A Performance Evaluation of the Use of Telehealth in a Hospital Setting: Impact of User Perceptions

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Abstract

Using a combination of quantitative data from an internally developed database and interviews with clinicians, this study investigated the impact of an innovation (i.e., telehealth) fast-tracked by the 2020 COVID lockdown in New Zealand on the performance of outpatient service delivery at one of the district health boards. As the relationship between innovation and service delivery is unpacked using data from the case study, a mediating factor, namely the perception of users, is found to be influencing their actions, which has impacted the continued uptake of the innovation and performance of outpatient service delivery. We found a change to a patient-centric approach, resulting in patients being offered the choice of telehealth appointments where benefits were perceived. This, in turn, showed greater accountability from patients, evident by reduced "did not attend" rates, which equated to reduced resource wastage in the form of non-productive clinical time. However, we also found that clinicians were concerned about missing critical non-verbal cues for telehealth patients, and as a consequence, they offered more re-appointments to patients. In a setting with a fixed number of appointments available for allocation, this translated to fewer patients being seen and discharged, which negatively impacted throughput. While we do not find telehealth to be the panacea for improving throughput and hospital productivity in this case study, this research highlights the importance of understanding the impact of user perceptions during performance evaluations of innovations and managing user perceptions when resources are fixed.

Keywords: Telehealth, service delivery, throughput, innovation, performance evaluation

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1. Introduction

Innovation, referring to new products, services, technologies, or new ways of working, is designed to significantly benefit the individual, the group, or wider society (West, 1990). Similarly, innovations in healthcare are generally viewed as positive and necessary for continued improvements in service delivery and patient care. However, the implementation of innovation can be complex with clinician's behaviour, risks to patient well-being and regulations acting as inhibitors of change (Faulkner & Kent, 2001; Länsisalmi, Kivimäki, Aalto, & Ruoranen, 2006). Hence, it is not surprising new ideas and initiatives in healthcare have long innovation processes, and diffusion of innovation, despite potential benefits, tends to be slow.

Conversely, COVID and its associated issues saw fast-tracked versions of innovations, and one of these was the implementation of telehealth in hospitals where lockdowns prevented patients from visiting doctors. Telehealth, defined by the Health Resource Services Administration as 'the use of electronic information and telecommunication technologies to support long-distance clinical health care and public health education (Ladner, 2017) was becoming a phenomenon in some countries pre-Covid (Papanagnou et al., 2018). However, its usage increased exponentially when governments started implementing lockdowns. For example, in Australia, telehealth was added to funding by Medicare in March 2020 during the COVID outbreak, and by September 2020, over 30 million consultations had been provided to 10 million Australians (Curtis, McCauley, & Bourke, 2020). In New Zealand, pre-Covid reports suggest just over 3000 telehealth consultations per week. During the March 2020 lockdown, which had widespread impacts across NZ, especially within the health sector, telehealth consultations increased to over 30,000 per week (NZ Telehealth Resource Centre, 2020).

This paper investigates how an innovation (telehealth) fast-tracked by the 2020 COVID lockdown in New Zealand affected the performance of outpatient service delivery in hospitals. In theory, telehealth promises to deliver many benefits for patients and organizations in terms of improved utilization of inputs, patient outcomes, and cost benefits. However, given the nature of health services, it is not always easy to obtain suitable measures of performance. As such, this research examines efficiencies from telehealth, with a particular emphasis on potential cost savings and changes in flow of patients (i.e. throughput) through an analysis of outpatient specialist appointment data from a New Zealand District Health Board (DHB).

The analysis shows a significant increase in the use of telehealth, which continued post-lockdown, though the extent of the continuation varied according to the medical specialty and the stage of the patient's journey (initial visit vs repeat consultations). This increase, as corroborated by the interview data and extant literature, tends to be driven by the patients' perceptions of cost savings and level of

care based on measures they regard as important e.g., patient travel time versus patient relationship with a clinician. The analysis of the appointment data also shows a reduction in throughput, with discharges of patients delayed due to clinicians' perceptions of potential risks of missing cues due to their inability to examine patients physically. Hence, patients were offered a higher number of re-appointments. While this helped manage the clinician's fear of misdiagnosing patients, this slowed the flow of patients through the hospital system. This was because the total number of clinicians and hence, the total number of appointments available for allocation was fixed. As a consequence, patients were needing to wait longer to get appointments, negatively impacting hospital productivity measures (Åhlin, Almström, & Wänström, 2022).

In summary, as we unpacked the relationship between innovation and service delivery, our results indicate that the impact of a new innovation tends to be influenced by users' actions, which are driven by their perceptions. Hence, for a new innovation to drive performance improvements, implementation teams must manage the perceptions of users. As shown in this case, the presence of risk perceptions during the adoption of telehealth resulted in a drop in hospital performance due to fixed resources. This suggests innovations like telehealth will not increase throughput and improve hospital productivity without an increase in resource allocations unless there is a change in clinicians' perceptions of risk. While showing that telehealth is not a panacea for improving throughput and hospital productivity, this research highlights the importance of understanding user perceptions during evaluations of innovations and managing user perceptions and their impact on performance when resources are fixed.

The remainder of the paper is structured as follows. The next section examines the literature on telehealth and measures of quantifiable costs and benefits. We then described the research methodology, followed by the results and discussion of our findings.

2. Literature Review

As highlighted by Åhlin et al (2022), accounting for the productivity of hospitals is of great importance to policymakers. It has been emphasized by international agencies such as World Health Organization and Organization of Economic Cooperation and Development. Previous research in this area has demonstrated that improved productivity can be achieved by directing a significant focus on the flow of patients through healthcare organizations (Åhlin et al., 2022; D'Andreamatteo, Ianni, Lega, & Sargiacomo, 2015; Litvak & Bisognano, 2011; Rumbold, Smith, Hurst, Charlesworth, & Clarke, 2015). and new technological innovations such as telehealth offer healthcare organizations the opportunity to change practices with the potential of improving service delivery.

Telehealth has become a widely used phenomenon in the healthcare setting, citing a prediction of 18% annual growth in 2018 alone, and it has become a commonly used term. In addition to the previous definition, Bashshur, Shannon, Krupinski, and Grigsby (2011) describe telehealth as an all-encompassing umbrella term for all 'systems, modalities and applications' that use electronic

communication for information exchange to provide health care. This research uses a narrower definition, namely the use of virtual technology (specifically video-enabled technology and phone calls) to provide healthcare.

Telehealth can impact multiple stakeholders and reach across provider groups, clinicians, and patients. Thus, the effects of telehealth should be considered from all perspectives and examined through multiple aspects such as quality, productivity, access, and workflow for providers (Bashshur et al., 2011). This literature review takes a multifaceted approach in considering these different aspects, which are grouped broadly under two main headings: patient outcomes (non-financial measures of patient outputs and outcomes) and measures of quantifiable benefits and costs.

2.1. Patient outcomes

Parikh, Touvelle, Wang, and Zallek (2011) found patients were equally satisfied with both telehealth and in-person appointments. Telehealth appointments are also cited as being less likely to be delayed or canceled, improving patient experience (Seewoonarain, Babu, Sangoi, Avasthi, & Ricketts, 2019). Cason's (2015) review of occupational therapy telehealth studies also identified improved patient satisfaction.

Kenealy et al. (2015) examined the efficacy and cost-effectiveness of the use of remote monitoring modes of telehealth. They found that patients had a positive experience with telehealth and experienced qualitative benefits such as feeling safe and taking a more active approach in their care management. However, they found little differences following the use of self-monitoring telehealth between the intervention and control groups in key outcome measures, including hospital admissions, length of stay in hospital and emergency hospital department visits.

Papanagnou et al. (2018) found that on a Likert scale of 1-10, a patient's likelihood to recommend a telehealth appointment was 8.5, with an average helpfulness rating of 8.2 for patients who had telehealth follow-up appointments after an emergency department visit.

Tousignant et al. (2011) examined patient satisfaction with telehealth. They found no difference between the two groups for patient satisfaction, suggesting patients are just as satisfied with telehealth modes as traditional modes of care. They also reported high levels of clinician satisfaction with the technology utilized in the study above. Pecci (2019) notes improved clinician satisfaction with telehealth, particularly regarding savings in travel time and parking costs. Pecci (2019) also notes that improved satisfaction comes with improved retention and, thus, savings in recruitment.

Some clinicians, however, have doubts regarding the effectiveness of telehealth. From a clinician's perspective, developing a relationship with the patient is critical for healthcare, particularly for chronic conditions, and this is developed much faster with traditional face-to-face contact modes of delivery

(Blumenthal, 2020). Blumenthal (2020) argues that for diagnosis in particular, a clinician needs to be able to use all of their senses, something that is not enabled through telehealth.

However, if telehealth clinics are run via strict protocols and managed well, they can also result in less variation in clinical practice (Seewoonarain et al., 2019). The findings in Cason's (2015) review of occupational therapy telehealth studies include improvements in readmissions and a reduction in complications from chronic diseases.

In summary, literature on patient outcomes provides evidence that telehealth modes of delivery are at least as effective as face-to-face modes, with some evidence, though not always consistent, of improvements in outcome measures such as hospitalizations and readmissions.

2.2. Measures of quantifiable benefits and costs

Thilly et al. (2017) describe different cost categories that should be considered when measuring the cost-effectiveness of telehealth. These include the purchase and maintenance of computer equipment and staff training. A review of what the authors term, patient-management-related costs is performed to capture the full cost of patients' journeys utilizing their telehealth system. It includes transport and visits to the patient's home, hospitalizations, and pharmaceutical costs.

Using a computer simulation, Pan et al. (2008) calculated a value of $4.3 billion annual savings if a hybrid model (which utilizes both telehealth and traditional face-to-face modes of delivery of care) was implemented in the United States' prisons, emergency rooms, nursing homes and physician clinics.

In a telehealth system reviewed by Ladner (2017), the annual cost was $1,600 per patient, compared with $13,121 for home-based primary services and $77,745 for aged residential care. Other cost savings mentioned in Ladner (2017) include clinician time savings and reduced hospital admissions. However, Ladner's (2017) literature review also found that research failed to show any cost savings to facilities. Notwithstanding, Ladner (2017) highlighted the potential for cost savings when a large population is targeted, and the care system can be re-engineered around the patient's home rather than a healthcare facility.

Speedie, Ferguson, Sanders, and Doarn (2008) describe cost savings from a reduction in office space as well as potential support staff. The authors also note the time saved by clinicians from the reduced need to travel to the clinic site to provide healthcare. Furthermore, nurses were able to see more patients virtually per day, resulting in an increase in productivity. With benefits to staff from less traveling time, the authors suggest cost savings in training from improved retention (less turnover requiring less orientation) as a further benefit.

Bashshur et al. (2011) studied telehealth across multiple settings, and found overheads accounted for up to 45% of a provider practice's fee, implying a large scope for savings if telehealth can reduce these overheads. Pecci (2019) cites a saving of $3,700 per employee from reduced facility and overhead costs.

Neufeld and Case (2013) measured efficiency as the difference in the percentage of billable hours (i.e., the revenue aspect), as the resources consumed for the different modes of delivery were stated to be the same for both modes of delivery in terms of overhead, staffing, etc. They were able to increase the billable time due to a reduction in DNAs, or what they referred to as 'no shows.' This was believed to be partly due to the population being geographically dispersed, so travel time and cost were previously prohibitive to patients attending traditional face-to-face healthcare delivery. This setting shows how a combination of telehealth and flexible scheduling helped achieve efficiencies by way of greater rates of conversion of clinician time into clinical time (and therefore, increase in revenue and profitability).

However, Kenealy et al. (2015) found no significant difference in direct costs between the telehealth group of patients versus the control group of patients. Melanson (2008) study in geriatric telehealth found incremental and average total costs were similar across the different modes (telehealth and face-to-face) of care delivery.

Table 1 summarises the literature review findings and the different settings. It can be seen that there are conflicting results, such as evidence of cost savings in some instances, no evidence of cost savings in others, and cost increases for the implementation of telehealth. Melanson (2008) noted that the measurement of costs is not done consistently across the literature, making the comparison and generalizability of findings difficult. We also believe these conflicting results could be attributed to differences in the lengths of time the cost calculations were covering or what was included in the cost calculations. These studies also raise questions such as whether the cost savings are a result of improved throughput and capacity, given savings from better utilization of time for both clinicians and patients. More specifically:

1. Are they due to reductions in appointment delays or cancellations resulting in lower failure to attend rates?
2. Do the calculations cover savings in travel time and parking costs?
3. Do these cost calculations include the potential savings in direct and indirect costs for service providers?
4. Does telehealth provide more timely treatment, improved outcomes and improved satisfaction for patients and clinicians?

While there remain many unanswered questions in relation to the impact of telehealth and how this impact is calculated, there is a general consensus that telehealth is beneficial and has positive outcomes from both patient and health service providers' perspectives.

Types of patients/providers	Origin of study	Authors	Measures/Findings
Mental health Clinics	Indiana, U.S.	Neufeld & Case (2003)	More timely treatment/improved outcomes, Improved throughput and capacity, Better utilisation of clinician time
Reviews telehealth research in Occupational therapy field	(Multiple)	Cason (2015)	More Timely treatment/Improved outcomes Improvements to Patient satisfaction
Geriatric patient clinics	Alberta, Canada	Melanson (2008)	No cost savings
Emergency department patients	Philadelphia, U.S.	Dimitrios et al. (2018)	Improvements to clinician satisfaction Improvements to patient satisfaction
Fracture clinic (orthopaedic outpatients)	St. Richard's hospital, United Kingdom	Seewoonarain et al. (2019)	Savings in travel time, More timely treatment/improved outcomes, Savings in product wastage
Continuous positive airway pressure for sleep patients	Illinois Neurological Institute, U.S.	Parikh et al. (2011)	Improvements to patient satisfaction
Taxonomy of telehealth - settings including patients with chronic conditions, wound care and recent discharges requiring continuation of care	(Multiple)	Bashshur et al. (2011)	Infrastructure/Facility savings
Patients with chronic kidney disease, including those on dialysis and post transplantation	France	Thilly et al. (2017)	More timely treatment/improved outcomes, Equipment costs Training costs
Adult community patients with chronic conditions: congestive heart failure, end-stage renal failure, mental disorders and obesity	Paris, France	Charrier et al. (2016)	Equipment costs Training costs
Patients with diabetes, congestive heart failure or chronic obstructive pulmonary disease in 2 hospitals & a rural primary care clinic	New Zealand	Kenealy et al. (2015)	Better utilisation of clinician time, Equipment costs Training costs
Multiple patient group studies discussed including hospitals and remote clinics	Alaska	Speedie et al. (2008)	Transport cost savings, Savings in Travel time, More timely treatment/improved outcomes, Infrastructure/facility savings
Adult patients in the community who had total knee anthroplasty surgery post discharge from hospital	Quebec, Canada	Tousignant et al. (2011)	Improvements to clinician satisfaction Improvements to patient satisfaction
Multiple patient group studies discussed	Multiple	Ladner (2017)	More timely treatment/improved outcomes, Increase throughput and capacity in the system Infrastructure/Facility savings
Multiple including patients in emergency departments, nursing homes, correctional facilities, and general practice offices	Throughout U.S.	Pan et al. (2008)	Increase throughput and capacity in the system Infrastructure/Facility savings Equipment costs Training costs
John Muir Health embodies multiple types of care including hospital and general practises	California, U.S.	Pecci (2019)	Savings in transport costs Savings in travel time
Obstetrics and Gynaecology	Throughout U.S.	Barbieri (2010)	Infrastructure/Facility savings
Primary care	U.S.	Blumenthal (2020)	Infrastructure/Facility savings

Table 1: Summary of extant research settings and findings

Among the many benefits of telehealth identified in the current literature, as summarised in Table 1, one common theme we investigate further in this study is the impact on service delivery. In this study, we measure performance of service delivery as number of patients seen. Given the timeframe of our study, we treat the number of appointment slots available to be fixed. This allows us to measure the impact of telehealth through a comparison of telehealth and non-health groups as elaborated in the next section.

3. Research Setting and Method

Like many countries, the detection of Covid cases in New Zealand resulted in the government taking drastic measures to minimize its spread. As restrictions and patients' reluctance to visit hospitals due to fear of catching Covid increased, medical facilities, especially those offering outpatient services, were forced to change how they delivered their services. One innovative approach that had previously been scarcely used, telehealth, became a go-to approach for many medical professionals.

In this study, using an outpatient specialist-specific clinic located in one of the larger hospitals in New Zealand, we examine the impact of this change, i.e., the increased use of telehealth, on the case organization's service delivery. This case site, referred to here as DHB, was chosen because the lead researcher was an employee and had access to the facility's internally developed patient database (Qlik). Qlik recorded service delivery modes and data relating to patient interactions, such as appointment bookings and attendance for appointments, that allowed for data collection in real-time. The literature suggests that telehealth may present different challenges depending on the context, so five different specialties were examined. The specialties chosen also offered a range of healthcare professional group perspectives and comprise Rheumatology, Dermatology, Endocrinology, Diabetes, and Allied Health.

The study examines data from January to August 2020. This time period was chosen because it captured a period before COVID entered New Zealand (a baseline period), the months during the COVID lockdown (event period), and three months post-COVID lockdown (new baseline). The patient-level data was broken down into two groups: the 'telehealth' group, defined as patients that received at least one telehealth appointment during the January to August 2020 period, and the non-telehealth group, those only offered face-to-face appointments during the January to August 2020 period. Data was analysed across these three time periods to see the impact of the lockdown on the uptake of telehealth appointments. Data was also collected after the study period from September 2020 to July 2021, to extend the study into a longer period of business as usual environment than the initial post-lockdown study period of 3 months. Auckland went back into level 3 lockdown in August 2021 for the rest of the year, and so July was chosen as the end point of the 'post study period'. Figure 1 shows the relevant timeline of the COVID pandemic as it pertains to New Zealand and the study period.

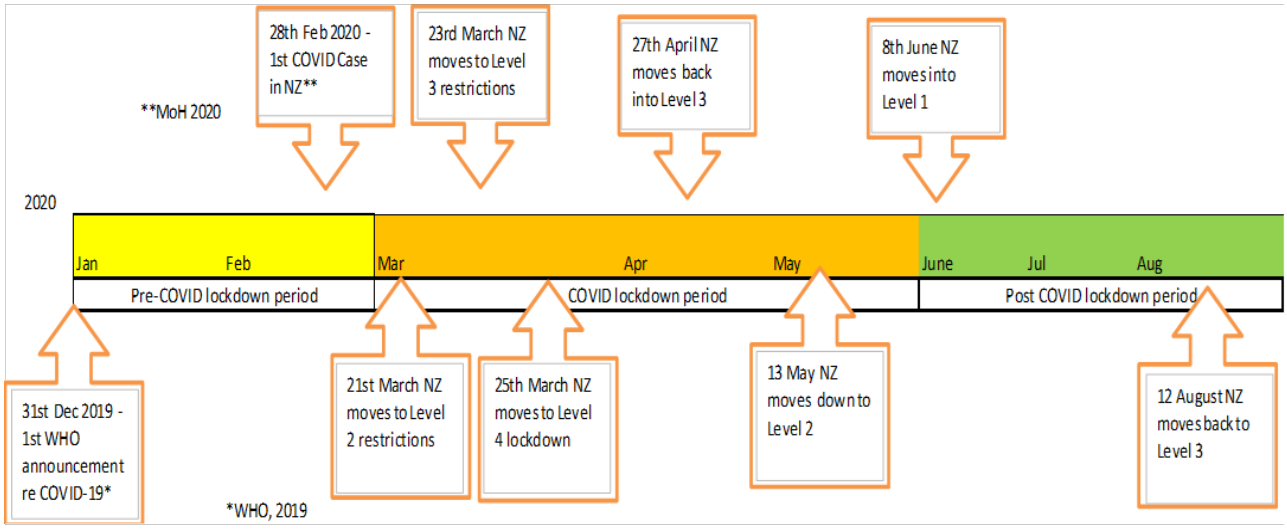

Figure 1: COVID-19 timeline for NZ and study period

The investigations in this study took a two-step approach as depicted in Figure 2. The first step examined the impact of the change, i.e., increased use of telehealth, on the performance of the service delivery organization. For this we collected and analysed data from the Qlik database at DHB both during the lockdown period when medical professionals were coerced into using telehealth due to government-imposed restrictions, as well as after the lockdowns when restrictions had been lifted.

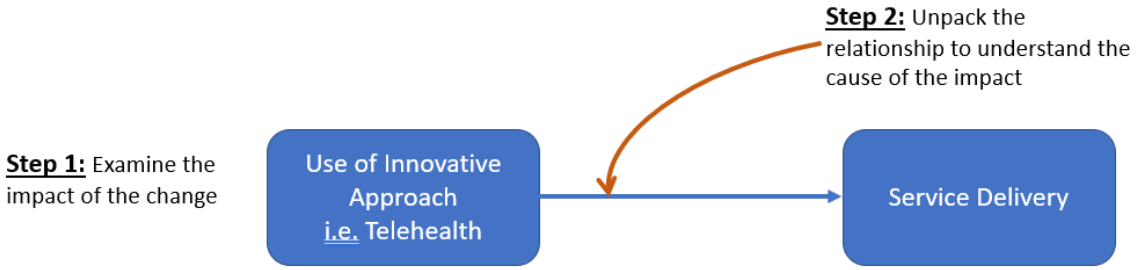

Figure 2: 2-Step Research Investigation

As expected, there was a spike in usage during lockdown, which can be explained by the lack of other options. However, we also found evidence of continued use of telehealth following the removal of restrictions, which led us to the second step of our investigation, where we unpacked the relationship between the use of telehealth and performance via interviews with clinicians to understand i) why they persisted with the use of telehealth and ii) how and why telehealth impacted on the performance of the organization, as established in step one using the quantitative data.

The interviews took place with clinicians covering a range of disciplines including specifically: two physiotherapists (including a musculoskeletal physiotherapist and a respiratory physiotherapist), one consultant doctor specialist for dermatology, one dietitian and one speech language therapist. The interviews were semi-structured and focused on the how, why and what aspects of the impacts of

telehealth on outpatient service delivery. These interviews were transcribed and translated into themes using the NVivo software. Ethics approval was obtained with details available from the authors.

4. Findings

As noted, we expected there to be an uptake in telehealth appointments given the lockdown and lack of face-to-face alternatives. Hence, the key focus of our analysis centred on the impact of the uptake on the performance of outpatient service delivery. In our case study, the facility space remained the same with all modes of delivery, and clinicians continued to work out of their own cubicles at the DHB. Similarly, the number of appointment slots available for allocation remained the same. Therefore, holding these constant, we focused on potential cost savings around improved throughput and capacity, as discussed below.

4.1. Uptake of telehealth

As shown in Figure 3, the uptake of telehealth appointments increased dramatically during the COVID lockdown for all specialties. The total number of telehealth appointments for all specialties during the COVID lockdown was the equivalent of 1860 appointments offered per month compared with only 253 appointments pre-COVID. This represents a sixfold increase.

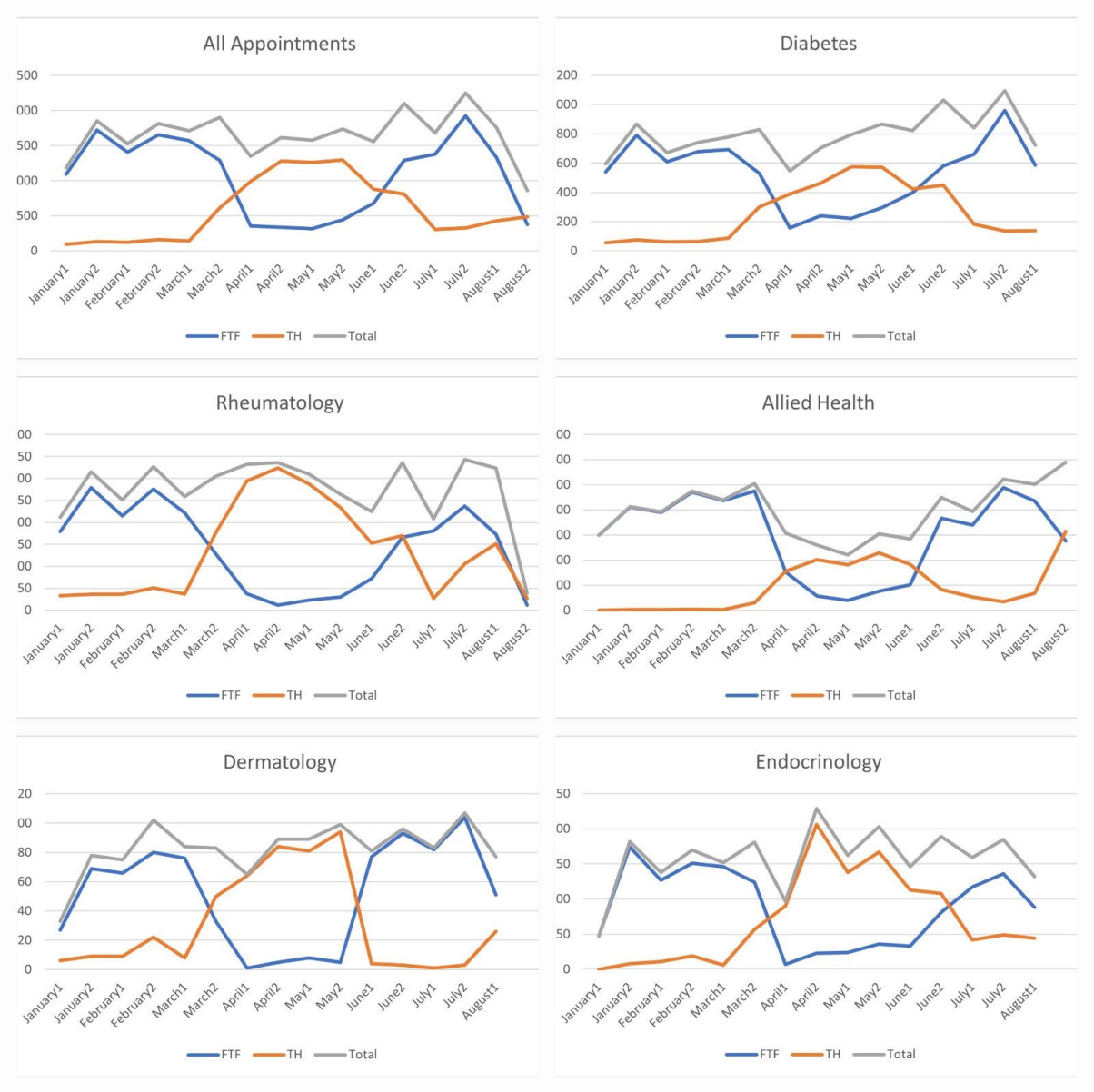

Figure 3: Number of Appointments by different service modes from January 2020 to August 2020

The Allied results are particularly significant as pre-COVID telehealth modes of appointments were almost non-existent, with a count of only four, compared with 266 being offered per month during COVID lockdown. All specialties dropped in uptake post-COVID lockdown, but most specialties (all except Dermatology) moved to a new 'baseline' level of telehealth appointments, which was still higher than in the pre-COVID period. For all specialties, this equated to an equivalent of 1077 appointments per month, and Allied did not move much lower than their COVID lockdown level, with a reduction of only 22 appointments, or 244 appointments offered, per month.

	Totals across time period				Equivalent per month			
Specialty	Pre-COVID lockdown	COVID lockdown	Post-COVID lockdown	Post study period	Pre-COVID lockdown	COVID lockdown	Post-COVID lockdown	Post study period
Rheumatology	156	1353	634	2362	78	451	211	215
Dermatology	46	381	48	242	23	127	16	22
Endocrinology	38	664	366	790	19	221	122	72
Diabetes	257	2384	1449	1525	128.5	795	483	139
Allied	8	799	733	370	4	266	244	34
Grand totals	505	5581	3230	5289	253	1860	1077	481

Table 2: Telehealth appointments pre, during and post Covid lockdown

Table 2 summarises the telehealth appointments pre, during, post-Covid, and post-study periods. As already shown in Figure 3, all monthly appointments declined in the post-Covid lockdown period. Comparing the post-Covid lockdown period with the post study period, all specialties moved to a lower telehealth appointment count per month, except Rheumatology, which increased slightly.

Many clinicians commented that telehealth "wasn't happening" pre-COVID, or if it was, it was being done minimally. This sentiment is evident in this quote by one of the clinicians,

> "telehealth ended up being in response to COVID… the DHB did not have much oomph in the way of telehealth before that….it just wasn't a standard practise".

However, with the NZ Government's messages around social distancing and limiting non-essential contact, healthcare providers, like other organizations had to change and adapt how patients were assessed and treated. Clinicians spoke of the importance of continuation of care during lockdown and how some patients were afraid to even go to their GP, and as stated by one of the clinicians, they were "quite apprehensive coming to the hospital".

Clinicians spoke of patients being grateful for any health care provision during COVID, with one commenting:

> "oh they just loved that they were able to be seen, even virtually… anything was better than nothing, so I think COVID was a bit unfair…because everyone was desperate just for anything",

While another clinician described telehealth uptake as:

> "the only good thing that's come out of COVID….in that it's actually pushed us into this century in terms of that kind of technology and options…. We've got to have a plus side from everything, so if that can be the one for this, then I can't be too mad about it".

However, clinicians also acknowledged limitations of assessing patients using telehealth. For instance, one physiotherapist commented that "they were at times eye-balling the patient's condition". However, "in the circumstances of its telehealth or nothing during lockdown, it was very much telehealth".

The conversations with the clinicians supported the view that the spike in telehealth uptake during the lockdown periods was driven by the lack of other options. Telehealth offered a viable alternative during this period, and it was embraced by service providers and patients alike. However, as highlighted by the clinicians, telehealth was not always a suitable substitute for face-to-face appointments. It was revealed that, at times, patients appeared distracted or not focused during appointments. Some patients appeared uncomfortable, as exemplified by the quote below from one of the clinicians:

> "patients who have had breast reconstruction surgery, you wouldn't expect somebody to reveal that part of their body over a camera, but if they were to come in, they're in a room that's locked, and there's a curtain, and you know it's only a clinician and patient in a room, they're more understanding, and they're more comfortable in that sort of environment."

Clinicians also mentioned issues with noticing non-verbal cues and difficulties in building rapport with patients as drawbacks of telehealth. One clinician noted that:

> "To me, it's all about picking up many signals from the patient, many of which are non-verbal, and they don't come across as well on Zoom."

The recognition that telehealth is not suitable for all scenarios explains the drop in telehealth appointments post-lockdown. Once restrictions were eased and face-to-face consultations became an option, the use of telehealth began to be driven by the suitability of service delivery mode and the comfort of users. While the above comments from clinicians highlight issues that led to more uptake of face-to-face appointments, there was also mention of positives that were taken from the users' experiences of telehealth during the lockdown period. For example, one of the clinicians stated:

> "they don't need to leave work. They can stay at home, especially new parents who maybe don't want to come into a hospital. That is being really, really flexible. And also, people who tend to rely on other people for transport, I know there's a lot of, a whole community of people around New Zealand that still tend to feel like a burden if they rely on people for transport to a hospital appointment."

Clinicians began to offer telehealth appointments where patients mentioned these convenience factors specifically. This helps to give some insight as to why telehealth continued, *albeit* at a lower level than during lockdown, but at a higher level than pre-COVID. This is evidence of clinicians moving their mode of delivery to being patient-determined as opposed to being indiscriminately pre-determined by the clinician for whole groups of patients, as was done during the COVID lockdown, given the lack of alternative options in that time period. One of the consequences of this increased shift to a patient-centric approach observed in our results was a drop in 'Did Not Attend' rates (DNAs) as discussed in the next section.

4.2. Reduction in DNAs

A DNA rate is the proportion of the total booked appointments in which patients did not attend. For our study period, DNAs were compared between the two groups to examine whether telehealth reduced resource wastage in the form of non-productive clinical time.

Table 3 displays the count of the total DNA appointments as well as the total appointments, for both the telehealth and non-telehealth group by specialty. The DNA rate is calculated as the total number of DNA appointments divided by the total appointments.

DNAs for telehealth modes of appointments vs face to face

	DNAs		Total appts		DNA Rates		P-Value
Specialty	Telehealth type appts	Non-telehealth appts	Telehealth type appts	Non-telehealth appts	Telehealth type appts	Non-telehealth appts	Diff in DNA Rate significant?
Rheumatology	76	148	2143	2243	4%	7%	0.0000*
Dermatology	20	91	475	783	4%	12%	0.0000*
Endocrinology	94	100	1068	1321	9%	8%	0.2772
Diabetes	662	1503	4090	8016	16%	19%	0.0004*
Allied	86	573	1540	4812	6%	12%	0.0000*
Grand totals	938	2415	9316	17175	10%	14%	0.0000*

Table 3: DNA rates for telehealth and non-telehealth patient groups by specialty during the study period January 20 to August 20

The results show that the DNA rates for telehealth are lower for four out of five specialties. These differences are statistically significant, except for endocrinology being close to even. The results show that the overall DNA rate is lower for telehealth indicating a reduction in clinical time wastage and an improvement in the outpatient service delivery system. During the interviews, clinicians spoke of DNA rates being impacted and offered some context for the improvement in the results above. The most common reason referenced was 'convenience', followed by reduced cost/savings to the patients and enhanced patient accountability. Convenience mainly described the patients having the appointment over the phone or zoom and not having to physically come in. As one clinician commented "I know the patients prefer not having to travel".

Clinicians began to offer telehealth appointments where patients mentioned these convenience factors specifically as exemplified in the following quote from one of the clinicians,

> "I will offer it to patients, and I will try to encourage it to patients who may be mentioned things like it took a long time to get here, parking, family commitments, things like that."

Another common reason for improved DNA rates referenced was 'enhanced patient accountability', and clinicians believed that telehealth gave the patients more accountability to be able to be more responsible for their health, and they would take their appointments more seriously and be more likely to attend.

Finally, according to clinicians, DNA rates improved due to the patients not needing to take time off work. One clinician explained this as:

> "something that I come across with my patients is that I see a lot of people who are self-employed. If they don't work they don't get paid. And that's very difficult for people who really need physiotherapy, you have to do this otherwise you're just going to get worse, but you can't put any understanding from my point of view on their financial situation. If they need to work, they need the money".

Another commented on other cost savings for patients through not needing to come in for face-to-face appointments, including:

> "the cost of petrol and the cost of parking in the hospital. It can really put patients off coming in…. they're coming to lots of different appointments, it can build up quite a lot financially. So having that access to telehealth means that they save money, which is really important".

In addition to explaining the reason for lower DNA rates for the telehealth group, these insights from the interviews also help to give some explanations as to why the uptake of telehealth continued at a lower level than during lockdown, but at a higher baseline then pre-COVID.

DNA data was also analysed for the 'post study period' i.e September 2020 to July 2021. The results for this period is presented in Table 4.

	DNAs		Total appts		DNA Rates		P-Value
Specialty	Telehealth type appts	Non-telehealth appts	Telehealth type appts	Non-telehealth appts	Telehealth type appts	Non-telehealth appts	Diff in DNA Rate significant?
Rheumatology	128	235	2362	4032	5.42%	5.83%	0.4903
Dermatology	7	147	242	1935	2.89%	7.60%	0.0001*
Endocrinology	61	135	790	2053	7.72%	6.58%	0.2983
Diabetes	225	1721	1525	8551	14.75%	20.13%	0.0000*
Allied	98	1303	370	8929	26.49%	14.59%	0.0000*
Grand totals	519	3541	5,289	25,500	9.81%	13.89%	0.0000*

Table 4: DNA rates for telehealth and non-telehealth patient groups by specialty post the study period (September 20 to July 21)

Unexpectedly the results for allied health changed significantly with DNA rates for the non-telehealth group being better than the telehealth group. However, consistent with the study period, the overall DNA rates are better for the telehealth group compared to the non-telehealth group indicating a reduction in spoilage from non-attendance. The benefits from reduction in DNAs was quantified through calculation of theoretical cost savings from reductions in wasted or unproductive variable costs, specifically, clinical personnel time. This was calculated using the difference in the DNA rate, multiplied by the total appointments offered in the sample period, multiplied by the variable cost per appointment drawn from the costing system. This is an acknowledgement that the fixed cost component

of the appointment is unavoidable such as the facility provided, and there will be no savings in that category from improved productivity.

These costs were obtained in line with the costing standards guidance from the Ministry of Health. All the different types of purchase unit codes were grouped (for example FSAs and FUPs) together in a single table for the other results. However, there needed to be a separation of these visits by purchase unit code since these are paid at different rates. For example, for the total dermatology appointments counted, there were two types of purchase unit codes, M15002 and M15003, for which, the variable costs per appointment were $340.43 and $251.29 respectively. The results are presented in Table 5.

							Total Appointments Cost		DNA total cost		DNA cost per non-DNA appointment (spoilage)		Ratios			
Specialty	PUC*	DNA Count Non-Telehealth	Total Non-telehealth	DNA Count Telehealth	Total telehealth	Variable cost per appointment	Telehealth type appts	Non-telehealth appts	Telehealth	Non Telehealth	Telehealth	Non Telehealth	Telehealth type appts	Non-telehealth appts	Diff in DNA rate	Savings*
Dermatology	M15002	44	364	9	192	340.43	65,362	123,916	3,064	14,979	$ 16.74	$ 46.81	5%	12%	-7%	- 14,007
	M15003	47	413	11	283	251.29	71,116	103,784	2,764	11,811	$ 10.16	$ 32.27	4%	11%	-7%	- 13,106
Rheumatology	M00010		226		39	153.30	5,979	34,645	-	-	$ -	$ -	0%	0%	0%	-
	M00011			11	64	154.58	9,893	-	1,700	-	$ 32.08	$ -	17%	0%	17%	1,700
	M70002	28	488	59	207	308.44	63,848	150,520	18,198	8,636	$ 122.96	$ 18.77	29%	6%	23%	48,800
	M70003	99	1335		1596	208.00	331,972	277,684	-	20,592	$ -	$ 16.66	0%	7%	-7%	- 45,210
	MS01001	21	194	6	237	153.22	36,314	29,726	919	3,218	$ 3.98	$ 18.60	3%	11%	-8%	- 5,477
Endocrinology	M00010		108		54	135.13	7,297	14,594	-	-	$ -	$ -	0%	0%	0%	-
	M20002	23	573	17	243	242.65	58,964	139,038	4,125	5,581	$ 18.25	$ 10.15	7%	4%	3%	5,904
	M20003	77	638	77	770	168.03	129,382	107,202	12,938	12,938	$ 18.67	$ 23.06	10%	12%	-2%	- 4,895
Diabetology	AH01001	234	908	191	990	145.94	144,484	132,516	27,875	34,151	$ 34.89	$ 50.67	19%	26%	-6%	- 17,944
	AH01006	477	3907	1	46	97.81	4,499	382,149	98	46,656	$ 2.17	$ 13.60	2%	12%	-10%	- 38,800
	AH01010	30	132	31	199	179.01	35,623	23,630	5,549	5,370	$ 33.03	$ 52.65	16%	23%	-7%	- 4,236
	M00010		3	0	63	135.71	8,550	407	-	-	$ -	$ -	0%	0%	0%	-
	M20004	68	340	48	221	327.72	72,425	111,423	15,730	22,285	$ 90.93	$ 81.93	22%	20%	2%	3,161
	M20005	153	675	130	829	262.68	217,764	177,311	34,149	40,191	$ 48.85	$ 76.99	16%	23%	-7%	- 27,597
	MS01001	504	1852	260	1704	204.59	348,623	378,903	53,194	103,114	$ 36.84	$ 76.49	15%	27%	-12%	- 86,980
Allied	AH01001					118.92	-	-	-	-	$ -	$ -	0%	0%	0%	-
	AH01005	376	4010	67	1364	107.07	146,038	429,336	7,173	40,257	$ 5.53	$ 11.08	5%	9%	-4%	- 25,688
	AH01010					233.70	-	-	-	-	$ -	$ -	0%	0%	0%	-
Totals									187,478	369,778	$ -			For Jan-Aug period		- 224,374
Note some items are counted under local PUCs and not funded so there will be a difference in total DNAs counted in this table														Extrapolated annually		- 336,561

Table 5: Variable cost saving from DNA rate improvement during study period (January 20 - August 20)

The table includes the variable cost per appointment and displays total variable costs for all appointments, being the variable cost per appointment multiplied by the number of appointments. It

also calculates the total variable cost of all DNA appointments for both telehealth and non-telehealth groups. The change in DNA rate is applied to the variable cost per appointment and multiplied by all appointments offered to calculate the total savings figure. Better utilisation of the available specialist outpatient appointments would have saved $224,374 in theory, over the January to August period for these specialisations. This could be extrapolated to a figure of $336,561 for a full year estimate.

There is also a measure of spoilage provided in Table 5, which spreads the variable cost of DNA appointments across the attended appointments. This represents the cost of wastage per unit of product. This allows for a measure that management could use to measure the success of initiatives, including implementation of telehealth, to drive down DNA rates and put a quantity and target on the savings managers could achieve. Although this varies by specialisation and purchase unit code, benchmarking across specialisations will show what is possible by learning from each other. This is not necessarily limited to telehealth and although these types of targets or measures are not readily available to management at present at DHB, there is potential to calculate and report them to management going forward.

The results show the costs of spoilage for telehealth appointments is significantly lower than for non-telehealth, with the most modest savings ranging from $4.39 (the difference between the telehealth spoilage estimate of $18.67 versus the non-telehealth spoilage estimate of $23.06) per appointment for Endocrinology PUC M20003, to $39.65 (the difference between the telehealth spoilage estimate of $36.84 versus the non-telehealth spoilage estimate of $76.49) per appointment for Diabetes PUC MS01001. Just three out of the 15 PUCs measured had an increase in spoilage costs per unit for telehealth, and one PUC, M00011 was because there were no non-telehealth appointments. The other two were Rheumatology PUC M70002 and Diabetes PUC M20004. Armed with the information that these are two outliers, managers of these areas could investigate reasons for this and implement changes in the telehealth space, such as re-organising appointments or types of patients for this mode of delivery, to ensure the DNA rates for telehealth improve in line with other areas.

It should also be noted that the study period occurred during a period of much disruption over COVID and includes months prior to telehealth being rolled out in a major way (January and February). It was initially thought that the DNA result saving calculation was conservative; however, as noted above in Table 4, the post study period, the DNA rate improvement is not as high as that experienced during the study period. Also as noted in Table 2, in the post study period, there was a lower number of telehealth appointments offered per month. Thus, the DNA rate saving is also re-calculated for the post study period, which showed an expected lower savings figure, extrapolated to $120k per annum, in Table 6.
In short, the above calculations show that improvements in DNAs in the telehealth group has the potential of cost saving for the health providers based on better utilization of clinician time and reductions in wasted variable costs. However, the above analysis does not consider capacity utilisation given our assumption that the number of appointment slots available is likely to be fixed. Missed

appointments or did not attend (DNA) rates result in lower levels of capacity utilisation and consequently, impact on throughput. Hence, for changes in DNA rates, a decrease would indicate less non-productive clinician time, i.e., less clinical time wasted on appointments that patients do not attend. This suggests an improved throughput of the outpatient appointment system. The study further analysed the available data to understand the impact of telehealth uptake on throughput and capacity as discussed in the next section.

							Total Appointments Cost		DNA total cost		DNA cost per non-DNA appointment (spoilage)		Ratios			
Specialty	PUC*	DNA Count Non-Teleheal	Total Non-telehealth	DNA Count Telehealth	Total telehealth	Variable cost per appointment	Telehealth type appts	Non-telehealth appts	Telehealth	Non Telehealth	Telehealth	Non Telehealth	Telehealth type appts	Non-telehealth appts	Diff in DNA rate	Savings*
Dermatology	M15002	73	869	1	15	340.43	5,106	295,833	340	24,851	$ 24.32	$ 31.22	7%	8%	-2%	- 5,218
	M15003	74	1061	6	78	251.29	19,601	266,622	1,508	18,596	$ 20.94	$ 18.84	8%	7%	1%	2,054
Rheumatology	M00010		14		780	153.30	119,573	2,146	-	-	$ -	$ -	0%	0%	0%	-
	M00011				10	154.58	1,546	-	-	-	$ -	$ -	0%	0%	0%	-
	M70002	33	798	1	29	308.44	8,945	246,137	308	10,179	$ 11.02	$ 13.31	3%	4%	-1%	- 1,753
	M70003	157	2694	104	1273	208.00	264,787	560,359	21,632	32,656	$ 18.50	$ 12.87	8%	6%	2%	19,324
	MS01001	45	526	23	270	153.22	41,371	80,596	3,524	6,895	$ 14.27	$ 14.33	9%	9%	0%	- 45
Endocrinology	M00010		8		304	135.13	41,080	1,081	-	-	$ -	$ -	0%	0%	0%	-
	M20002	29	882	3	36	242.65	8,735	214,016	728	7,037	$ 22.06	$ 8.25	8%	3%	5%	11,239
	M20003	106	1161	58	450	168.03	75,613	195,081	9,746	17,811	$ 24.86	$ 16.88	13%	9%	4%	10,175
Diabetology	AH01001	0	0	0	0	145.94	-	-	-	-	$ -	$ -	0%	0%	0%	-
	AH01006*	775	6708	0	17	97.81	1,663	656,119	-	75,804	$ -	$ 12.78	0%	12%	-12%	- 75,996
	AH01010	0	0	0	0	179.01	-	-	-	-	$ -	$ -	0%	0%	0%	-
	M00010		21		113	135.71	15,336	2,850	-	-	$ -	$ -	0%	0%	0%	-
	M20004	155	940	4	33	327.72	10,815	308,053	1,311	50,796	$ 45.20	$ 64.71	12%	16%	-4%	- 13,929
	M20005	336	1779	64	372	262.68	97,718	467,314	16,812	88,262	$ 54.58	$ 61.17	17%	19%	-2%	- 9,508
	MS01001	1229	5415	157	811	204.59	165,923	1,107,861	32,121	251,442	$ 49.11	$ 60.07	19%	23%	-3%	- 42,511
Allied	AH01001	440	2010	61	322	118.92	38,293	239,037	7,254	52,326	$ 27.79	$ 33.33	19%	22%	-3%	- 8,171
	AH01005	0	0		0	107.07	-	-	-	-	$ -	$ -	0%	0%	0%	-
	AH01010	56	377	35	194	233.70	45,338	88,106	8,180	13,087	$ 51.44	$ 40.77	18%	15%	3%	4,253
Totals									103,464	649,743	$ -			For Sep 20 - Jul 21 pe		- 110,085
Note some items are counted under local PUCs and not funded so there will be a difference in total DNAs counted in this table														Extrapolated annual		- 120,093

Table 6: Variable cost saving from DNA rate improvement post study period (Sep 20 to Jul 21)

4.3. Throughput and capacity

The outpatient *Qlik* application records the outcome of each patient appointment. This was analysed over the two patient groups, for the January to August 2020 period of this study to examine whether there were any differences in the proportion of patients being discharged versus being rebooked for a follow up appointment, with the discharging levels acting as a proxy of throughput of the system.

For throughput, Table 7 shows the outcome of appointments for the two patient groups, including those that had re-appointments and those who were discharged. In total *Qlik* reported 15,173 telehealth outcomes and 11,318 non-telehealth. The number of appointments within each category of outcome is displayed, as well as the relative proportions in each appointment outcome, for the non-telehealth and telehealth groups.

	Telehealth group		Non-telehealth group	
Appointment outcome	Count	%	Count	%
Discharged	1,877	12%	2,107	19%
Re-appointment	11,972	79%	7,518	66%
Other	1,324	9%	1,693	15%
Total	**15,173**	**100%**	**11,318**	**100%**

Table 7: Appointment outcomes for telehealth and non-telehealth groups January-August 2020

Discharges increasing alongside the number of appointments would support gained efficiencies of the system; however, if there is a decrease in discharges and an increase in rebooking, then this supports telehealth causing unnecessary appointment levels potentially due to the telehealth mode of delivery not being adequate to perform all assessments necessary for the patient's condition.

The level of discharging for the telehealth patient group was 1,877 (12%) which was lower than the non-telehealth group 2,107 (19%). Re-appointments on the hand were higher for the telehealth group at 79% versus 66% for non-telehealth. Hence, contrary to our expectation, this analysis does not support an increase in throughput for telehealth. Instead, it is indicative of additional appointments being added unnecessarily to the system and indicates potential wastage of clinician time. According to the interview data, this result is driven by clinicians' perceptions of risk and their views that telehealth does not allow them to adequately pick up on non-verbal cues that they saw as important for assessing patients conditions. As stated by one of the clinicians,

> "There are many things that they don't talk about, and so it's all about establishing that relationship… it's all about getting trust".

Another clinician emphasized this point as below:

> "many subtle clues that are missed on zooming are totally missed in telehealth, you're just relying on a few pic[ture]s, you're just making it up and you're just winging it, so on an initial consult, telehealth is very poor."

Our data showed that the telehealth group had a higher proportion of follow-up patients (76%) than the non-TH group (67%). Thus, we performed further analysis breaking down the follow-up and new patient groups to study appointment outcomes.

	Non-TH Group - New pt		TH Group - New Pt		Non-TH Group - Follow up		TH Group - Follow up	
Appointment outcome	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**
Discharge	1148	31%	702	20%	959	13%	1175	10%
Re-appointment	1881	51%	2367	67%	5637	74%	9605	82%
Other	655	18%	440	13%	1038	14%	884	8%
Total	**3684**	**100%**	**3509**	**100%**	**7634**	**100%**	**11664**	**100%**

Table 8: Analysis of appointment outcomes for new and follow-up patients

The results as presented in Table 8, confirm that a high proportion of patients in the telehealth group get re-appointments instead of discharges. This result holds even after taking the different patient profiles of appointments (new versus follow-ups) into account. While these re-appointments may be due to a perceived lower cost of appointments through telehealth or the perceived uneasiness of clinicians due to their belief that they may have missed important non-verbal cues, the increase in re-appointments may indicate potential wastage in the system and inefficiencies in the telehealth group. This indicated a negative impact on throughput.

Furthermore, clinicians noted that service delivery through telehealth was consequently "more draining", and they needed "brain breaks" in between, which means it is likely that the number of appointments being offered in total in their usual work day would not be able to be increased. They also noted this had the potential to negatively impact on their relationship building with their patients. One clinician noted that:

> "some clinicians felt that, or had concerns around being overworked in the sense that at one point there was this talk of it's efficient, it's great, and people were like well does that just going to mean I'm just going to churn out more and more people, we already feel overstretched, so there was concern from that point of view".

Another clinician commented:

> "I wonder if that's why there's some resistance, because if people are doing all video calls then they'll be expected to have more contact, because it's like efficient, but I don't think it's straight forward like that based on my points shared today, the fatigue, the technology".

Thus, the clinicians themselves were wary and concerned at suggestions they may be able to fit more patients in their day due to telehealth being more 'efficient'. It was noted that telehealth would lose support and potentially have a reduction in usage if such suggestions were to be made.

Overall, our analysis found that the cost savings during the time period of this case study was mainly from better utilisation of clinical time through reduced DNAs, allowing for more appointments being completed per patient in the same time period. However, we also find that this savings was likely negated by an increase in re-appointments as clinicians took a cautionary approach due to fear that they may have missed important non-verbal cues.

5. Discussion and Conclusion

Findings from this study suggest that telehealth will likely become a permanent feature of healthcare going forward. However, the impact of this change on service delivery is not yet that clear. As summarised in table 9 and 10, there is an array of metrics in the literature as well as ones identified in this study that help measure the benefits and costs of using telehealth as a mode of service delivery from both patients' and service providers' points of view.

	nVivo Theme	Benefits	Potential Metric	Relevant References
Patients' perspective	-Convenience -Patient preference & experience -Savings for patients	Savings in transport costs	Parking charges (patient rates), ave km to travel to hospital site for patient population in the district x mileage rate	Speedie et al. (2008)
	-Convenience -Patient preference & experience -Savings for patients	Savings in time - from reduced need to travel	average time taken across the district to get to the hospital site x average wage in NZ	Speedie et al. (2008) Seewoonarain et al. (2019)
Both/ Overlap	-Better than nothing -Staying in touch with patients -Patient outcomes	More timely treatment (resulting in improvement to outcomes)	Improvements in wait times for appointments Reduction in wait lists Improvement in specific targeted patient outcomes Reduction in follow ups Reduction in hospitalisations & emergency visits	This research Seewoonarain et al. (2019) Ladner (2017) Dimitrios et al. (2018) Neufeld & Case (2013) Speedie et al. (2008) Thilly et al. (2017)
	Patient outcomes	Increase throughput and capacity in the system	Greater appointments per patient in same time period	This research Neufeld & Case (2013) Pan et al. (2008) Ladner (2017)
Staff/ Organisation perspective	Waitlist and DNA improvements	Better utilisation of clinician time	DNA rate improvement and clinician variable/direct cost savings	This research Neufeld & Case (2013) Kenealy et al. (2015)
	Convenience	Savings in transport costs	Parking charges (staff rates), ave km to travel to hospital site for staff population in the district x mileage rate	Pecci (2019)
	Convenience	Savings in time - from reduced need to travel	average time taken across the district to get to the hospital site x average wage in the DHB	Speedie et al. (2008) Pecci (2019)
	[Facility] cost savings	Infrastructure/Facility savings	facility cost per appointment x non-telehealth appts which could be converted to telehealth appts Cost of telehealth vs cost of FTF appt	Facility/infrastructure: This research Speedie et al. (2008) Barbieri (2010) Bashur et al. (2011) Other direct cost savings: Blumenthal (2020) Pan et al. (2008) Ladner (2017)

Table 9: Metrics[1] for measuring benefits of telehealth

[1] Note some of the papers in the literature did not describe the specific measures they used and only mention the specific cost categories they measured. In the absence of these, some suggestions have been put forward for potential measures.

	nVivo Theme	Costs	Potential Metric	Relevant References
Patients' perspective		None identified		
Both/ Overlap	Patient outcomes	Reduced throughput of patients	Decrease in discharge rates	This research
Staff/ Organisation perspective	One off set up costs	Equipment	Average cost of equipment/useful life/no of appts Charges for rental/usage	Thilly et al. (2017) Charrier et al. (2016) Pan et al. (2008) Kenealy et al. (2015)
	One off set up costs	Training	Cost of release of staff time on training, cost of trainer, cost of preparing training material	Thilly et al. (2017) Charrier et al. (2016) Pan et al. (2008) Kenealy et al. (2015)
	-Accuracy of telehealth vs face to face -Complexity & specialist context -Relationship management and non-verbal cues -Practicality	Misdiagnosis or delayed diagnosis	Misdiagnosis of telehealth vs FTF patient groups	None noted
	Practicality	Receiving [in]correct (sized) products (wastage)	Value of wasted materials and products - number of returns x purchase price	Seewoonarain et al. (2019) (but savings found in this case)
	Technological issues	Wasted appointments (due to technology not working)	DNA rate changes	This research (except an improvement to DNA rate found in this case)

Table 10: Metrics for measuring costs of telehealth

Conversations with clinicians during this study showed that these metrics influence the uptake of the innovation i.e. telehealth in this case. For instance, patients that saw benefits such as travel cost savings or not needing to take time off from work, were more likely to use the telehealth option over face-to-face appointments. Similarly, clinicians that recognized these benefits were more willing to be patient centric and offer the choice of telehealth to these patients. As a consequence, we find patients take greater accountability evident by lower DNA rates for the telehealth group equating to less wasted clinician time. However, we find that the increased uptake of telehealth did not directly translate into an increase in throughput. Instead, we find that clinicians provide more follow up appointments to the telehealth patients largely driven by their fear that they might have missed important non-verbal cues. With the number of appointments available for allocation staying the same, this means less appointments can be allocated to new patients which inadvertently equates to longer wait times and less patients being seen by clinicians in a timely manner.

So, in summary as depicted in Figure 4, the analysis of benefits and costs using metrics such as ones highlighted in Tables 9 and 10 above influence users' decisions on whether to use the innovation (i.e telehealth) or not. However, when evaluating the impact of the uptake of the innovation on the performance of service delivery, it is important to go beyond just the metrics for measuring costs and

benefits of the innovation itself but also take into consideration the resulting actions of the users based on their perceptions. For instance, in this case the perceptions of the clinicians that led them to be more patient centric, possibly resulted in an adverse impact on the performance of service delivery due to a greater number of re-appointments being offered.

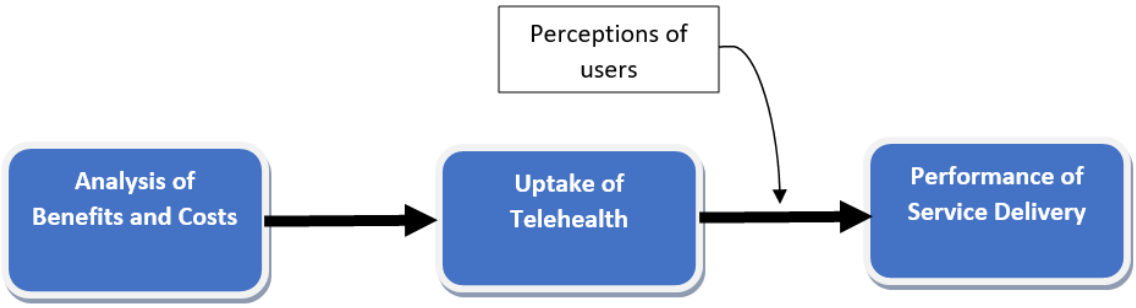

Figure 4: Summary of findings

It is important to note that the perspective of users that influence their actions are based on measures that they regard as important. What different users value most varies even among the same user groups and hence it is not possible to generalise specific measures from this single case study. However, the findings of this study contribute to our understanding of the relationship between innovation and performance by identifying the perceptions of users as a mediating factor. In other words, the study shows that the perceptions of risks or benefits impacts the actions of the users which has either a positive or negative influence on performance. The results further highlight that in a setting with fixed resources, it is important teams implementing changes like new technological innovations, to understand users' perceptions and manage resulting practices to avoid wastage of resources that negatively impact performance.

We acknowledge this research focused on an outpatient setting during a global pandemic. The time period examined initially was limited to only a few months of 'normality', and even then, at the end of the 'post-COVID' period examined, New Zealand was entering into further lockdowns and restrictions. Given the learning curve principles that the longer one performs a task, the more learning that takes place (Grange & Mulla, 2015), the research findings could differ in a non-pandemic environment, as clinicians and health systems mature in their approach to utilising telehealth. Teething issues were evident in the beginning of the up scaling of telehealth, such as technology not readily being available at the beginning, and people having difficulties learning the technology. Similar to, other forms of technology such as the smart phone, there is always an unsettled period of learning, and once these technologies are embedded into the health system's processes and into society, the results of future studies may change. Charrier, Zarca, Durand-Zaleski, Calinaud, and ARS Ile de France telemedicine group (2015) mentions that telehealth requires organisation-wide change which takes time, and that immediately after the introduction of telehealth, there may have been a lack of acceptability amongst

its users. Hence, we encourage future studies on this topic with longer study periods to further enlighten the conversation on the impact of innovations like telehealth on the service delivery of healthcare providers.

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