

A supported primary health pathway for mild traumatic brain injury quality improvement report

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ABSTRACT

Introduction. Best-practice guidelines recommend that patients are followed-up to check if they have recovered following a mild traumatic brain injury (mTBI) and to refer to concussion services, if needed. However, in New Zealand, rates of follow-up are low and access to concussion services can be delayed. **Aim.** We aimed to improve rates of follow-up and access to concussion services for mTBI patients aged ≥ 8 years by the implementation of a supported health pathway and test its success. **Methods.** The pathway included a decision support tool, funded follow-up appointments, clinician training and a patient education resource. Sociodemographics, injury details and proportions of patients receiving a follow-up by type and time were extracted from the Accident Compensation Corporation (ACC) database between 18 May 22 and 30 June 23 and compared to national ACC data prior to implementation. **Results.** Data were extracted for 220 patients, with a mean age of 31.5 years, 51.4% female and 21.4% Māori and Pacific. There was an increase in the proportion of patients receiving a follow-up from 36% pre-implementation to 56.8% post-implementation. Sixty-three patients (28.6%) accessed a concussion service post-implementation compared to 10% pre-implementation. Time to concussion service reduced from an average of 55 (s.d. = 65.4) to 37 days (29.5). **Discussion.** Risk factor criteria within the decision support tool need to be weighted to improve specificity of referrals. Timing from injury to medical review in primary care needs to be considered. This quality improvement project provides preliminary evidence for implementation of a supported health care pathway for mTBI.

Keywords: assessment, clinical decision support, concussion, general practice, mild traumatic brain injury, primary care, screening, TBI.

Introduction

Nearly a third of adults will have experienced at least one mild traumatic brain injury (mTBI, including concussion) before the age of 25.¹ Evidence now shows that without treatment, between a third to a half of people experience persistent symptoms^{2–4} that can affect their ability to perform at work/school and function in everyday life.^{2,5} One of the biggest challenges experienced by patients and their whānau is that the health system is difficult to navigate.⁶ In New Zealand (NZ), a key barrier to health care access is the assumption that a person and/or their whānau have the knowledge and resources to seek help for their injury if they do not recover naturally.

A challenge for health professionals in primary care is confidence in how to support a person's recovery.^{7,8} This is particularly the case as 40% of GPs see <5 mTBIs per year.⁷ International mTBI guidelines recommend that patients should be followed up routinely by a medical professional to check if the patient has recovered or not.⁹ However, in NZ, Accident Compensation Corporation (ACC) data reveals that only one-third of mTBI claims between 2016 and 2018 received a follow-up by any health professional.¹⁰ If people do not recover naturally, referral to interdisciplinary rehabilitation services (often known as concussion services) is recommended.⁹ Access to interdisciplinary rehabilitation services can improve symptoms, functioning, mood and community participation.¹¹ Studies in both NZ and overseas have shown that delayed presentation to a concussion service is linked to

WHAT GAP THIS FILLS

What is already known: Some patients with mild traumatic brain injury (mTBI) can experience persistent symptoms for many years if not treated early. Early access to specialist services such as concussion services can significantly improve patient recovery.

What this study adds: This study provides initial evidence that a supported health care pathway following mTBI is feasible to implement in primary care and can facilitate early access to concussion services for those who need it.

higher symptoms on admission.¹² Additionally, early advice and management (within 7 days of injury) is linked to quicker recovery¹³ and lower health care costs.¹⁴

However, in NZ, there can be long delays (often several months) to access a concussion service for those experiencing a prolonged recovery.¹⁰ This is likely due to patient delays in seeking medical care after injury¹⁴ and uncertainty among general practitioners (GPs) about who, when, where and how to refer.⁷ Consequently, there is a need to identify people at risk of a prolonged recovery and implement a change to clinical practice to facilitate earlier access to health care for those who need it. The aims of this quality improvement study were to increase the proportion of patients receiving a follow-up and to decrease the mean duration in days to a concussion service for those who need it.

Methods

Overview of quality improvement methodology

The Plan, Do, Study, Act (PDSA) as a stand-alone quality improvement method was utilised to test the feasibility and evaluate the implementation of the supported health pathway on health system access after mTBI. To address the identified issues within the current health pathway for mTBI, the supported primary care pathway for mTBI included a range of components outlined in Box 1. Further details of the BIST can be seen in Supplementary Information 1.

A collaborative approach between the Accident Compensation Corporation (ACC), Primary health organisations

(PHOs: ProCare, Pegasus, Well South and Nelson Bays), Manage my Health (secure health portal provider) and academics was undertaken. The digital health pathway was developed, tested and refined by Manage my Health in collaboration with the project team. ACC and academic team members contributed to the development of the education and training resources. PHOs were responsible for recruiting practices and clinicians, reviewing all referrals, providing peer support, relaying feedback from clinicians to the project team and administrative help eg application of funding reimbursement codes.

Once a practice had signed up, GPs, nurse practitioners and nurses from that practice could register to be part of the quality improvement project. Participating clinicians had to complete at least one online training module to be given access to the digital supported health care pathway tool for mTBI. Participating practitioners were asked to use the tool to guide their assessment of children (aged ≥ 8 years) and adults who presented with a suspected mTBI (including concussion). mTBI was defined as being an injury to the brain resulting from an external force resulting in disruption of brain function and alteration in mental state (such as feeling dazed and confused or loss of consciousness).¹⁶ While the pathway could be used for all patients with a suspected mTBI to support clinical assessment and diagnosis, eligibility for follow-up was based on a clinical diagnosis of mTBI or concussion. Delivery of the supported health pathway is outlined in Fig. 1.

On completion of the pathway assessment, if there was a high symptom burden and/or presence of another risk factor (eg previous prolonged recovery), the digital pathway generated a recommendation for the clinician to consider a referral to a concussion service. If no risk factors were present, the tool generated a recommendation to arrange primary care follow-up in 7–10 days to determine how they were recovering. Indicators of high-risk patients who may need a CT scan generated a recommendation for the clinician to consider a referral to an emergency department (ED). Referrals to concussion services could still be made at follow-up if the person was not recovering as expected. Clinicians were informed that the tool was only a guide and that triaging decisions ultimately remained their responsibility. An open text box was made available in the pathway tool to enable clinicians to outline their reasons if their action taken was different to the tool recommendation to aid identification of potential tool modifications.

Box 1. Components of the supported primary care pathway for mTBI.

1. Integration of a digital pathway support tool into the MedTech patient management software system (Versions 32 and Evolution), with capability of linking follow-up assessments to track recovery over time.
2. Integration of the Brain Injury Screening Tool (BIST) to facilitate assessment and identification of patients at risk of prolonged recovery.¹⁵
3. Funding for up to three 15–30-min consultations per patient within primary care.
4. Development of two online training modules (30-min duration) to upskill primary care practitioners.
5. Development of an updated patient recovery advice sheet that was made available in electronic and paper form (<https://www.acc.co.nz/assets/im-injured/acc8319-concussion-education-sheet.pdf>).

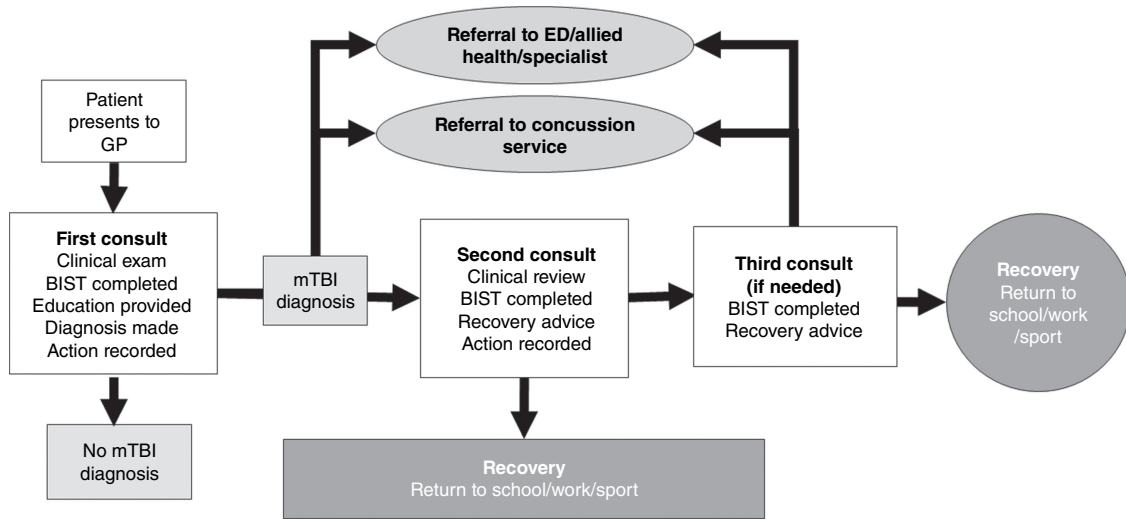


Fig. 1. Overview of the ACC supported primary health care pathway improvement strategy for mTBI.

Quantitative data was collected continuously over the course of the project, alongside feedback received from clinicians via the PHOs. This enabled a continuous and responsive test and learn approach. In line with the PDSA method, two PHOs were initially identified and recruited by ACC (ProCare and Pegasus) to ensure inclusion of clinicians working across the north and south islands of NZ. Initial learnings from the first PDSA cycle revealed that it was difficult to initially enrol practices due to high demands placed on primary care at the time. However, once enrolled there was positive feedback from clinicians on usability and utility of the tool. Refinements made to the tool following clinician feedback included the need for flexibility in the timing of appointments (eg on some occasions a 30-min second consultation was needed to complete the initial assessment, particularly in cases of multiple injuries or complex presentations). The wording of the ED referral recommendation was reframed to reflect cases where an ED referral was not appropriate eg person presents several months post-injury. Further clarification for practices on claiming for funding of the appointments was also provided.

Following these changes, the project was extended to include other PHOs servicing other areas of the country, including rural and high tourist areas (WellSouth and Nelson Bays PHOs). By the end of the second PDSA cycle, 10 PHOs were involved, encompassing 56.8% of the NZ population. The PHO areas were broadly representative of the national context as shown in Supplementary material S2, based on age, sex, ethnicity and deprivation extracted from the Ministry of Health.

Following the second PDSA cycle, further refinements were identified including the need to separate out triggers for the ED and concussion service. It became evident that in a few cases, early referral to a concussion service was being recommended unnecessarily eg patients presenting with a

history of mental health but who had low acute symptom burden. On review of these cases, it became evident that this was a result of each risk factor being weighted equally. To improve the specificity of referrals, weightings were assigned to individual risk factors following a conjoint analysis process. Concerns were raised about the inability to provide appropriate follow-up appointments after the initial assessment due to service demand constraints. User feedback also favoured access to the pathway tool with as few ‘clicks’ as possible, such as access through a desktop or toolbar icon.

Evaluation of the quality improvement project

To evaluate the impact of the supported health pathway, routinely collected data were extracted from ACC databases. Prior to commencing the quality improvement project, ACC data revealed that 36% of patients received a follow-up appointment by any health professional.¹⁰ The mean time to concussion services was also found to be 55 days (s.d. = 65.4).¹⁴ It was determined that a successful pilot should see an increase in the relative proportion of clients receiving a follow-up appointment by any health professional and that there should be a decrease in mean time to concussion services for those who need it. Sociodemographic data on age, sex, ethnicity, injury code(s), time from injury to primary care appointment, number and type of follow-up received and referrals made were extracted from the ACC database. Frequencies and proportions were used to describe the sample and the impact of the supported primary care pathway on the proportion of patients receiving at least one follow-up appointment by type. For those requiring a concussion service, the mean time from injury to first appointment within the concussion service was recorded in days.

Table 1. Characteristics of the sample.

Characteristic	Frequency (%)
Sex	
Male	107 (48.6)
Female	113 (51.4)
Ethnicity	
European	143 (65.0)
Māori	36 (16.4)
Pasifika	11 (5.0)
Asian	11 (5.0)
Other	16 (7.3)
Unknown	3 (1.4)
Age (years)	
<14	30 (13.6)
15–21	51 (23.2)
22–34	68 (30.9)
35–64	57 (25.9)
≥65	14 (6.4)
Time from injury to GP (days)	
<3	47 (21.4)
3–7	61 (27.7)
8–14	45 (20.5)
15–30	37 (16.8)
31–60	13 (5.9)
>60	17 (7.7)
Medical code	
Concussion (S60)	178 (80.9)
Head Injury (S646)	23 (10.5)
Other (eg open wound or contusion to scalp, face, forehead, neck sprain, whiplash)	19 (8.6)
Services received (could be more than one)	
Emergency department	10 (4.5)
Concussion service	78 (35.5)
Follow-up in primary care	90 (40.9)
Other	18 (8.2)
None	114 (51.8)
Number of follow-up appointments in primary care	
None	130 (59.1)
One	54 (24.5)
Two	28 (12.7)
Three	6 (2.7)
Four	2 (0.9)

(Continued on next column)

Table 1. (Continued)

Characteristic	Frequency (%)
BIST total symptom score at first appointment	
<24 h post-injury (0–120)	57.4 (37.7)
>24 h post injury (0–160)	34.9 (26.4)

Risks and benefits of the proposed system change

The potential benefits of operationalising international best practice guidelines for mTBI was considered to outweigh the potential risks for patients. Any possible risks to patient care were mitigated by empowering clinicians to use the tool as part of a comprehensive assessment and to override the recommendation. All completed Brain Injury Screening Tool (BIST) assessments were checked by an experienced medical practitioner at the PHO who contacted the clinician if necessary. Subsequent use of the BIST at follow-up appointments also ensured that any deterioration in symptoms was detected and that any patients not recovering as expected would result in a recommendation for the clinician to consider a referral to a concussion service at that time. Data was collated into an excel spreadsheet and all identifying details were removed by a member of ACC staff before being shared for analysis to protect privacy. De-identified data were stored on secure, password protected Auckland University of Technology (AUT) and ACC servers.

Ethics and consent to participate

As a quality improvement project using deidentified patient data, patient consent and ethics approval was not required.

Results

This manuscript presents data extracted as part of the supported primary care pathway for mTBI between 18 May 2022 and 30 June 2023. Reasons for non-participation included: (1) not having the capacity to provide follow-up appointments; (2) using a different patient management software system to MedTech; and/or (3) being too busy to take something new on. Further issues raised by practices within high tourist areas was that the reimbursement payments from ACC did not cover the additional expense they incur in providing services to non-registered patients. Links with HealthPathways (HealthPathways provides clinicians with an online place where locally agreed information on management of a wide range of medical conditions and injuries is stored to support clinicians at the point of care) were needed to clarify referral processes and ensure consistency.

The 31 practices represented 99 practitioners (GPs and nurse practitioners). The supported health pathway was implemented with 220 patients (Table 1). The sample was 51.4% female, with a mean age of 31.5 (s.d. 17.7) years. The

most common injury code used was S60 Concussion. There were 17 (7.7%) patients who did not have a concussion code. Median days from accident to GP appointment was 8 days (interquartile range of 15) with a wide range between 0 and 384 days. Sixty-seven (30.4%) patients attended their GP > 14 days after their injury.

Impact on follow-up rates

The number of patients who received at least one follow-up appointment (by any health professional) increased from 36.0% pre-implementation to 56.8% post-implementation. There were 28 patients (12.7%) who were followed up both in primary care and a concussion service.

Impact on referral and time to access concussion services

Sixty-three patients (28.6%) received a referral to a concussion service compared to 10% pre-implementation. The mean time from accident to concussion service reduced from 55.0 days (s.d. 65.4) pre-implementation to 36.8 days (s.d. 29.5) post-implementation. There were three people who were identified as experiencing significant delays between their claim lodgement date and access to a concussion service post-implementation. On reviewing these cases, it was identified that there had been a claim lodgement date within 2 days of injury (either an ED presentation or primary care consultation not involved in the project), however, the person had not presented for their primary care appointment within the quality improvement project until 77–126 days post-injury. All three of these cases had received a concussion service within 1 month of their primary care appointment.

Discussion

This quality improvement project increased the proportion of people with mTBI receiving a follow-up by any health professional by 20.8% and reduced time to concussion services by 18.2 days compared to usual practice. The findings provide preliminary evidence that a supported health pathway is feasible to implement within primary care and may improve service accessibility post-mTBI for those at risk of prolonged recovery post-mTBI.

This quality improvement project aimed to close mTBI evidence-practice gaps by supporting clinicians to identify those at risk of prolonged recovery, proactively monitoring recovery and facilitating appropriate early referral where needed. As the supported health pathway contained multiple components, it is difficult to determine if any specific components made the biggest contribution to health system efficiency. However, our consultation with stakeholders across the sector and people with personal experience of

mTBI to co-create this pathway suggests that without each component, the supported health care pathway would not have addressed need. This is aligned with evidence suggesting that successful change in primary care is often multifactorial in nature.¹⁷ Further work is warranted to evaluate the impact of the supported health care pathway for mTBI in other health care settings such as in emergency departments to facilitate consistency of care. Research studies would also be beneficial to determine if the supported health pathway for mTBI effectively improves patient recovery.

There were 9% of patients who did not have a brain injury code documented in their medical notes. These cases included high risk injuries (eg high speed car crash, traumatic incidents such as assaults and high symptom burden) suggesting that the experience of multiple injuries may confound coding accuracy. This finding supports evidence from the emergency department that mTBIs are often incorrectly coded or are missed.¹⁸ Accuracy of coding is important to prevent delays in access to services post-mTBI. While coding of mTBI was not a specific aim of the project, this was an unanticipated learning that suggests that additional guidance may need to be integrated into the supported health pathway to facilitate accurate coding in the future.

While there was an improvement in follow-up rates and a reduction in time to concussion services, there remained a proportion of people (43%) who did not receive a follow-up. The reasons why follow-up did not occur is not clear. Previous research has shown that about half of people recover naturally in the days to weeks following mTBI.^{2–4} It may also be the case that receiving up to date evidence-based medical advice on first medical presentation may have reduced the need for subsequent follow-up appointments.¹⁹ However, it is also likely that current pressures on primary care in NZ may have prevented some patients from being able to book in for a follow-up appointment. Further work is needed to determine if other health professionals such as physiotherapists could assist in providing follow-up appointments to increase accessibility for patients.

More than half of the sample in this quality improvement project was female. Males have been found to have an increased risk of mTBI.²⁰ Evidence has also shown that males are less likely to seek medical help than females.²¹ It is not clear if males are attending other services such as physiotherapy or the emergency department or if they are simply not seeking health care. It was interesting that the median time from injury to first primary care appointment was 8 days, with >30% of people presenting to a primary care practitioner >2 weeks after their injury. This suggests that people may be delaying seeking health care until their recovery has not progressed as they would have expected it to.

A key limitation of this project is that only national pre-implementation data were available. It was not feasible to get pre-implementation data specific to the 31 practices due

to gradual expansion of the project over time and need to combine data from different ACC databases. Additionally, not all clinicians within a practice engaged in the project. The only locality specific issue identified was the failure of universal reimbursement to cover the expense incurred by rural practices in providing services to non-registered patients. More widely, many practices were not able to participate in the project as they did not use the MedTech patient management software system. This project is now being extended to determine impact of the refined supported health pathway on clinician confidence, time in the pathway and health care costs, and to test if the risk factor weightings integrated into the BIST tool improve specificity of recommendations.

Conclusions

The findings provide preliminary evidence of improved follow-up rates and reduced time to concussion services following implementation of a supported health pathway for mTBI. Use of a quality improvement method enabled continuous testing and refinement of the supported health pathway. Key learnings from this quality improvement project included the need to take into account time between injury and appointment, separation of ED and concussion service criteria and the need to weight the risk factors of prolonged recovery to improve specificity of recommendations. There is also a need to make the tool accessible to other patient management software systems to facilitate implementation.

Supplementary material

Supplementary material is available [online](#).

References

- McKinlay A, Grace RC, Horwood LJ, *et al.* Prevalence of traumatic brain injury among children, adolescents and young adults: prospective evidence from a birth cohort. *Brain Inj* 2008; 22(2): 175–81. doi:10.1080/02699050801888824
- Theadom A, Parag V, Dowell T, *et al.* Persistent problems 1 year after mild traumatic brain injury: a longitudinal population study in New Zealand. *Br J Gen Pract* 2016; 66(642): e16–23. doi:10.3399/bjgp16X683161
- McMahon P, Hricik A, Yue JK, *et al.* Symptomatology and functional outcome in mild traumatic brain injury: results from the prospective TRACK-TBI study. *J Neurotrauma* 2014; 31(1): 26–33. doi:10.1089/neu.2013.2984
- Nelson LD, Temkin NR, Dikmen S, *et al.* Recovery after mild traumatic brain injury in patients presenting to US Level I Trauma Centers: a Transforming Research and Clinical Knowledge in Traumatic Brain Injury (TRACK-TBI) Study. *JAMA Neurol* 2019; 76(9): 1049–59. doi:10.1001/jamaneurol.2019.1313
- Madhok DY, Rodriguez RM, Barber J, *et al.* Outcomes in patients with mild traumatic brain injury without acute intracranial traumatic injury. *JAMA Network Open* 2022; 5(8): e2223245. doi:10.1001/jamanetworkopen.2022.23245
- McPherson K, Fadyl J, Theadom A, *et al.* Living life after traumatic brain injury: phase 1 of a longitudinal qualitative study. *J Head Trauma Rehabil* 2018; 33(1): E44–52. doi:10.1097/HTR.0000000000000321
- Stuart C, Reid D, Theadom A, *et al.* Knowledge and management of sport-related concussion in primary care in New Zealand. *N Z Med J* 2022; 135(1548): 31–41.
- Thomas E, Chih H, Gabbe B, *et al.* A cross-sectional study reporting concussion exposure, assessment and management in Western Australian general practice. *BMC Fam Pract* 2021; 22: 46. doi:10.1186/s12875-021-01384-1
- Ontario Neurotrauma Foundation. Guidelines for concussion/mild traumatic brain injury and persistent symptoms, 3rd edn. Toronto, Canada; 2018. Available at <https://www.braininjuryguidelines.org/>
- Bastos Gottgroy R, Hume P, Theadom A. Health care pathways for mild traumatic brain injury patients in New Zealand determined from Accident Compensation Corporation data. *N Z Med J* 2022; 135(1563): 36–51.
- Möller MC, Lexell J, Wilbe Ramsay K. Effectiveness of specialized rehabilitation after mild traumatic brain injury: a systematic review and meta-analysis. *J Rehabil Med* 2021; 53(2): 1–12. doi:10.2340/16501977-2791
- Forrest RHJ, Henry JD, McGarry PJ, *et al.* Mild traumatic brain injury in New Zealand: factors influencing post-concussion symptom recovery time in a specialised concussion service. *J Prim Healthcare* 2018; 10(2): 159–66. doi:10.1071/HC17071
- Kontos AP, Jorgensen-Wagers K, Trbovich AM, *et al.* Association of time since injury to the first clinic visit with recovery following concussion. *JAMA Neurol* 2020; 77(4): 435–40. doi:10.1001/jamaneurol.2019.4552
- Bastos Gottgroy R, Hume PA, Theadom A. Describing the patient journey through healthcare pathways following mild traumatic brain injury in New Zealand using novel Graph analysis. *Brain Inj* 2023; 37: 1294–304. doi:10.1080/02699052.2023.2230878
- Theadom A, Hardaker N, Bray C, *et al.* The Brain Injury Screening Tool (BIST): tool development, factor structure and validity. *PLoS One* 2021; 16: e0246512. doi:10.1371/journal.pone.0246512
- Menon DK, Schwab K, Wright DW, *et al.* Position Statement: Definition of Traumatic Brain Injury. *Arch Phys Med Rehabil* 2010; 91: 1637–40. doi:10.1016/j.apmr.2010.05.017
- Lau R, Stevenson F, Ong BN, *et al.* Achieving change in primary care—causes of the evidence to practice gap: systematic reviews of reviews. *Implement Sci* 2016; 11(1): 40. doi:10.1186/s13012-016-0396-4
- Tranter-Entwhistle W, Evans M, Johns S, *et al.* What a headache! Reviewing mild traumatic brain injury management in a new trauma service. *N Z Med J* 2021; 134(1532): 59.
- Ponsford J, Willmott C, Rothwell A, *et al.* Impact of early intervention on outcome following mild head injury in adults. *J Neurol Neurosurg Psychiatry* 2002; 73(3): 330–2. doi:10.1136/jnnp.73.3.330
- Feigin VL, Theadom A, Barker-Collo S, *et al.* Incidence of traumatic brain injury in New Zealand: a population-based study. *Lancet Neurol* 2013; 12(1): 53–64. doi:10.1016/S1474-4422(12)70262-4
- Wang Y, Hunt K, Nazareth I, *et al.* Do men consult less than women? An analysis of routinely collected UK general practice data. *BMJ Open* 2013; 3(8): e003320. doi:10.1136/bmjopen-2013-003320

Data availability. Deidentified ACC data is accessible for use via data.govt.nz and Stats NZ.

Conflicts of interest. A. T. was part of the BIST development working group. A. M. was employed by Manage my Health during the course of the quality improvement project. The other authors have no competing interests to declare.

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