 06 3569099 ext 85271, email humanethics@massey.ac.nz."

Please note, if a sponsoring organisation, funding authority or a journal in which you wish to publish requires evidence of committee approval (with an approval number), you will have to complete the application form again, answering "yes" to the publication question to provide more information for one of the University's Human Ethics Committees. You should also note that such an approval can only be provided prior to the commencement of the research.

Yours sincerely

Professor Craig Johnson
Chair, Human Ethics Chairs' Committee and Director (Research Ethics)

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

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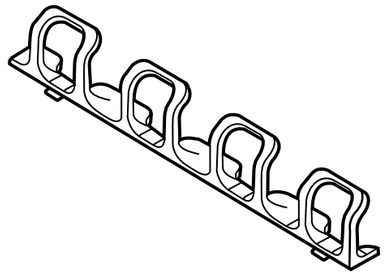
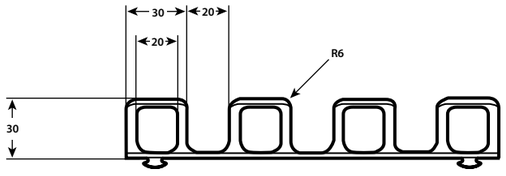
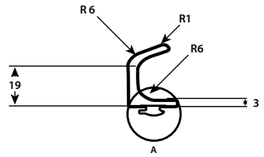
Yours sincerely

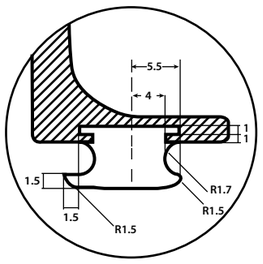
Dr Brian Finch Chair, Human Ethics Chairs' Committee and Director (Research Ethics)

TECHNICAL DRAWINGS

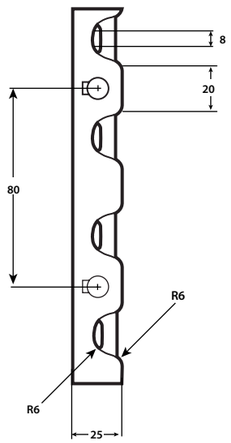




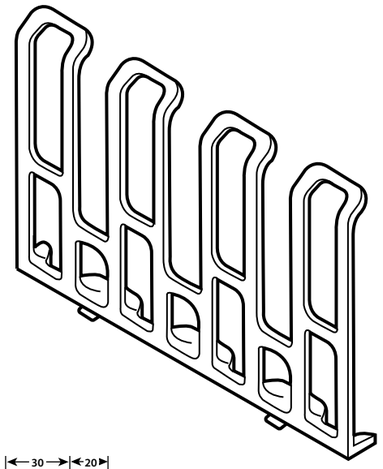


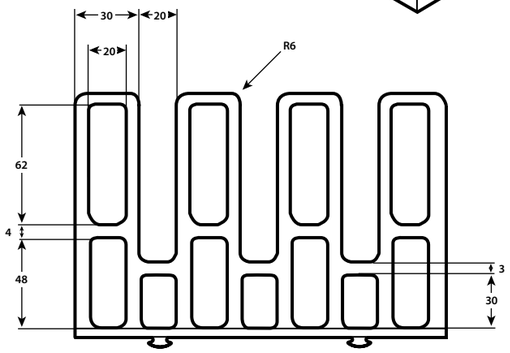


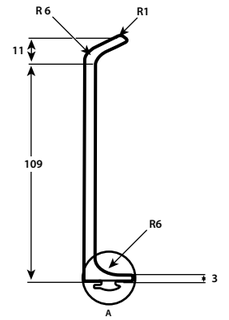
A (2:1)

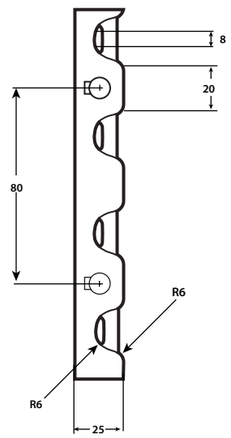


DATE: 11/04/23		DESIGNED: Sarah Lakomy	TITLE: Bumper
SIZE: A4	UNIT: mm	DRAWN: Sarah Lakomy	
SCALE: 1:1		CHECKED: Zene Krige / DATE: 11/04/23	DRAWING NO: 01
			SHEET 1 OF 3

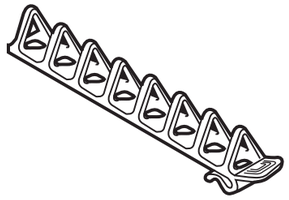


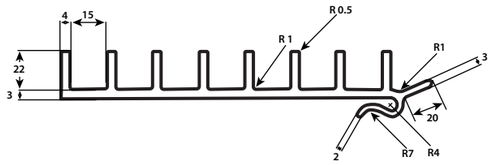


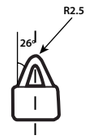


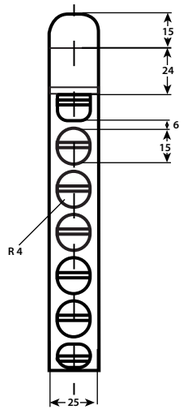


DATE: 11/04/23		DESIGNED: Sarah Lakomy	TITLE: Two Tier Bumper
SIZE: A4	UNIT: mm	DRAWN: Sarah Lakomy	
SCALE: 3:4		CHECKED: Zene Krige / DATE: 11/04/23	DRAWING NO: 01
			SHEET 2 OF 3









DATE: 11/04/23		DESIGNED: Sarah Lakomy		TITLE: Spacer
SIZE: A4	UNIT: mm	DRAWN: Sarah Lakomy		
SCALE: 1:1		CHECKED: Zene Krige	DATE: 11/04/23	DRAWING NO: 01
				SHEET 3 OF 3

PILOT TRIAL
FEEDBACK SHEET

Feedback

Cold Chain Trial - Bumpers, Spacers & Clip

Your feedback would be greatly appreciated and will contribute directly to the design development.
This survey is anonymous and voluntary.

We are developing accessories for pharmaceutical refrigerators to improve confidence that the contents are being stored in alignment with cold chain standards, by facilitating sufficient spacing.

Bumper
To prevent medications touching the fridge walls and reaching below +2°

Spacer
To facilitate appropriate spacing between medications to encourage airflow

Clip
To improve accuracy of data logger alerts by fixing it in place

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. The bumpers and spacers being trialled are easy to use	☐	☐	☐	☐	☐
2. The bumpers and spacers improved my use of this refrigerator	☐	☐	☐	☐	☐

Please explain: _____

3. The bumpers, spacers and clip give me confidence this refrigerator is meeting cold chain standards	☐	☐	☐	☐	☐

4. Do you have any recommendations to improve the design of the bumper, spacer or clip? _____

_____

_____

Thank you

Please rate your experience participating in this trial ☺ 😐 ☹

Optional

If you are interested in providing further feedback please leave your details below

Name _____ Professional Practice _____

Contact Number OR email _____

sarah.lakomy@ccdhb.org.nz

Cold Chain Project Reflection

Kia ora koutou,

Thanks for taking the time to complete this survey!

Please share your honest thoughts on how various methods contributed to your experience in this project.
Methods include: co-design workshop, semi-structured interviews, observations, iterative design process, prototyping & a pilot trial.

1. Have you been involved in an interdisciplinary healthcare & design team before?

   Mark only one oval.

   - ◯ Yes
   - ◯ No
   - ◯ Other: _____

2. How valuable did you find this collaborative process?

   Mark only one oval.

Not at all	
1	◯
2	◯
3	◯
4	◯
5	◯
Highly	

3. Please explain why:

   _____
   _____
   _____
   _____
   _____

4. Was the process of this project unique to other projects you've been involved in? Why/why not?

   _____
   _____
   _____
   _____
   _____

5. How effective were the method(s) implemented in creating quality communication across the various stakeholders & was there a particular aspect that stood out?

   _____
   _____
   _____
   _____
   _____

6. How would you consider the designs (spacers, bumpers & pottle clip) to be valued?

   _____
   _____
   _____
   _____
   _____

VACCINE STOAGE AND TRANSPORT CERTIFICATE

The Immunisation Advisory Centre

MINISTRY OF HEALTH
MANATŪ HAUORA

2021 Vaccine storage and transport

Evidence of 2 hours of professional development

Sarah Lakomy

May 05, 2022

This does not allow the participant to be an authorised or approved vaccinator.
Authorisation is obtained from a Medical Officer of Health.

Course Content
Storage and handling of vaccines

Loretta Roberts

National Manager
The Immunisation Advisory Centre

7. Do you have any notable learnings from this project?

8. Do you think this project's process will influence future projects in your practice? Why/Why not?

9. What would you like to see prioritised as a next step for this project?

10. Other comments:

Ngā mihi nui.

Sarah Lakomy
2023