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Clinical and Healthcare Improvement through My Health Record usage and Education in General Practice: The CHIME-GP Study

Final report

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List of Acronyms

ADHA	Australian Digital Health Agency
ANZCTR	Australian New Zealand Clinical Trials Registry
BZD	Benzodiazepines
CPD	Continuing Professional Development
CTs	Computerised Tomography Scan
GPs	General Practitioners
ICC	Intra-Cluster Correlation Coefficient
ICS	Inhaled Corticosteroids
IQR	Interquartile Range
FBC	Full Blood Count
LFTs	Liver Function Tests
MBS	Medicare Benefits Schedule
MHR	My Health Record
MSU	Midstream Urine
NSAIDs	Nonsteroidal Anti-inflammatory Drugs
PBS	Pharmaceutical Benefits Scheme
PenCS	Health analytics company providing data extraction for the project
PIP	Practice Incentives Program
PIS	Participant Information Sheet
PPIs	Proton Pump Inhibitors
PSA	Prostate Specific Antigen
QI	Quality Improvement
RRMA	Rural, Remote and Metropolitan Areas
SD	Standard Deviation
SEIFA	Socioeconomic Indexes For Areas
SHS	Shared Health Summary
TFT	Thyroid Function Test
UCE	Urea, Creatinine and Electrolytes
UOW	University of Wollongong

CHIME-GP Study Key Messages

The CHIME-GP study evaluated the effectiveness of a multifaceted educational intervention, regarding rational use of medicines, pathology, and imaging in the context of use of My Health Record (MHR). One hundred and six general practitioners (GPs) enrolled in the education, randomised to prescribing, pathology testing or imaging education. Selected potentially inappropriate medicines and tests ordered by participants were measured in the six months before and after the education and compared between education arms. The results were evaluated in the context of pre- and post-intervention interview and education outcome data.

KEY FINDINGS

- The combined evaluation results indicated that the education positively influenced GP behaviour in reducing selected potentially inappropriate medicines and tests.
- Participants reported increased confidence and frequency of use of MHR as a result of the education.
- With an extreme outlier removed, there were consistent trends towards relative reductions in costs appropriate for each education arm of the trial. When assessed regardless of completion status of the education by participants, these trends were not statistically significant.
- In the cohort that completed the education modules, the relative reduction in selected pathology ordering costs was statistically significant.
- In the context of the COVID-19 pandemic, uptake of the trial was slow and approximately 60% of enrolled participants did not complete all education modules.
- The study suggests that substantial relative health system savings may be achieved by the intervention, with most confidence placed in the effect of the pathology education component.

RECOMMENDATIONS

- The pathology education intervention should be a particular focus of future intervention development, with an emphasis on the integration of the use of MHR and rational pathology ordering.
- The effect of the test ordering education interventions may be enhanced by combining the education with real-time audit and feedback of test-ordering behaviour, and we recommend testing the addition of audit and feedback in future developments.
- To improve recruitment and retention in future similar interventions, we recommend designing them to support practitioners with their professional accreditation requirements.
- Any such large-scale rollouts should be robustly evaluated. We recommend real-time evaluation during a staged roll-out, using pragmatic, efficient evaluation designs.
- Timely and accurate data collection will be crucial to the success of such a program of evaluation. If this evaluation was to be undertaken, we recommend significant investment in development of automated data collection tools and data analysis capacity.

Executive Summary

INTRODUCTION

There is international evidence that education regarding rational pathology and imaging test ordering and medication prescribing, as well as system-based strategies, promote health cost savings. My Health Record (MHR), Australia's online patient-controlled health record, provides an opportunity to combine education and training in the use of a centralised health record with evidence-based prescribing and test ordering for general practitioners (GPs).

To inform future policy making decisions and resource allocation, the Australian Digital Health Agency (ADHA) requested a proposal for a trial that was designed to improve practitioner knowledge; change practitioner behaviour; facilitate incorporation of clinical behaviour change and technology usage into routine care; make meaningful improvements in clinical care; and result in tangible economic benefits.

The aim of the CHIME-GP study was to evaluate the effectiveness of a multifaceted educational intervention, regarding integrating the MHR system and rational use of medicines, pathology, and imaging in an Australian general practice setting.

METHODS

The study was undertaken in general practice settings across urban and regional Australia, using a mixed methods approach that incorporated a three-arm pragmatic cluster randomised parallel trial, as well as a prospective qualitative inquiry. The three arms included a deprescribing education intervention, a pathology-ordering education intervention, and a diagnostic-imaging education intervention. The focus of the education was selected potentially inappropriate medicines, pathology tests and low-back imaging. All three arms were designed to explore the potential healthcare benefits of integrating of MHR into clinical practice. The effectiveness of the intervention, in each arm, was assessed using the other two arms as controls. The primary outcome was an economic analysis of the cost per 100 consultations of the selected prescriptions, pathology and radiology test ordering in the six months following the intervention, compared with six months prior to the intervention.

Data were collected from GP participation in the online education programs provided by Medcast Pty Ltd and electronic health records generated by GP participants. Data were also collected, before and after the educational interventions, from semi-structured interviews with selected GP participants. Between-arm differences across the course of the trial were assessed for changes in educational quiz responses and prescribing, pathology, and imaging rates. Health economic outcomes were assessed for within-trial cost changes and estimates of longer-term health system effects. The semi-structured interviews were analysed using the COM-B framework to identify patterns across the qualitative interview data.

RESULTS

In total, 106 GPs enrolled in the CHIME-GP study and were randomised across the three educational arms (i.e., deprescribing, pathology-ordering and diagnostic-imaging). Forty-four GPs fully completed the education sessions.

Primary outcomes: intention-to-treat analysis

Primary outcomes were assessed by all participants for whom we had data at the end of the trial (n=97), regardless of education completion status. By the end of the follow-up period, the pathology arm showed on average $95.09 (95% CI -$229.45, $39.27) lower pathology costs than the medication arm and $41.98 (95% CI -$154.53, $70.58) lower pathology costs than the imaging arm. The imaging arm showed on average $8.73 (95% CI -$33.18, $15.72) lower imaging costs than the medication arm and $10.18 (95% CI -$30.84,

$10.48) lower imaging costs than the pathology arm. With a participant removed who had extreme outlying results, the prescribing arm showed on average $23.10 (95% CI -$56.37, $10.15) lower medication costs than the pathology arm and $36.13 (95% CI -$66.89, -$5.36) lower medication costs than the imaging arm by the end of the intervention period. These results were not statistically significant.

Per-protocol analysis

We re-analysed the data for the 44 GPs who completed all education modules as a per-protocol analysis; comprising 15 in prescribing, 15 in pathology and 14 in the imaging educational arm. The pathology education arm showed statistically significant (p = 0.019) lower pathology costs of $186.52 than the medication arm and $8.62 lower pathology costs than the imaging arm by the end of the follow-up period. The prescribing and imaging education results were similar in magnitude to the intention-to-treat analysis and not statistically significant.

Health Economic Analysis

Based on the per-protocol findings on a per 100 visits basis, the highest absolute savings were achieved by the pathology educational arm, followed by the prescribing and imaging educational arms. Relative to the average cost for medication, pathology and imaging across the sample, the savings in imaging amounted to 42%, in prescribing to 16%, and in pathology to 13%. For a typical GP in Australia with 5,438 visits per annum, we estimate the savings amounting to $3,442 (-$8,071; $1,187) for prescribing, $10,612 (-$23,430; $2,206) for pathology and $2,196 (-$4,856; $465) for imaging over two years following the education.

Quiz data results

Sixty participants completed baseline questionnaires and 37 completed post-education arm questionnaires. There were statistically significant overall improvements in confidence and self-reported use of MHR over the course of the study. Similarly, there was a statistically significant increase in the cohort overall in confidence in deprescribing, self-assessed frequency of review of pathology test ordering and confidence in evidence-based imaging ordering for low back pain.

Semi-structured interview qualitative data

Twenty-six participants participated in pre-intervention interviews and 19 in post-intervention interviews. Pre-intervention, GP participants experienced varying degrees of engagement with MHR and for many, there were gaps in their knowledge about using MHR. Post-intervention participants reported an increase in their MHR capability, including an increase in their rational prescribing and test ordering capability in the context of MHR. Following the educational intervention participants were motivated to engage with MHR more and to incorporate it into their practice routines, despite it still being perceived as non-user friendly by some. They were also motivated to change their prescribing and test ordering behaviours. Participants gave examples of how their confidence in deprescribing and reducing test ordering had increased and how their prescribing and test ordering behaviours had changed. Some participants also applied concepts learned in their study arm across to areas covered in the other arms.

DISCUSSION

The CHIME-GP study makes an important contribution to the literature on healthcare quality improvement in the context of MHR. There are few randomised controlled trials of quality improvement education interventions in primary care, and fewer that assess economic outcomes. While not statistically significant, our findings suggest that modest reductions in potentially inappropriate medicine prescribing, and low-back imaging are attainable with the availability of multi-faceted online education. This is consistent with the literature regarding traditional educational techniques. Substantial, though not statistically significant, reductions in potentially unnecessary pathology ordering on intention-to-treat analysis were also noted.

These changes were statistically significant in the cohort completing the education. In those completing the pathology education, there were significantly lower pathology costs by $186.52 (95% CI -$340.28, -$32.77) in the pathology arm compared with the medication arm. The study suggests that substantial relative health system savings may be achieved by the intervention, with the pathology education component providing the most confidence in savings projections. Limitations of the study include slow uptake and low completion of the education intervention during the COVID-19 pandemic.

KEY FINDINGS

- The combined evaluation results indicated that the education positively influenced GP behaviour in reducing selected potentially inappropriate medicines and tests.
- Participants reported increased confidence and frequency of use of MHR as a result of the education.
- With an extreme outlier removed, there were consistent trends towards relative reductions in costs appropriate for each education arm of the trial. When assessed regardless of completion status of the education by participants, these trends were not statistically significant.
- In the cohort that completed the education modules, the relative reduction in selected pathology ordering costs was statistically significant.
- In the context of the COVID-19 pandemic, uptake of the trial was slow and approximately 60% of enrolled participants did not complete all education modules.
- The study suggests that substantial relative health system savings may be achieved by the intervention, with most confidence placed in the effect of the pathology education component.

RECOMMENDATIONS

- The pathology education intervention should be a particular focus of future intervention development, with an emphasis on the integration of the use of MHR and rational pathology ordering.
- The effect of the test ordering education interventions may be enhanced by combining the education with real-time audit and feedback of test-ordering behaviour, and we recommend testing the addition of audit and feedback in future developments.
- To improve recruitment and retention in future similar interventions, we recommend designing them to support practitioners with their professional accreditation requirements.
- Any such large-scale rollouts should be robustly evaluated. We recommend real-time evaluation during a staged roll-out, using pragmatic, efficient evaluation designs.
- Timely and accurate data collection will be crucial to the success of such a program of evaluation. If this evaluation was to be undertaken, we recommend significant investment in development of automated data collection tools and data analysis capacity.

Introduction

BACKGROUND

My Health Record (MHR), established in 2012, is the national digital health record system administered by the Australian Digital Health Agency (ADHA). All Australians have an MHR, unless they opted-out prior to 31 January 2019. MHR is a secure online summary of patients' health information. A patient can control what goes into it and who is allowed to access it; for instance, patients can choose to share their health information with their doctors, hospitals, and/or other healthcare providers. They can also choose to permanently delete their record. Among other proposed benefits, MHR aims to improve medication safety and reduce unnecessary test duplication. A key objective of the ADHA is to support clinicians in the optimal use of MHR (1).

It is important that policy makers and funders have high quality evidence to support decisions, especially where there are significant clinical safety and financial implications. Pragmatic trials are viewed as a means of rigorously assessing the effectiveness of interventions in real-world settings to assist clinical or policy decision making (2). In addition, the extensive literature concerning uptake of innovations in clinical practice (such as use of MHR) demonstrates that the process is complex, highly variable, non-linear, and related to features of the innovation itself, the context into which the innovation is intended, and the facilitatory supports for uptake (3-5). Appreciation of the complexities of evaluating evidence implementation into healthcare systems has driven research approaches that have the capacity to describe not only the numeric end-result of the translation activities, but also the important individual and system antecedents - in particular, what worked for whom, in what circumstances, and why (3, 6). Such 'realist' approaches are important for policy makers so that the likelihood of achieving intended policy outcomes is maximised. This enables policies to be implemented in congruence with the context of the absorptive capacity of end-users and their environments.

This trial seeks to evaluate the effectiveness of a multifaceted education package for general practitioners (GPs) in realising some of MHR's proposed benefits in order to inform future ADHA policy making decisions and resource allocation. The rational ordering of pathology and radiology, as well as appropriate medication prescribing, has significant implications for patient safety and efficient utilisation of healthcare resources and budgets. There is some evidence in Australia that education in rational test ordering reduces unnecessary and/or not evidence-based use as practitioners become more advanced in their training (7). In addition, system-based strategies such as protocol-based test ordering and use of clinical guidelines have been shown to promote rational ordering and cost savings (8, 9).

The literature cites numerous interventions that have been trialed in attempts to change prescribing and test ordering patterns. The most effective interventions seem to be those that adopt a multifaceted approach, in particular practitioner education and feedback combined with systems change (10). Interventions that include the use of guidelines, audit, reflective practice (usually by way of clinical audit), workshops, and academic detailing show the most benefits (11-16). In addition, GP alerting systems combined with practitioner education (including online tools) and feedback have been shown to be beneficial in changing test ordering practices (17-19), as have clinical decision support technologies and drug usage advice for rational prescribing (20, 21). To this end, primary care 'groups' have been shown in trials to effectively allow practitioners to compare ordering and prescribing statistics and to receive education (22).

Exploring and influencing medical practitioner habits can be challenging and requires a pragmatic approach. The opportunity to deploy a multifaceted intervention in conjunction with the audit capacity facilitated by MHR has the potential to augment educational impact. The additional benefits of MHR with respect to

shared decision-making and the future possibilities of patient interventions should also be considered (23). Patient engagement and health responsibility is enabled by MHR, and improvements in multimorbidity outcomes in primary care have resulted from better case planning and care coordination, further reinforcing the intended benefits of eHealth (24). An exemplar of the synergies between education interventions and eHealth can be seen in the Extension for Community Healthcare Outcomes (ECHO) project which utilised telehealth, best practice protocols, and multidisciplinary case based learning to improve Hepatitis C healthcare outcomes in an underserved population (25). Even in the absence of education interventions, the implementation of eHealth records and the increased documentation they provide have proven to be beneficial in areas such as smoking cessation (26). In addition, eHealth data can be used to facilitate primary care audit and research (27). It can also facilitate collation of prescribing utilisation analysis and related cost data which can enable reflective practice to explore prescribing and test ordering habits (28).

Educational interventions in general practice also have the potential for significant savings to the Medicare Benefits Schedule (MBS) and the Pharmaceutical Benefits Scheme (PBS), with three recent systematic reviews showing effect sizes in a number of trials resulting in 15-20% reductions in prescriptions (29), a 10-25% reduction in diagnostic imaging (30) and 10-20% reductions in pathology ordering (10). However, there is a paucity of robust randomised controlled trials of scalable education interventions. In addition, the advent of MHR provides a new context for quality and safety improvement interventions in healthcare. It is therefore timely to investigate an appropriately designed, online, multifaceted education intervention, coupled with MHR.

Rationale for extending Phase I into Phase II

A Phase I study carried out in 2018 (ethics reference 2018/047) indicated that an education intervention and use of MHR in clinical practice (based on GPs' responses around their intended clinical actions) could change GP behaviour around rational ordering of pathology and diagnostic imaging, testing and prescribing. Overall, the Phase I project findings demonstrated knowledge, skill-level and attitude changes among study participants regarding evidence-based deprescribing and ordering of pathology and diagnostic imaging tests. Phase I also demonstrated uptake of an "is this needed" step in participants' clinical reasoning, as well as increased attention to reducing unnecessary healthcare expenditure. With regards to changes in provider behaviour using MHR, GPs reported that they were more motivated to use MHR and were checking it more often, as well as feeling more confident about using it (post-intervention). In addition, there were significant behaviour changes post-intervention regarding deprescribing. GPs reported that they discussed deprescribing with patients more often, reduced rates of prescribing Seretide (inhaled cortico-steroid) and reduced prescribing of metformin (diabetes medication) and Panadeine Forte (pain medication) (among a subset of participants who had been prescribed these medications). There was also a significant reduction in self-reported test ordering of full blood count (FBC) and liver function tests (LFTs) from pre-intervention to post-intervention. The evaluation also measured economic impact, indicating the potential for significant cost savings to the MBS and PBS.

Phase I was limited by the following factors:

- Small sample size
- Lack of a control group
- Inability to access real-world outcomes to measure changes in clinician behaviour (using quantitative data) over time; and
- Resultant restrictions on health economics analysis.

The current Phase II study is sufficiently powered to overcome the limitations of Phase I, based on the following objectives:

- Achieve scalability - via a randomised controlled trial that is powered to achieve statistical significance at a 95% confidence level based on the evaluation design and an evidence-based best practice educational intervention.
- Produce objective, robust results - via collecting quantitative data at the provider level to measure changes in provider behaviour as a result of
    - MHR access and interaction, and
    - Participation in the multifaceted education intervention.

STUDY AIMS

The trial (CHIME-GP) investigated whether a multifaceted education intervention on rational prescribing and investigation ordering led to reductions in health-service utilisation and costs in the context of use of a national digital health record system in an Australian general practice setting (31).

The education intervention conducted by Medcast Pty Ltd on behalf of the funding body, the Australian Digital Health Agency (ADHA), was designed to support best-practice clinical behaviour and practice for prescribing, pathology, and diagnostic imaging ordering utilising MHR. While the mixed-methods study addresses the objectives using a combination of quantitative and qualitative methods, we use resource utilisation as a composite primary quantitative outcome measure for hypothesis testing. The study tests the primary hypothesis that the education intervention results in a difference between intervention and control groups in changes in the cost per 100 consultations of selected prescriptions, pathology and radiology test ordering in the six months following the intervention, compared with six months prior to the intervention.

Methods

STUDY DESIGN

The evaluation design is a pragmatic cluster-randomised three arm parallel trial and a prospective qualitative enquiry. The effect of the intervention in each arm was assessed using the other two arms as controls. The evaluation synthesises the results in a mixed-methods analysis, embedding qualitative pre/post interviews in the quantitative results to further explore behaviour change and mechanisms. A schematic diagram of the study design is presented in Figure 1.

Inclusion criteria

- Participants must hold an Australian Pharmaceutical Benefits Scheme (PBS) prescriber number and Medicare provider number.
- Participants must undertake clinical work at least one day per week in a clinical practice having compatible electronic health records with PenCS (health analytics company providing data extraction services for the project) data extraction tools installed and MHR access.
- Participants must reside in a jurisdiction where pathology and imaging results are included in MHR.

Exclusion criteria

- Absence from clinical work for more than eight weeks over the study period.

The primary outcome includes an economic analysis of the cost per 100 consultations of selected prescriptions, and pathology and radiology test ordering in the six months following the intervention compared with six months prior to the intervention. Secondary outcome measures include the rates per

100 consultations of selected prescriptions, pathology, and radiology test ordering six months pre and post intervention, and comparison of knowledge assessment tests made pre and post intervention.

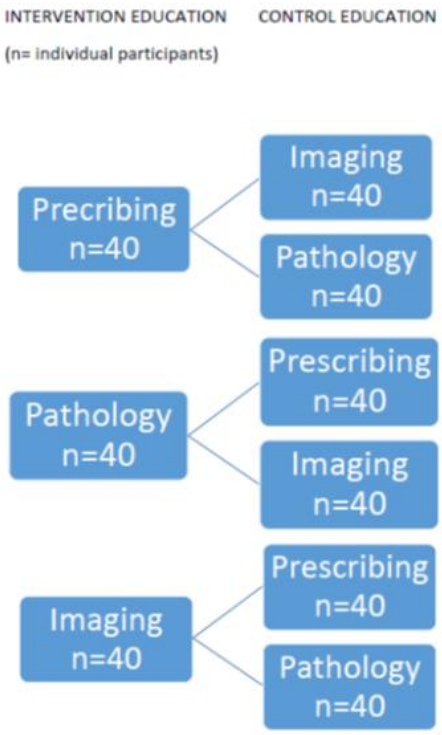

Figure 1. Study design

The 'Choosing Wisely' recommendations (32), an initiative of the National Prescribing Service Australia, were used to inform the education content, along with other sources of current evidence-based practice (33-38). The evidence-based Choosing Wisely recommendations are supplied and endorsed by every peak medical and nursing body in Australia. The prescriptions and tests included in the study were specified a-priori for the education sessions and then assessment. These same tests and prescriptions were assessed across all three arms of the trial 6 months pre- and post-intervention. The intervention pathology tests, imaging tests and prescription medication were chosen based on their frequency in general practice, cost to the PBS and potential for adverse outcomes in patients (13, 14, 39, 40) (see Table 1).

Table 1. Choosing Wisely drugs and tests that informed the development of the educational material

List of Choosing Wisely based items
Rational Prescribing
Proton pump inhibitors (PPIs)
Diuretics
Inhaled corticosteroids (ICS)
Benzodiazepines
Opiates
Nonsteroidal anti-inflammatory drugs (NSAIDS)

Pathology Ordering
Full Blood Count (FBC)
Urea, creatinine and electrolytes (UCE)
Liver Function Test (LFT)
Thyroid Function Test (TFT)
Vitamin D
Midstream urine (MSU)
Diagnostic Imaging
Low back pain imaging - lumbosacral spine x-ray and lumbosacral spine CT scan

SAMPLE SIZE

The study was conservatively powered for testing significance in sub-group analyses (e.g., change in prescribing rates or change in pathology test ordering) with a 1:1 intervention: control allocation. A medium intervention effect (f2 = 0.15) is detectable at 80% power and $\alpha = 0.05$ with 55 participants, in a two-arm trial (27.5 in each arm), analysed using a linear mixed model. The generally accepted practice level intra-cluster correlation coefficient (ICC) of GP behaviour is 0.05, with an average of three participating GPs per practice assumed. This results in a conservatively estimated design effect of 1.1. Thus, the target recruitment was a minimum of 31 participants in each of the three arms of the trial (n=93). To allow for 25% attrition, the study aimed to recruit 40 participants in each of the three arms (n=120). Following an extensive recruitment drive, 106 GP participants were enrolled in the trial.

RECRUITMENT

Following ethics approval, the trial was registered with the Australian New Zealand Clinical Trials Registry (ACTRN12620000010998). As a pragmatic trial, we aimed to create study conditions that replicated real-world conditions that would be encountered if the study intervention was rolled-out as a policy initiative. Medcast, PenCS, ADHA, UOW, RACGP and Primary Health Networks were all involved in disseminating information about the trial to practices and GPs involved in their pre-existing networks. Organisations sending out invitations did not have access to any email databases except their own.

Invitations with participant information sheets (PIS) and consent forms were sent in waves via email, fax or another electronic medium. After two reminders, further invitations to new samples of GPs and practices were sent. More than 100,000 invitations, including follow-ups, were distributed to potential participants. Due to the COVID-19 pandemic and its impact on recruitment into the study, we extended the recruitment period to eight months (January-August 2020) instead of the initially planned four months (January-April 2020) and conducted the education intervention in two waves instead of one. Wave 1 activities were undertaken in June to August, and then Wave 2 in September to November 2020. In addition, we sought ethics approval for two further reminder emails to be sent to all GP contacts. This enabled us to enroll 106 GPs in the study and run the trial at power.

Interested practices and GPs responded by faxing or emailing completed consent forms to the UOW research team. Although consent was obtained from the practice and the individual GP, only data relating to the consenting GPs was extracted from the clinical information systems in each practice. Contact details of consenting practices and GPs were supplied to Medcast and PenCS by UOW to enable them to enroll GPs and practices in the education and data extraction activities.

During the consent process, GPs were asked to indicate if they were willing to be contacted regarding participation in pre-and post-intervention interviews and their preferred method of contact. Ninety-four of the 106 participants agreed to be contacted. A maximum diversity sample of these consenting GPs were then contacted for interviews.

RANDOMISATION

Following consent to participate, participants and their practices were randomised to one of the three intervention arms on a 1:1:1 basis. A stratified randomisation approach was used to ensure a balance of practice sizes (≤5 GPs vs ≥6 GPs) and geographic location categorised by Rural, Remote and Metropolitan Areas (RRMA).

While analysis was at the level of individual participants, the education intervention was randomised at a practice level to minimise contamination of control groups. The study statisticians applied a computerised stratified randomisation algorithm RALLOC (using STATA) to ensure a balanced allocation across the three arms according to practice size and remoteness area. The statisticians provided the project officer with the randomisation sequence, who then allocated the practices into the three trial arms on a first-come, first-served basis. The statisticians remained blinded to the education intervention assigned to each group for analysis. The study participants were not blinded as to their allocation.

DATA COLLECTION

The ADHA requested a proposal for a trial that was designed to (1) improve practitioner knowledge, (2) change practitioner behaviour, (3) facilitate incorporation of clinical changes and technology usage into routine care, (4) make meaningful improvements in clinical care and, (5) result in tangible economic benefits. Data were collected to assess these outcomes. Data were collected from the participation of GPs in the online educational program, the electronic health records generated by the participating GPs, and from telephone interviews with selected participants.

To assess the knowledge and skills acquisition directly attributable to the education intervention, each participant participated in pre- and post-intervention assessments for each of the prescribing, pathology, and imaging domains. The assessments were developed as a component of the study activities in a collaboration between Medcast Pty Ltd and UOW. Participants completed pre- and post-education questionnaires which were identical across all three study arms. Items included Likert-type response items for confidence in MHR use, evidence-based deprescribing, pathology and imaging test ordering. Categorical items recorded responses for self-assessed frequency of MHR use and evidence-based prescribing, pathology, and imaging clinical activities. The questionnaire also included case-study items and free-text responses. The questionnaire is included in Appendix A. Participants engaged in pre- and post-education case studies which were specific to the education arm they were allocated. These case studies required free text and some categorical responses. Due to the small sample size of each of these education groups (n=32), and a lack of control groups, analysis of those results are not included in this report.

Both waves of the educational intervention were delivered over a period of three months with a total time commitment for participants being approximately six hours. Figure 2 shows the Medcast support QI methodology for the three arms of the educational interventions.

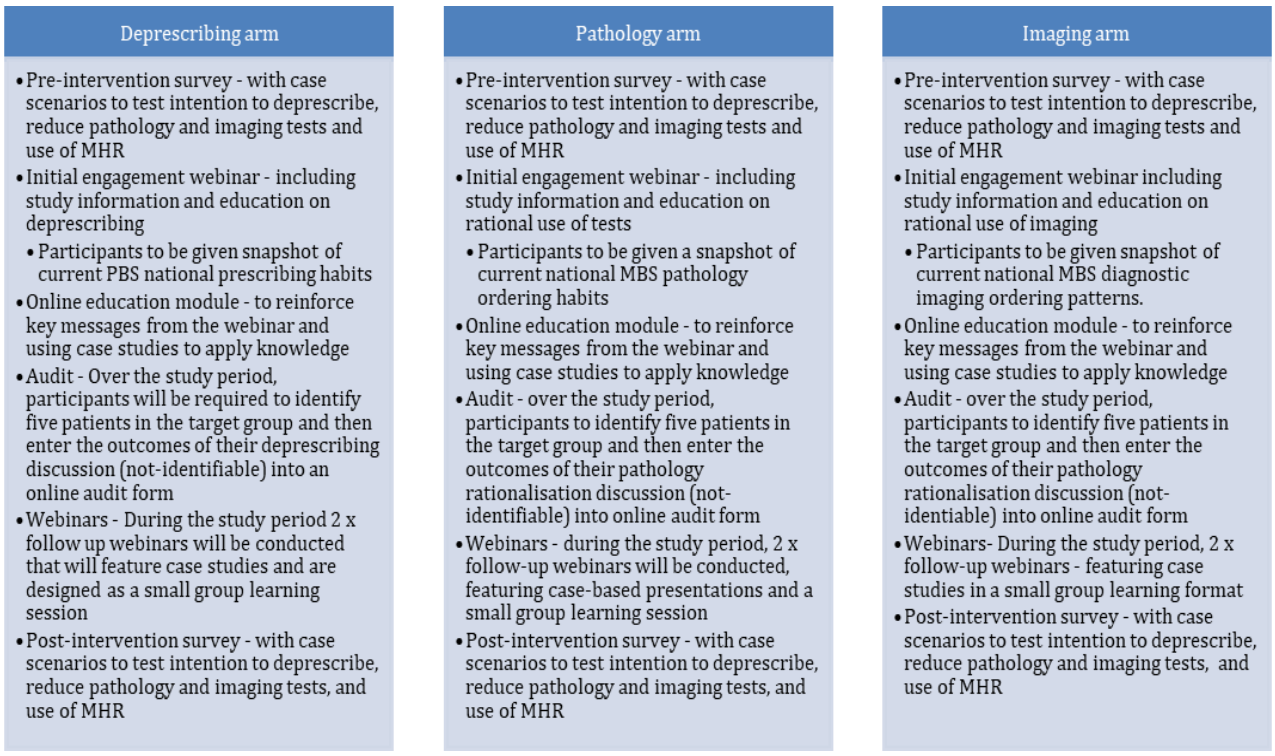

Figure 2. Description of education intervention activities for each trial arm

To assess clinical behaviour change and the resultant health economic impacts, we undertook an audit of participants' prescribing, pathology and imaging ordering using de-identified data extracted from the participants' electronic health records (EHRs). We also were able to extract data concerning rates of upload of MHR shared health summaries (SHS) from the participants' EHRs as a proxy for MHR use. It was not possible to collect data concerning MHR page views by participants. PenCS software automatically performed coding and de-identification of study data on-site, within the participating practices' computing environments. The data collected, for six months prior to and six months following the intervention, included: age and sex of patients; consultation rates at a practitioner level; baseline and post-intervention rates of prescribing, pathology, and imaging ordering at a practitioner level and SHS uploads. We assessed consultation rates by extracting episodes from the EHR that were coded as a surgery visit.

The prescription records were reviewed by one member of the evaluation team (CK) who classified prescriptions in to one of the six selected groups of medications. The identification of relevant pathology and imaging orders was an iterative process that involved data processing and definition of search terms, followed by review of the results by another member of the evaluation team (AB). This process was repeated several times until the search terms accurately identified all relevant orders.

Subsequently, the relevant Medicare Benefits Schedule (MBS) and Pharmaceutical Benefits Scheme (PBS) items were identified along with their costs for the 2020/21 financial year. For MBS items, the Medicare Item Reports[1] were used to determine the actual average cost. This was calculated as total Medicare contribution divided by the total number of national services. Unfortunately, similar data were not available for all PBS items. Therefore, the scheduled PBS dispense price was used for all medication prescriptions.

All semi-structured pre-intervention individual interviews were conducted over the telephone by the same researcher of the project team. The interview questions were used to elicit the participants' perceptions

[1] See http://medicarestatistics.humanservices.gov.au/statistics/mbs_item.jsp

and attitudes about MHR, as well as their perceptions about facilitators and barriers to achieving the expected outcomes of the education intervention (see Appendix B). Interviews were approximately 30 minutes in length.

ANALYSIS

Quantitative analysis

Project practice data analysis

To assess clinical behaviour change and the resultant health economic impacts, linear mixed models and health economic analyses of clinical data were undertaken.

Between-arm differences to changes in prescribing, pathology, and imaging ordering from baseline to follow-up were analysed using linear mixed models with GP participant ID included as a random effect to account for repeated measures. For the intention-to-treat analyses, all available data were used prior to unblinding the study results. Per-protocol analyses included GP participants who had completed the educational interventions, were not absent for long periods and had not withdrawn from the study. P values < 0.05 were considered significant.

Modelled results showed mostly a change with a negative sign and a corresponding confidence interval that included 0. In the text we generally omit the negative sign and instead refer to savings.

Educational quiz analysis

Likert-type and categorical items which were suitable for numeric analysis were included. Relevant quiz items were treated as either ordinal or nominal categorical data. Between-arm differences in changes in topic specific items pre-and post-intervention were analysed using multi-level ordinal logistic regression models. The MHR education component was similar in all three arms; therefore, MHR-related items were assessed for changes pre- and post-education across all study arms. The GP participant ID was included as a random effect to account for repeated measures within individuals in regression models. All available data for items were used in the intention-to-treat analyses prior to unblinding, including data from participants who did not complete the educational activities. Post hoc sensitivity analyses used data from only the participants who completed the educational activities and collapsed the study arms into two categories (education topic and control) for regression modelling.

Qualitative analysis

To assess use of MHR in clinical decision making and integration of MHR into clinical systems, the trial includes analysis of pre/post qualitative interviews with 25 participants. A COM-B framework (41, 42) was used to enable us to identify patterns across the qualitative data. The framework proposes that people need capability (C), opportunity (O), and motivation (M) to perform a behaviour (B). Michie et al developed the COM-B framework, which is part of the larger Behaviour Change Wheel (BCW) framework (41, 42), and the associated Theoretical Domains Framework (TDF) (43, 44), to guide understanding of behaviour in context and to develop behavioural targets as a basis for intervention design. Importantly, the COM-B framework helps enable us to understand human behaviour (B) through the interactions between capability (C), opportunity (O), and motivation (M). As we conducted pre and post intervention qualitative interviews (with the same participants) we were able to examine the interactions of these components in the COM-B framework, and to look at the resulting changes in behaviour towards using MHR and rational prescribing and test ordering.

Results

PARTICIPANT SAMPLE

One hundred and six participants enrolled in the trial: 56 participants in Wave 1 and 50 in Wave 2 (see Table 2 and Figure 3). Nine participants withdrew from the study (six prior to the education intervention activities commencing but after randomisation, and three after the education intervention commenced). Two participants that withdrew permitted their data to still be extracted for analysis. Participants cited lack of time as a reason for withdrawal; one participant had been incorrectly enrolled.

Table 2. Participants randomised by education arms for each wave

Education Arms	Wave 1 participants	Wave 2 participants	Total participants
Prescribing	19	16	35
Pathology	21	15	36
Imaging	16	19	35
Total	**56**	**50**	**106**

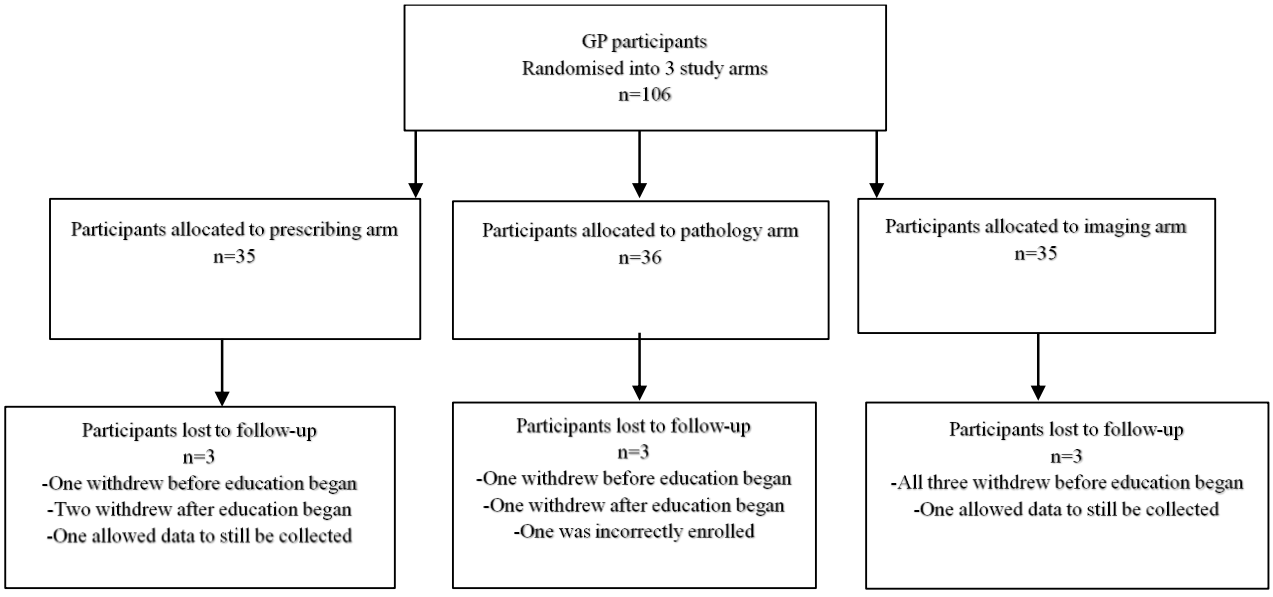

Figure 3. Participant allocation diagram CHIME-GP

Table 3 presents the participant sample. It shows GP participants by age, sex, practice size, location (rural, remote and metropolitan), and socio-economic index for area (SEIFA).

Table 3. CHIME-GP participant sample characteristics

		Wave 1	Wave 2	Total
TRIAL ARM	**Prescribing**	19	16	**35**
	Pathology	21	15	**36**
	Imaging	16	19	**35**
Sex	Female	14	25	**39**
	Male	42	25	**67**
Age*	≤45	20	19	**39**

	≥46	34	30	**64**
Practice size	≤5	22	19	**41**
	≥6	34	31	**65**
RRMA**	RA1-2	40	35	**75**
	RA3-5	15	15	**30**
	RA6-7	1	0	**1**
SEIFA***	1-5	28	25	**53**
	6-10	28	25	**53**

* Missing data for age n=3
** Rural, remote, and metropolitan area (RRMA): 1-2 - metropolitan; 3-5 - rural; 6-7 - remote
*** Socio-Economic Indexes for Areas (SEIFA) decile of advantage and disadvantage with 10 being the most advantaged and 1 being the least.

QUANTITATIVE OUTCOMES

In this section we first present the results of the intention-to-treat analysis followed by the per-protocol analysis. The results are organised around the trial hypotheses.

Primary hypothesis:

- The education intervention will result in a reduction in the cost per 100 consultations of specified prescriptions, pathology, and radiology test ordering in the intervention versus control groups in the 6 months following the intervention, compared with 6 months prior to the intervention.

Secondary hypotheses include that the intervention will result in the following:

- A reduction in the rate per 100 consultations of specified prescriptions in the intervention versus control groups in the 6 months following the intervention compared with 6 months prior to the intervention
- A reduction in the rate per 100 consultations of specified pathology test ordering in intervention versus control groups in the 6 months following the intervention compared with 6 months prior to the intervention
- A reduction in the rate per 100 consultations of specified radiology test ordering in the intervention versus control groups in 6 months following the intervention compared with 6 months prior to the intervention
- An improvement in knowledge assessment test scores in the intervention versus control groups in tests conducted following the intervention compared with prior to the intervention.

The specified prescriptions, pathology and radiology items are listed in Appendix C.

Intention-to-treat analysis

For the primary outcomes we undertook intention-to-treat analyses, where all participants for whom we had data were included. This included participants who did not undertake or complete the education modules, or who withdrew but still permitted use of their data. Clinical data extracts were received for 97 GPs; 33 in prescribing, 32 in pathology and 32 in the imaging arm. The average age was 49 years (SD 11) and 36% were female. Thirty-eight percent of GPs were working in small practices (up to 5 GPs) and the remaining 62% in large practices (6 or more GPs). The majority (69%) of GPs worked in metropolitan zones; 30% worked in rural zones and only 1% in remote zones. According to the socio-economic indexes for areas (SEIFA), 29% of GPs worked in the most disadvantaged areas, compared to 26% who worked in the most

advantaged areas (based on quintiles). During the baseline period, the average patient age was 48 years (SD 24); 58% of them were female. GPs had on average 3,104 visits (SD 2,939) at baseline. These characteristics corresponded well to the total study sample (see Table D1 in Appendix D).

Primary outcomes

Overall cost changes across intervention arms

At baseline, the mean costs per 100 visits were $202.94 (SD $168.87) for medication, $720.65 (SD $389.73) for pathology and $51.51 (SD $50.54) for imaging across the sample. At the end of the follow-up period, these costs had reduced to $177.76 (SD $88.83) for medications, increased to $826.12 (SD $409.72) for pathology and increased to $70.99 (SD $64.85) for imaging (see Table D2 in Appendix D).

Prescribing intervention

The prescribing intervention arm showed on average $23.93 (95% CI -$71.83, $119.69) higher medication costs than the pathology arm and $33.07 (95% CI -$64.68, -$1.47) lower medication costs than the imaging arm at the end of the follow-up period. Regression models for prescribing showed that both main effects, change in prescribing costs ($F = 2.22$; $p = 0.139$) and study arm ($F = 2.13$; $p = 0.125$) were not significant. The interaction term indicating different rates of change from baseline to follow-up for the three arms was not statistically significant ($F = 2.46$; $p = 0.091$) (see Table 4).

Pathology intervention

By the end of the follow-up period, the pathology arm showed on average $95.09 (95% CI -$229.45, $39.27) lower pathology costs than the medication arm and $41.98 (95% CI -$154.53, $70.58) lower pathology costs than the imaging arm. The pathology regression models showed a statistically significant change in pathology costs (main effect; $F = 21.28$; $p < 0.001$), but no statistically significant study arm main effect ($F = 0.08$; $p = 0.925$). The interaction term indicating different rates of change from baseline to follow-up for the three arms was not statistically significant ($F = 1.01$; $p = 0.369$) (see Table 4).

Imaging intervention

The imaging arm showed on average $8.73 (95% CI -$33.18, $15.72) lower imaging costs than the medication arm and $10.18 (95% CI -$30.84, $10.48) lower imaging costs than the pathology arm by the end of the follow-up period. The imaging regression models showed a statistically significant change in imaging costs (main effect; $F = 19.05$; $p < 0.001$) but no statistically significant study arm main effect ($F = 0.23$; $p = 0.796$). The interaction term indicating different rates of change from baseline to follow-up for the three arms was not statistically significant ($F = 0.51$; $p = 0.602$) (see Table 4).

Table 4. Estimated change in costs from baseline to follow-up by study arm

Change per 100 visits (in $)	Prescribing arm		Pathology arm		Imaging arm		Interaction	
	estimate	(95% CI)	estimate	(95% CI)	estimate	(95% CI)	F Value	Pr > F
Prescribing	-27.79	(-47.64; -7.94)	-51.72	(-145.39; 41.96)	5.28	(-19.31; 29.88)	2.46	0.09
Pathology	161.72	(70.16; 253.28)	66.63	(-31.71; 164.97)	108.60	(53.85; 163.36)	1.01	0.37
Imaging	22.77	(4.22; 41.32)	24.21	(11.05; 37.37)	14.03	(-1.90; 29.96)	0.51	0.60

Secondary outcomes

We assessed changes in prescribing, pathology ordering and imaging ordering per 100 visits as secondary outcome measures. Table D3 in Appendix D shows the corresponding average rates for the three study arms at baseline and follow-up.

The prescribing regression models for proton pump inhibitors (PPIs), diuretics, inhaled corticosteroids (ICS), benzodiazepines, opiates, and nonsteroidal anti-inflammatory drugs (NSAIDS) showed no statistically significant interaction terms (indicating different rates of change from baseline to follow-up for the three arms) (see Table 5).

On average the rates of full blood count (FBC), urea, creatinine and electrolytes (UCE), liver function test (LFT), thyroid function test (TFT) vitamin D and midstream urine (MSU) orders increased from baseline to follow-up. While the pathology regression models did not detect the interaction term (indicating different rates of change from baseline to follow-up for the three arms) as statistically significant for all these, the average increase in ordering rates was lower in the pathology arm than in both control arms (see Table 5).

Ordering rates of x-rays and CT scans increase from baseline to follow-up. However, no statistical difference could be found for the rate of change from baseline to follow-up for the three arms (interaction term) (see Table 5).

Table 5. Estimated change in secondary outcomes from baseline to follow-up by study arm

Change per 100 visits (in $)	**Prescribing arm**		**Pathology arm**		**Imaging arm**		**Interaction**	
	estimate	(95% CI)	estimate	(95% CI)	estimate	(95% CI)	F Value	Pr > F
Prescribing								
Benzodiazepines	-0.07	(-0.24; 0.09)	-0.25	(-0.49; 0.00)	0.07	(-0.06; 0.20)	2.89	0.06
Diuretics	-0.06	(-0.27; 0.15)	0.02	(-0.28; 0.31)	0.13	(-0.04; 0.30)	0.99	0.37
ICS	-0.24	(-0.47; -0.01)	-0.21	(-0.45; 0.02)	-0.05	(-0.23; 0.12)	1.08	0.34
NSAIDs	0.49	(0.08; 0.90)	-0.19	(-1.38; 1.01)	0.59	(0.19; 1.00)	0.76	0.47
Opiates	-0.13	(-0.34; 0.08)	-0.21	(-0.82; 0.41)	0.11	(-0.13; 0.36)	1.30	0.28
PPI	-1.27	(-1.93; -0.61)	-2.70	(-6.36; 0.96)	-0.63	(-1.57; 0.31)	1.00	0.37
Pathology								
FBC	2.14	(0.96; 3.31)	0.93	(-0.45; 2.31)	1.33	(0.52; 2.14)	1.00	0.37
LFT	1.71	(0.72; 2.70)	0.69	(-0.59; 1.97)	1.23	(0.47; 1.99)	0.80	0.45
TFT	1.62	(0.61; 2.63)	0.48	(-0.66; 1.61)	0.88	(0.40; 1.36)	1.24	0.30
Vitamin D	1.08	(0.26; 1.90)	0.92	(0.29; 1.55)	1.01	(0.49; 1.53)	0.05	0.95
MSU	0.16	(-0.12; 0.43)	-0.32	(-1.02; 0.37)	0.21	(-0.01; 0.44)	1.07	0.35
UCE	1.91	(0.92; 2.90)	0.78	(-0.66; 2.21)	1.07	(0.28; 1.85)	1.18	0.31
Imaging								
X-ray	0.05	(-0.01; 0.11)	0.04	(-0.01; 0.08)	0.06	(-0.01; 0.12)	0.15	0.86
CT scan	0.08	(0.01; 0.16)	0.09	(0.04; 0.15)	0.04	(-0.02; 0.11)	0.76	0.47

Additional analysis

However, it should be noted that there was one outlier in the pathology arm that heavily influenced the findings for the prescribing analysis (see Figure 4). Therefore, the prescribing analyses have been repeated without that participant.

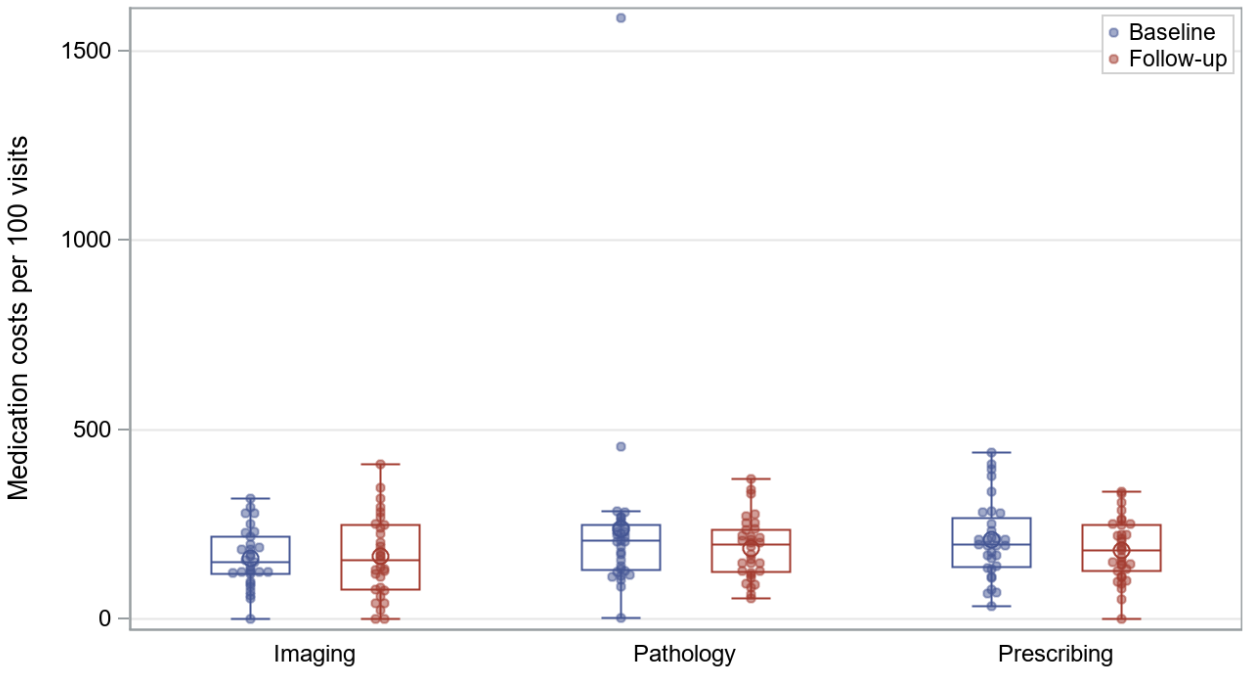

Figure 4. Prescribing cost at baseline and follow-up (including outlier)

Prescribing intervention, outlier removed

With the outlier removed, the prescribing arm showed on average $23.10 (95% CI -$56.37, $10.15) lower medication costs than the pathology arm and $36.13 (95% CI -$66.89, -$5.36) lower medication costs than the imaging arm by the end of the intervention period. The interaction term indicating different rates of change from baseline to follow-up for the three arms remains not statistically significant (F = 2.87; p = 0.062) when the outlier is not included (see Table 6, and Appendix E). The findings for pathology and imaging remain virtually unchanged.

Table 6. Estimated change from baseline to follow-up by study arm (without outlier)

Change per 100 visits (in $)	Prescribing arm		Pathology arm		Imaging arm		Interaction	
	estimate	(95% CI)	estimate	(95% CI)	estimate	(95% CI)	F Value	Pr > F
Medication costs	-28.80	(-48.40; -9.20)	-5.69	(-32.56; 21.18)	7.33	(-16.38; 31.04)	2.87	0.062
Benzodiazepines	-0.07	(-0.24; 0.09)	-0.15	(-0.32; 0.01)	0.07	(-0.06; 0.20)	2.44	0.093
Diuretics	-0.06	(-0.27; 0.15)	0.00	(-0.30; 0.31)	0.13	(-0.04; 0.30)	1.01	0.367
ICS	-0.24	(-0.47; -0.01)	-0.22	(-0.46; 0.02)	-0.05	(-0.23; 0.12)	1.10	0.337
NSAIDs	0.47	(0.07; 0.88)	0.36	(-0.20; 0.91)	0.61	(0.21; 1.01)	0.29	0.751
Opiates	-0.12	(-0.33; 0.09)	0.09	(-0.12; 0.31)	0.12	(-0.12; 0.36)	1.45	0.241
PPI	-1.30	(-1.95; -0.65)	-0.87	(-1.68; -0.06)	-0.60	(-1.53; 0.34)	0.84	0.434

Shared Health Summary

Additionally, rates of shared health summary (SHS) uploads per 100 visits were analysed. Because the education intervention did not differ in regard to SHS across the study arms, we only compared baseline with follow-up. The average SHS upload rate was 1.03 (SD 2.24) at baseline and 0.89 (SD 1.53) at follow-up. The time main effect in the regression model showed a reduction of 0.13 (95% CI -0.39; 0.12) which was not statistically significant (F = 1.05; p = 0.31). However, it should be noted that the pathology arm included one influential outlier who influenced the findings (see Figure 5).

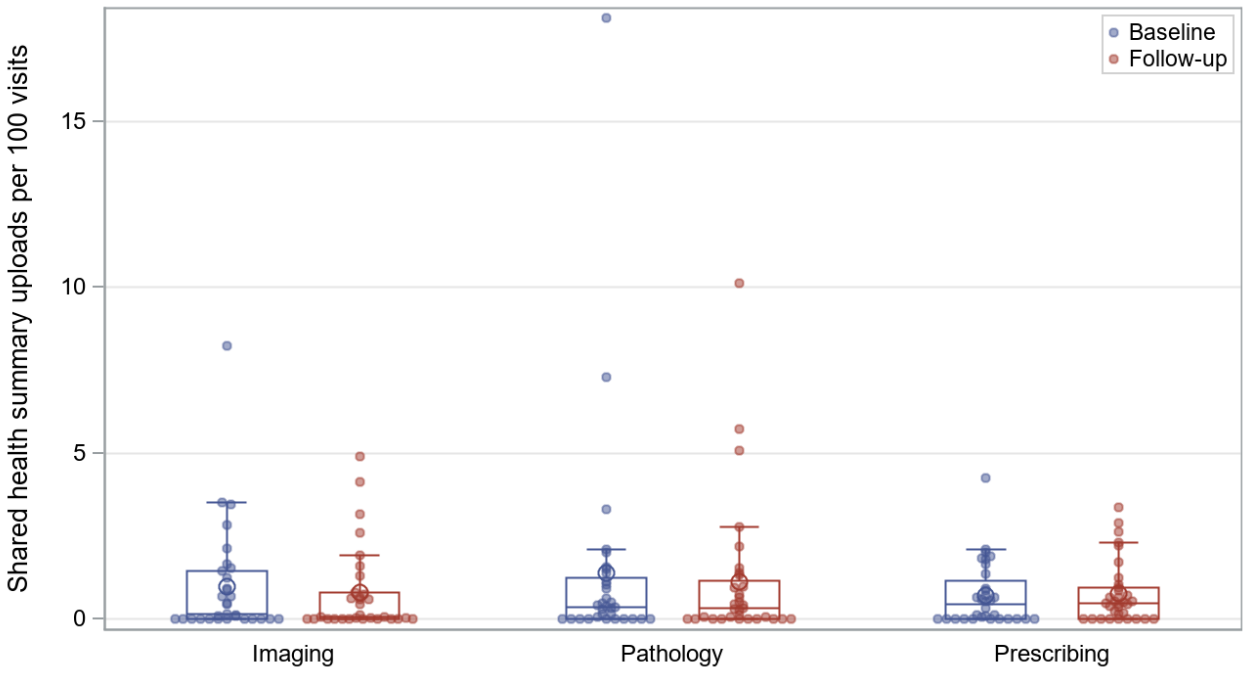

Figure 5. SHS uploads at baseline and follow-up (including outlier)

After removal of the outlier, the average SHS upload rate was 0.85 (SD 1.38) at baseline and 0.80 (SD 1.21) at follow-up. The reduction of 0.05 (95% CI -0.25; 0.15) was not statistically significant (F = 0.24; p = 0.63).

Per-protocol analysis

Forty-four GPs were included in the per-protocol analyses: 15 in prescribing, 15 in pathology, and 14 in imaging. These were GPs who had completed all education sessions, were not absent for long periods, and had not withdrawn from the study.

The average age was 50 years (SD 11) and 36% were female. Forty-one percent worked in small practices (up to 5 GPs) and the remaining 59% in large practices (6 or more GPs). The majority (64%) of GPs worked in metropolitan zones, 34% in rural zones and 2% in remote zones. According to the socio-economic indexes for areas (SEIFA), 27% of GPs worked in the most disadvantaged areas and another 27% of GPs worked in the most advantaged areas (based on quintiles). During the baseline period, average patient age was 48 years (SD 24) and 58% of them were female. GPs had on average 3,561 visits (SD 3,785) at baseline (see Table F1 in Appendix F).

Primary outcomes

Overall cost changes across intervention arms

At baseline, the mean cost per 100 visits were $202.64 (SD $93.49) for medication, $747.30 (SD $305.22) for pathology and $48.31 (SD $46.69) for imaging across the sample. During the follow-up period these costs had reduced slightly to $197.59 (SD $81.75) for medications, increased to $846.04 (SD $381.04) for pathology, and increased to $70.52 (SD $60.18) for imaging (see Table F2 in Appendix F).

Prescribing intervention

The prescribing arm showed on average $32.40 (95% CI -$81.94, $17.13) lower medication costs than the pathology arm and $30.90 (95% CI -$83.66, $21.86) lower medication costs than the imaging arm by the end of the follow-up period. Regression models for prescribing showed that both main effects, change in

prescribing costs (F = 0.33; p = 0.572) and study arm (F = 3.00; p = 0.062) were not significant. The interaction term indicating different rates of change from baseline to follow-up for the three arms was not statistically significant (F = 1.14; p = 0.329) (see Table 7).

Pathology intervention

The pathology education arm showed statistically significant (p = 0.019) lower pathology costs of $186.52 (95% CI -$340.28, -$32.77) than the medication arm, and $8.62 (95% CI -$127.64, $110.39) lower pathology costs than the imaging arm, by the end of the follow-up period. The pathology regression models showed a statistically significant change in pathology costs (main effect; F = 11.34; p = 0.002) but no statistically significant study arm main effect (F = 0.11; p = 0.893). The interaction term indicating different rates of change from baseline to follow-up for the three arms was statistically significant (F = 3.72; p = 0.033) (see Table 7). Further post-hoc analyses have shown that pathology ordering rates and costs had significantly increased in the prescribing education group in comparison to the pathology and imaging education groups.

Imaging intervention

At the end of the follow-up period, the imaging arm showed on average $25.07 (95% CI -$57.70, $7.55) lower imaging costs than the medication arm and $15.30 (95% CI -$42.52, $11.92) lower imaging costs than the pathology arm. The imaging regression models showed a statistically significant change in imaging costs (main effect; F = 11.33; p = 0.002) but no statistically significant study arm main effect (F = 0.09; p = 0.910). The interaction term indicating different rates of change from baseline to follow-up for the three arms was not statistically significant (F = 1.42; p = 0.253) (see Table 7).

Table 7. Estimated change from baseline to follow-up by study arm (per-protocol participants only)

Change in costs per 100 visits	Prescribing arm		Pathology arm		Imaging arm		Interaction	
	estimate	(95% CI)	estimate	(95% CI)	estimate	(95% CI)	F Value	Pr > F
Prescribing	-27.22	(-58.90; 4.46)	5.18	(-32.90; 43.26)	3.68	(-38.51; 45.87)	1.14	0.329
Pathology	215.92	(94.42; 337.43)	29.40	(-64.82; 123.62)	38.02	(-34.69; 110.73)	3.72	0.033
Imaging	33.19	(5.44; 60.94)	23.42	(2.29; 44.55)	8.12	(-9.04; 25.27)	1.42	0.253

Secondary outcomes

We have again assessed changes in prescribing, pathology ordering, and imaging ordering per 100 visits as secondary outcome measures in the pre-protocol study sample. Table F3 in Appendix F shows the corresponding average rates for the three study arms at baseline and follow-up.

The prescribing and imaging regression models showed no statistically significant interaction terms (indicating different rates of change from baseline to follow-up for the three arms) for any of the medications, x-rays or CTs (see Table 8).

The pathology arm showed on average 2.06 (95% CI -4.24, 0.11) lower FBC ordering rates than the medication arm and 1.03 (95% CI -0.62, 2.68) higher FBC ordering rates than the imaging arm. The pathology ordering regression models for FBC showed a statistically significant change in ordering (main effect; F = 14.51; p < 0.001) but no statistically significant study arm main effect (F = 0.21; p = 0.812). The interaction term indicating different rates of change from baseline to follow-up for the three arms was statistically significant (F = 4.88; p = 0.013) (see Table 8). Further post-hoc analyses have shown that there was a significant difference between the prescribing arm and the imaging arm.

The pathology ordering regression models for urea, creatinine and electrolytes (UCE) showed a statistically significant change in ordering (main effect; F = 11.04; p = 0.002) but no statistically significant study arm main effect (F = 0.46; p = 0.636). The interaction term indicating different rates of change from baseline to

follow-up for the three arms was statistically significant (F = 5.65; p = 0.007). The pathology arm showed on average 1.80 (95% CI -$.60, 0.01) lower UCE ordering rates than the medication arm and 1.02 (95% CI -0.61, 2.65) higher UCE ordering rates than the imaging arm (see Table 8). Further post-hoc analyses have shown that there was a significant difference between the prescribing arm and the imaging arm.

Table 8. Estimated change in secondary outcomes from baseline to follow-up by study arm

Change in costs per 100 visits	Prescribing arm		Pathology arm		Imaging arm		Interaction	
	estimate	(95% CI)	estimate	(95% CI)	estimate	(95% CI)	F Value	Pr > F
Prescribing								
Benzodiazepines	0.01	(-0.23; 0.26)	-0.07	(-0.21; 0.07)	0.02	(-0.16; 0.20)	0.39	0.678
Diuretics	-0.20	(-0.50; 0.09)	0.08	(-0.29; 0.46)	0.18	(-0.15; 0.52)	1.68	0.200
ICS	-0.19	(-0.47; 0.10)	-0.27	(-0.64; 0.11)	-0.24	(-0.54; 0.06)	0.07	0.934
NSAIDs	0.67	(0.12; 1.22)	0.43	(-0.22; 1.07)	0.75	(-0.01; 1.52)	0.26	0.772
Opiates	-0.20	(-0.57; 0.18)	0.08	(-0.33; 0.49)	0.05	(-0.23; 0.33)	0.72	0.494
PPI	-1.44	(-2.26; -0.61)	-1.12	(-2.28; 0.04)	-0.71	(-2.60; 1.18)	0.30	0.746
Pathology								
FBC	3.22	(1.48; 4.96)	1.16	(-0.15; 2.47)	0.13	(-0.87; 1.14)	4.88	0.013
LFT	2.41	(1.09; 3.73)	0.54	(-0.69; 1.78)	0.35	(-0.86; 1.55)	3.22	0.051
TFT	2.01	(0.53; 3.48)	-0.30	(-1.50; 0.90)	0.39	(-0.26; 1.05)	3.08	0.057
Vitamin D	1.22	(0.51; 1.92)	0.19	(-0.63; 1.00)	0.71	(0.02; 1.40)	1.88	0.165
MSU	0.28	(-0.21; 0.78)	-0.23	(-0.69; 0.23)	0.18	(-0.21; 0.56)	1.39	0.260
UCE	2.69	(1.37; 4.00)	0.89	(-0.34; 2.13)	-0.13	(-1.20; 0.94)	5.65	0.007
Imaging								
X-ray	0.10	(0.00; 0.20)	-0.02	(-0.07; 0.03)	0.03	(-0.05; 0.10)	2.29	0.115
CT scan	0.11	(0.00; 0.22)	0.11	(0.01; 0.20)	0.03	(-0.04; 0.09)	1.56	0.223

Shared Health Summary

Additionally, rates of shared health summary (SHS) uploads per 100 visits were analysed as a proxy for MHR usage in the pre-protocol participants. We compared baseline with follow-up because the education regarding SHS did not differ across the study arms. The average SHS upload rate was 1.12 (SD 2.78) at baseline and 1.05 (SD 1.80) at follow-up. The time main effect in the regression model showed a reduction of 0.10 (95% CI -0.52; 0.32) which was not statistically significant (F = 0.23; p = 0.638). SHS uploads data were the only available data on MHR usage. However, they do not include all activities of MHR usage, such as looking up medical records.

Health economic analysis

Medcast received funding from ADHA to provide the multifaceted educational intervention. The total funding of $724,545 (excl. GST) included funds for the evaluation ($294,471, University of Wollongong) and practice data extraction ($62,250, PenCS). The 'core' funding to Medcast for the educational intervention was $367,824.[2] For the health economic evaluation, the core funding will be used as the basis.

Economic outcomes were assessed based on the per-protocol findings for 15 GPs in prescribing, 15 in pathology and 14 in the imaging arm and the associated MBS/PBS item costs. Table 9 below shows the change in cost per 100 visits from baseline to follow-up for prescribing, pathology and imaging ordering, relative to the change observed in the respective two control arms combined. On a per 100 visits basis the highest absolute savings were achieved by the pathology arm, followed by the prescribing and imaging educational intervention arms.

[2] This included $24,000 for participant incentive payments and approx. 20% project management costs.

Table 9. Estimated change from baseline to follow-up of intervention arm relative to combined control

Arm	GPs	Estimate	(95% CI)
Prescribing	15	-31.65	(-74.21; 10.91)
Pathology	15	-97.57	(-215.43; 20.28)
Imaging	14	-20.19	(-44.65; 4.28)

Relative to the average cost for medication ($202.64; SD $93.49), pathology ($747.30; SD $305.22) and imaging ($48.31; SD $46.69) across the sample, the savings in imaging amounted to 42%, in prescribing to 16% and in pathology to 13%. During the trial follow-up period the total savings across the three arms were estimated to be $91,021.89, the 95% confidence interval ranging between -$203,188.18 and $21,140.36. However, multifaceted educational interventions have been shown to have long-term impact on prescribing and test ordering habits (45, 46). Therefore, we have conservatively assumed that the impact of the education will last for two years. Hence, the total savings can be expected to be $364,088 (-$812,753; $84,561) (see Table 10).

Table 10. Estimated total savings in intervention arms relative to combined control during two years

Arm	Estimate	(95% CI)
Prescribing	-64,186	(-150,498; 22,125)
Pathology	-275,421	(-608,116; 57,246)
Imaging	-24,481	(-54,139; 5,190)
Total	**-364,088**	**(-812,753; 84,561)**

Compared to the cost of the education, as approximated by the amount of 'core' funding received ($367,824; excl. GST and evaluation/data extraction costs) this amounted to a net benefit of -$3,736 and a benefit to cost ratio of 0.99. For every dollar of funding for the education intervention the program saved $0.99 of MBS and PBS costs during the following two years. It should be noted that these include only direct savings in MBS and PBS item costs and do not take into account additional indirect benefits and cost savings. A selection of these is separately listed in Table G1 in Appendix G.

Based on the savings per 100 visits it is possible to estimate savings for a typical GP in Australia with 5,438 visits per annum (47, 48). The savings amount to $3,442 (-$8,071; $1,187) for prescribing, $10,612 (-$23,430; $2,206) for pathology and $2,196 (-$4,856; $465) during the two years following the education.

To model the likely savings of a wider rollout we have calculated three scenarios representing low, medium and high uptake and the expected savings within two years of completion (see Table 11).

Table 11. Estimated total savings in modelling scenarios

	Low uptake (in $m)	Medium uptake (in $m)	High uptake (in $m)
Participating GPs	300 (approx. 1%)	1,500 (approx. 5%)	3,000 (approx. 10%)
Prescribing	-1.0 (-2.4; 0.4)	-5.2 (-12.1; 1.8)	-10.3 (-24.2; 3.6)
Pathology	-3.2 (-7.0; 0.7)	-15.9 (-35.1; 3.3)	-31.8 (-70.3; 6.6)
Imaging	-0.7 (-1.5; 0.1)	-3.3 (-7.3; 0.7)	-6.6 (-14.6; 1.4)
Total	**-4.9 (-10.9; 1.2)**	**-24.4 (-54.5; 5.8)**	**-48.7 (-109.1; 11.6)**

Educational quiz analysis

Sixty participants returned baseline questionnaires and 37 returned post-education questionnaires. Thirty-nine of the baseline participants and all 37 post-education participants completed the education activities. The age and sex distribution of respondents were broadly similar to the study sample as a whole. The proportion of respondents who rated themselves as 'Extremely confident' in MHR use changed from 8.3% at baseline to 35% at the end of the education. Those who reported using MHR over 30 times in the previous three months also changed, from 1.7% at baseline to 8.1% post-education (see Table H1 in Appendix H for a summary of respondent demographics and MHR related items). Summaries of responses to the topic specific quiz questions are presented in Tables H2, H3, and H4 in Appendix H.

Regression models demonstrated statistically significant overall improvements in confidence and self-reported use of MHR over the course of the trial (log(OR) 2.1; 95% CI 1.2,2.9; p< 0.001 and log(OR) 1.6; 95% CI 0.84, 2.4; p<0.001) (see Table H5 in Appendix H).

Similarly, there was a statistically significant increase in the cohort overall in confidence in deprescribing at the end of the trial in comparison with baseline (log(OR) 1.8; 95% CI 0.51,3.1; p=0.006). However, there were no significant between-group differences (see Table H6 in Appendix H).

The pathology education regression models demonstrated a statistically significant increase in the cohort overall in self-assessed frequency of review of pathology test ordering regimens for patients (log(OR) 1.3; 95% CI 1.3,1.3); p<0.001). There was a significant increase in self-assessed review frequency in the pathology education arm compared with the other arms (p<0.001) (see Table H7 in Appendix H).

Confidence in evidence-based imaging ordering for low back pain, and frequency of discussions for reasons for not ordering imaging, increased overall over the course of the trial (log(OR) 3.6; 95% CI 3.6,3.6; p<0.001 and log(OR) 1.1; 95% CI 0.00,2.1; p<0.049). There was a statistically significant increase in confidence in evidence-based imaging in the imaging education arm compared with the other education arms (imaging vs pathology p=0.001; imaging vs. prescribing p<0.001) (see Table H8 in Appendix H). The sensitivity analyses did not substantively improve the primary analysis models.

QUALITATIVE OUTCOMES

Qualitative analysis

A purposive sampling approach was used to derive the GP participant qualitative interview sample. For maximum diversity, participant age, sex, clinic size, and location were considered.

Semi-structured interviews were conducted with 26 GPs enrolled in the study prior to undertaking the education intervention, and with 19 GPs post intervention. All interviewees consented to be interviewed and to have the interview recorded. Interviews were transcribed verbatim. The research team agreed that data saturation was reached with the 26 interviews pre intervention. The same GP participants were contacted for a follow-up interview post education intervention. Nineteen of the 26 (pre-education intervention participants) responded and agreed to be interviewed (post-education intervention). Two of the 26 participants withdrew from the study. Both participants had not begun the education intervention when they withdrew. One allowed their data (qualitative and quantitative) to be used and the other one asked for all their data to be removed. Table 12 presents the sample of GPs that were interviewed (excluding the one participant which withdrew their data) - 25 participants and a total of 44 semi-structured interviews.

Table 12. Qualitative interview participant sample

		Pre-Interview participants	Post-interview participants
TRIAL ARM	**Prescribing**	8	7
	Pathology	7	7
	Imaging	10	5
Sex	Female	7	7
	Male	18	12
Age	≤45	9	8
	≥46	16	11
Practice size	≤5	11	11
	≥6	14	8
RRMA	RA1-2	16	10
	RA3-5	8	8
	RA6-7	1	1
SEIFA	1-5	14	12
	6-10	11	7

Pre-intervention interviews were held with eight interview participants in the prescribing arm, seven in pathology, and 10 in imaging. There were seven females (three ≥46; four ≤45) and 18 males (12 ≥46; six ≤45). Eleven of the participants were from practices with ≤5 GPs and 14 from practices with ≥6 GPs. Fourteen of the participant practices were from SEIFA decile 1-5 and 11 were from decile 6-10. Sixteen participant practices were from RA1-2, eight from RA3-5, and one from RA6-7.

Post-intervention interviews were held with seven interview participants in the prescribing arm, seven in pathology, and five in imaging. The same seven females were interviewed pre- and post-intervention. Twelve of the 19 males (7 ≥46; five ≤45) were interviewed post-intervention. The same eleven participants from practice sizes with ≤5 GPs were interviewed pre- and post-intervention. Eight of the 14 participants from practices with ≥6 GPs were interviewed post-intervention. Ten of the 16 participants from practices with a classification of RA1-2 were interviewed post-intervention. The same eight participants from practices with a classification RA3-5 and the one participant from RA6-7 were interviewed both pre- and post-intervention. Post-intervention, twelve participants were from practices with a SEIFA decile between 1-5 and seven between 6-10.

COM-B Framework

Pre and post interview data were analysed using the COM-B framework (41, 42). This framework proposes that human behaviour (B) is best understood through the interaction between three main components: Capability (C), Opportunity (O) and Motivation (M). Findings of the interview data are presented below under the COM-B headings.

Capability

Pre-intervention, all GP participants had engaged with MHR, albeit to varying degrees. Some were regular and opportunistic users, encouraging others in their practice as well as patients to be engaged with MHR. These participants had experience in uploading shared health summaries, updating records, checking medications, pathology, imaging, and discharge summaries. Others had little engagement or only engaged with it for the purposes of the Practice Incentives Program (PIP) incentive:

*I'm a GP and I've just been completing **opportunistically**. I feel like it's something when I have a spare second I'll open up the My Health Record and upload any information I've got including the standard past history, immunisations... (GP11pre, pathology, male)*

*I kind of have used it, but not very much…I think **I only do it when I'm prompted** at the moment. (GP7pre)*

*Well, to be honest, we do My Health Records health summary uploads **in order to fulfil the criteria for the quality improvement incentive**. (GP18pre, imaging, male)*

For many participants there were gaps in knowledge about using MHR and using it in the context of rational prescribing and test ordering:

***I'm just not knowledgeable** enough in the utility of My Health Record. (GP14pre, pathology, female)*

*So some of it's probably **lack of knowledge** of how to sign people up properly and what to upload, and just how the whole thing works with the individual patient as well. (GP16pre, imaging, female)*

*The only thing that it causes me in terms of any concerns are, perhaps am I utilising it exactly the way it should be used; **is there more I could be doing for the patients** through it? (GP25pre, prescribing, male)*

Post-intervention, most participants reported an increase in their MHR capability, including practical skills such as learning how to use the program and creating shared health summaries. This increase in capability learned through the education intervention not only enabled but encouraged participants to use MHR more:

*I was on the imaging arm of the trial, and it **made me more aware** where to look up if people have previous imaging or pathology, or who else they'd being seeing. Often, it's difficult to find that out. (GP9post, imaging, male)*

*I think, became a bit **more confident and familiar with the My Health Record**, obviously. **As a result, I've used it more than I would have otherwise**. (GP4post, prescribing, male)*

Many participants also noted that post intervention their rational prescribing and test ordering capability in the context of MHR increased:

***I learnt about the resources that could be used for deprescribing and how it could be done safely and involving patients in making that decision about reducing the pill burden**. And, of course, also **using home medication review to reduce and also to identify interaction of all the prescribed medications**. These are all the things I've learnt, but also, actually, **I never knew about some of the resources** that they had given us through the course about each medication that could be safely deprescribed (GP23post, prescribing, female)*

*…**knowing how I could access past pathology results or past healthcare encounters was useful** and **gave me more information in terms of what I should know of the patient**. (GP19post, pathology, female)*

However, post-intervention, several participants still felt that they had knowledge gaps in regard to using MHR, and that they needed further training to feel confident in using it:

***I still don't feel confident of what should I be uploading to the My Health Record**. **How do I make the most of the resources that are there?** So, I guess, I'm just a bit unfamiliar with the technology and really how to get the most out of it. I found it was **outside the scope of what was being discussed**... I didn't feel we were really educated on how to upload results we had so that other*

people access them, or how to really use My Health Record from a technical point of view. (GP16post, imaging, female)

Opportunity

Many participants in the pre-intervention interviews noted that time constraints were a major barrier to using MHR. Participants noted that it was a "user unfriendly" system, and perceived it to be "slow" and "clunky" to use:

> *I find it **very cumbersome, it's quite user unfriendly**…workflow wise, it's an extra step and we're already time poor. It doesn't integrate very well within the workflow of things (GP14pre, pathology, female)*

> *Look, it's **really slow to upload, so it's just a clunky thing**. Within the practice software, it takes a long time for the system to be ready and to upload it. (GP21pre, pathology, female)*

The education intervention was perceived as an opportunity to increase MHR capability and knowledge; "to fill in those gaps" (GP23pre, prescribing, female). The majority of GPs also perceived that the education intervention may have a positive impact on their work efficiency and clinical practice:

> *I'm **hoping that through education I'll be a better proponent for the tool,** and that I'll **use the tool more effectively**. (GP25pre, prescribing, male)*

> ***Efficiency, reduce duplicity**, I think it's just trying to figure out how I can engage with it, **workflow wise to improve the workflow, and also to save time and money** because they're always talking about how the health budget is so big and whatever. (GP14pre, pathology, female)*

> *The education - I think **it might make me more efficient**. In GP practice you're doing a whole lot of things at the same time and so to upload at the same time as doing everything else, if you're more slick at doing it because you've practiced and been educated, I think it's better. (GP12pre, prescribing, female)*

Pre-intervention, several participants perceived it may impact on their ordering of pathology and radiology and on prescribing but were not sure about the processes involved.

Post intervention participants gave examples of how the intervention presented an opportunity to increase their MHR knowledge and capability. The intervention also provided an opportunity to learn about rational prescribing and test ordering:

> *I wasn't really doing much uploading of Health Summaries and things for patients because I just wasn't sure how to do it and I didn't want to accidentally upload the wrong thing, but obviously I can see the benefit of having the uploaded view of the patient because there's so much that you can access. So, **I think I did learn a lot from the experience**. (GP7post, imaging, female)*

> ***I'm just thinking about looking at it now [MHR], where I didn't even bother** with most of my patients. (GP16post, imaging, female)*

> *Learning educationally, so it wasn't just about the health record, it **was the reminding myself about what the potential side effects of medications were, and the interactions**. (GP12post, prescribing, female)*

Many participants noted that the education helped increase **awareness** of MHR and rational prescribing/test ordering:

*I had been using it to a degree beforehand, mostly to upload shared health summaries, but **much more aware of using it to have a look at what's already on there**. So more **raising awareness** rather than the how-to for me since I more or less knew how to before. (GP9post, imaging, male)*

*I found that they [the webinars] were useful for me as in **reinforcing some things I knew, both teaching me things I didn't know**. (GP19post, pathology, female)*

*It's probably **made me realise it's a very worthwhile thing to be doing**. There's plenty of polypharmacy around…Obviously, having done the course, I'm aware that people just get left on this stuff and the tablet burden just seems to snowball. (GP4post, prescribing, male)*

It was noted that the education provided an opportunity for participants to engage in **critical thinking** about rational prescribing, test ordering, and MHR:

*It's very easy to lull into "this is my shortcut for this, and therefore I'll just click that and it will order all these tests". Whereas trying to **think more critically** about a patient, I've been trying to do that a lot more. (GP19post, pathology, female)*

*Even though I've been doing this all the time, certainly it makes me **think a little bit harder** about look – GPs, we tend to put more and more medications on…so a lot of the things are more done, in a reactive manner, but I think like now I'll be a bit more proactive in going through the medications. (GP8post, prescribing, male)*

*Whereas trying to **think more critically about a patient**, sometimes I mean I've been trying to do that a lot more but it takes more time to do that, and it takes a lot more effort and energy to do that… I am sort of **questioning**, do I really need to do this test, do I not? (GP14post, pathology, female)*

*I guess, I've started **to think more** about what I'm ordering. (GP16post, imaging, female)*

*For me it was just **not routinely ordering stuff** because that's what we always do. (GP21post, pathology, female)*

It was also noted that the education provided a structure to engage in rational prescribing and an opportunity to reflect on prescribing and test ordering behaviour:

*So prior to going on to the study, I was aware of the need for deprescribing… So it **helped to consolidate that fact, but more importantly, it gave me a structure**…and that was one of the greatest things I got out of this was it definitely gives you an **arsenal of resources**… So it's given me a **starting block**. It's given me resources I could go to, to inform the cycle of prescribing thereafter. It's given me a structure as to how that cycle will progress, and **the information on how to better arm that conversation between me and the patient**. (GP25post, prescribing, male)*

*It was actually quite **helpful from a reflection point of view**, and I think that for me at least, that was what sort of **changed my behaviour, having to reflect back on the cases that I've done**… having to submit those cases, pushing me into doing, having that first step in, and changing how I order tests. (GP14post, pathology, female)*

Motivation

The main motivator GPs expressed for participating in the study was to learn how to use MHR, and/or to improve their use of MHR. Many GPs also hoped to improve their clinical practice, and some hoped to learn more about deprescribing/rational test ordering in the context of MHR. Others hoped that being part of the study would give them comparative feedback about how they are doing in relation to their peers. Several

GPs also noted that the continuing professional development (CPD) points from completing the education component were a main motivator.

> *I have the best intentions of sitting down and having a good look around, but I don't because there's no time. So I guess in a way **I'm hoping that it [the education intervention] then gives me almost a bit of quarantined time** to really have a better look at it and see what else is there and see how else I can be using it. (GP21pre, pathology, female)*

> *Well in terms of **pathology** it would be quite **useful if I could access recent blood tests and investigation results and reports** and not have to go back and do them again if someone else has done them. Also, it would be good if I can put them somewhere where they can be accessed by say specialists or outpatient clinics instead of having to shuffle around a lot of paper all the time, sending through copies of investigations we've done only to find them being repeated anyway, unnecessarily. Quite apart from **saving the health system some money**, which would be good, it would just save a bit of mucking around and patients getting stuck by needles when they don't really need to. (GP6pre, pathology, male)*

> *Look, I think it will be useful to reflect on what my referral to **imaging** practice is. Because I know from NPS audits that I order some things more than my peers and other things less. So I guess it would be interesting to actually look at that and **reflect on it and to feel that the things I'm referring for that are best practice**. (GP16pre, imaging, female)*

> *With **prescription**, that is an arm in particular that I have not utilised before, so this will be quite interesting to see the impact…**I really have definitely been under-utilising it... It doesn't inform my current practice, My Health Record, and it probably should** and **hopefully post-education there will be a change**. (GP25pre, prescribing, male)*

> *I'm **hoping that it highlights what I'm ordering too much of, or I'm not ordering enough** of or how I'm not **comparing with my peers**, I think, so I can learn from that and then yeah. Puts it in the back of your mind, so improves your practice. (GP11pre, pathology, male)*

> *The **key point that attracted me to attend this project is the CPD points**. (GP13pre, prescribing, male)*

Post intervention, there are many examples of the education having motivated participants to engage with MHR more and to incorporate it into their practice routines. However, despite being motivated, others continued to perceive MHR as being "clunky" and non-user friendly:

> *I find that after the first online seminar, I realised, gee, I actually need to do a bit of searching into what I'm doing... **Coming out of the [education] program, I feel really guilty that I never looked [at MHR]** (GP3post, pathology, male)*

> *I'm getting used to the process of using My Health records for a patient. **But it will become like a habit**, the same as looking at the patient's medications when I am seeing new patients, patients who come back or a new patient, and do all the medications. (GP19post, pathology, female)*

> *I'm still **trying to integrate that into my routine**. It is a **bit clunky still getting that up**. I mean because I'm doing this interview the last patient I've just clicked on her document list. It takes a while for that to come up. And then it takes – it's a bit of a wade through. (GP11post, pathology, male)*

> ***Things have changed for me doing the course**, but **at the same time, the interface is still very, very clunky**. You get a summary page of all the results, but in order to try and get to look at the results, you have to click into it, and then you have to exit the whole thing and then re-enter My Health*

Record again to go into look at the next one. ***So it's really slow and really clunky****. (GP14post, pathology, female)*

Many participants also gave examples of the education being a motivator for deprescribing and rational test ordering:

I think it was more saying to me, right, you know what, ***you need to look at your own practice software and tidy up notes even more than you are, and particularly in the prescribing section****. I guess once I'd done that, as you see – well, I know that our practice is very guilty of this, that things get left on for years when a patient is no longer using them, and it would make me go through and check everything, make sure that what was on their medication list was current, and then I would upload that on to the eHealth record as the most recent summary. So I guess, yeah, for that reason* ***it just enthused me to do that perhaps a bit more than I would otherwise****. (GP12post, prescribing, female)*

I think it's changed my practice *in those regards, having done the course… actually,* ***having the impetus to actually do the job of deprescribing, which I suppose is a lot harder than prescribing****. But it's just, normally, you'd go, maybe, I'll do that next time, but because I've done the course and have realised that it is quite an important thing to be doing at every opportunity, I've rolled my sleeves up and done it. (GP4post, prescribing, male)*

Also it just ***gave me a bit more agency*** *to be able to say to people, "Look actually, we've checked the TSH [thyroid-stimulating hormone] every 12 or 18 months for the last four or five years, and it's always been normal, and this is what the evidence tells us…* ***it's reinvigorated being able to be a bit more reserved****. (GP21post, pathology, female)*

Now ***I'll be a bit more proactive in going through the medications*** *and seeing like would some of the medications be really necessary or can we try to stop it…****I think that's a change in practice that I will see in the health record as well.*** *(GP8post, prescribing, male)*

Change in behaviour post intervention

Capability, opportunity, and motivation can be seen to interact to change behaviour post intervention. Most participants reported that their behaviour in using MHR had changed. Participants were confident in utilising MHR once the intervention had provided the opportunity and motivation to increase MHR capability:

But now actually coming back, yeah ***it has actually changed the way I look at things and doing more searching for online results****, which I did this morning for a patient. (GP3post, pathology, male)*

I am using My Health Record more*. I've been* ***trying to navigate my way around it a bit more*** *and* ***use it more****. (GP26post, imaging, female)*

I'll upload my patients probably more frequently than I would have otherwise *with a health summary. And then I'll also think to check on, say, a new patient, someone I'm not familiar with –* ***because I've been aware of it, I've done that quite a few times****. (GP4post, prescribing, male)*

Participants gave examples of rational prescribing and test ordering behaviour change post intervention. Some participants in the prescribing arm gave examples of how they have begun deprescribing and how the education has given them the tools to do so. Participants in the imaging and pathology arms noted how the education has given them the "confidence" to say no to tests when they felt it was justified:

I've almost, kind of, I wouldn't say aggressively ***seeking people to deprescribe*** *than as, yeah, with* ***a bit more enthusiasm****, I suppose. (GP4post, prescribing, male)*

*I am already doing some deprescribing in my practice... **I think I have deprescribed some antihypertensives indefinitely or at least reduced the dose. Aspirin is another one that I am taking elderly patients – taking off Aspirin unless there is an absolute indication for it**. And if I see side effect, such as easy bruising or bleeding profusely… I'm definitely having a discussion about the medication. As well as **having a discussion about polypharmacy** when they come with, for example, pain or urinary symptoms or – so **giving a word of caution before prescribing and educating them about the potential side effects**. (GP23post, prescribing, female)*

*I'll actually just **start the conversation, and say, "I've just done this. I just went to some training in this sphere. Would you like to talk about it? We can discuss it."** And, sometimes, it's just coming down to using your innovation in reviewing; planting the seed, and we'll return to it. And, sometimes, we get to even start the deprescribing cycle that very day, so, yeah… **It's empowered me to do something of great need, and the patients' needs**, so it's good. (GP25post, prescribing, male)*

*I think it was more saying to me, "right, you know what, you need to look at your own practice software and tidy up notes even more than you are, and particularly in the prescribing section". I know that **our practice is very guilty of this, that things get left on for years when a patient is no longer using them, and it would make me go through and check everything, make sure that what was on their medication list was current**, and then **I would upload that on to the eHealth record as the most recent summary. So I guess, yeah, for that reason it just enthused me to do that perhaps a bit more than I would otherwise**. (GP12post, prescribing, female)*

***I've started say, no, more to some patients when I feel the test isn't really clinical indicated**, and **feel more confident with that, saying no**, rather than just ordering a test just to make sure, because the patients pushing for it. (GP16post, imaging, female)*

*Yes, **I made a very considered effort to stop ordering as many ultrasounds of shoulders and things**. Particularly musculo-skeletal I think because there is a lot that you can just diagnose on examination and inevitably when you look on My Health Record and look at their previous imaging, they've had like seven ultrasounds of their shoulders in the past two years because every time they get a sore shoulder, someone decides to ultrasound it. So, I think from that perspective, **it has been quite impactful in the way that I am practicing**. (GP7post, imaging, female)*

*I'm also involved in medico-legal work and I do some reports, and I did one recently which involved neck pain, and **I was able to sort of cite in that report the appropriateness of not doing imaging for someone with neck pain**… and I was able to sort of cite the West Australian guidelines and say, "Look, it's not appropriate to do that so early," and therefore by resourcing what the GP did. So it helped in that sort of area as well. (GP10post, imaging, male)*

*I've been a GP 30 years, **I do try and think about what I order with my pathology tests and this has really brought it into focus** for me. And I'm **far more comfortable now not ordering tests**… And you know I've long known in the past that TSH subclinical hypothyroidism, you don't need to go chasing that as much as we do and putting people on low dose thyroxine for no good reason. So I found that really helpful. PSAs [prostate-specific antigen], I've got a 98-year-old guy who keeps insisting that we measure his PSA. I've now got the courage to say to him, "Mate, are you going to live another 7 years?" I'm not going to do it this time. (GP11post, pathology, male)*

There are also examples of participants reporting applying concepts learned in their study arm and applying it in another; for example, participants in the imaging arm also changing their deprescribing behaviour:

So I was looking to see how I can use My Health Record to help patients out in terms of continuity of care, and also to help make better clinical decisions about the management of their health problems. ***And so just knowing how I could access past pathology results or past healthcare encounters was useful and gave me more information in terms of what I should know of the patient…Also it helps with checking medications and seeing if it's up to date, have a look at the health record of the patient…****I've made some changes as in I'm getting used to the process of using My Health records for a patient.* ***But it will become like a habit, the same as looking at the patient's medications when I am seeing new patients, patients who come back or a new patient, and do all the medications.*** *(GP19post, pathology, female)*

It seemed to be a way of getting information to us as how to use things like My Health Record, in line with things like imaging for me, particularly… But also for, you know, other investigations and prescriptions for others*. (GP10post, imaging, male)*

I was on the imaging arm of the trial, and it made me more aware where to look up if people have previous ***imaging or pathology****, or who else they'd being seeing. (GP9post, imaging, male)*

Participant perceptions of the education intervention format

Participants were asked about their perspectives on the format of the education intervention. A summary of these findings is presented under the headings of enablers and barriers. Refer also to Appendix I for a table of quotations that illustrate the points below.

Enablers

The majority of GPs were satisfied with the education format, finding it to be both acceptable and useful. The interactive webinars were perceived to be accessible and flexible, especially as the live webinars were also recorded so that they could be viewed later. Many participants commented on being satisfied with the content of the webinars. Activities such as the audit were helpful in facilitating discussion and translation into clinical practice. Several participants commented that they were satisfied with the amount of time allocated to the education, and that it reflected the CPD points attached. Some participants indicated that they would be interested in participating in the education from the other arms in the study, and for it to be accessible to other colleagues at their practice.

Barriers

The main barriers that participants reported were challenges with time and navigating the education program. Despite participants having had considerable online experience during the COVID-19 pandemic, functionality of this type of format was still perceived as problematic. Although online learning was perceived as more convenient than face-to-face, time was still an issue due to busyness, especially during the pandemic, and with webinars scheduled in the school holidays and across different time zones. It was also noted that a longer time frame was needed for the audit exercise. Challenges were noted regarding the navigation of the online education, including online meeting challenges, as well as challenges in communication and with uploading activities. Participants gave suggestions to help lessen these challenges in communication and technology.

Discussion

SUMMARY

This mixed-methods study evaluated the effectiveness of a multifaceted education package for general practitioners (GPs) in rational prescribing and test ordering in the context of MHR as a quality improvement tool.

Qualitative outcomes

Our findings show that post intervention most interviewees were reporting utilising MHR more frequently, particularly to aid informational continuity of care, and to help make better clinical decisions in the management of the health of their patients. However, some participants considered MHR still required work to improve its ease of use. Some participants wanted more targeted education around the technical side of using MHR, including accessing information and troubleshooting.

Most interviewees reported finding the education useful. They saw it as an opportunity for learning new things, for reinforcing what they already knew, and for motivating change of behaviour in ordering fewer unnecessary tests and prescriptions. The format of the education was accessible, and the hands-on approach meant that many participants took things learned straight back to their practice. There were, however, challenges with time and with technology and communication in navigating the education activities. Some thought the content could be expanded; for example, to include a broader range of tests. The qualitative findings suggested that the educational package had impact in increasing GPs' awareness, knowledge, capability with, and use of MHR. In addition, participants noted increased confidence in deprescribing, and in rational pathology and imaging ordering. Participants also noted using MHR as one of their new-found tools in reducing unnecessary tests.

Quiz outcomes

These qualitative findings were reinforced by the quiz results. There was a significant increase in confidence using MHR, and a corresponding increase in self-reported frequency of MHR use. There were similar all-cohort changes pre-post intervention in confidence in deprescribing, frequency of review of pathology ordering regimens and evidence-based imaging. There were significant between-arm improvements in the pathology arm in self-assessed frequency of pathology regimen reviews, and in the imaging arm in confidence in evidence-based imaging. Combined, the qualitative findings and quiz results strongly suggest that the education had a positive impact on improving attitudes and behaviours towards MHR use, and towards rational prescribing and test ordering. The findings also suggest participants saw the synergies between MHR use and achieving reductions in unnecessary medicines and tests.

There is some indication that there was an overlap of the effects of the educational interventions across arms. In the qualitative interviews, participants reported applying concepts of critically evaluating their practice that they had learned in one domain (e.g., the use of medicines) and applying it in another (e.g., investigations). This was reflected in the quiz results, with all-cohort increases in confidence in deprescribing and evidence-based imaging and frequency of pathology regimen review, independent of participant's intervention arm.

Prescribing and test ordering outcomes

Costs for prescribing were relatively stable, and costs for tests increased across the cohort overall during the trial, consistent with international data demonstrating rising primary care testing costs (10). The results of the prescribing, pathology and imaging ordering analyses were congruent with the education impact findings. With an extreme outlier removed, there were consistent trends towards relative reductions in

costs appropriate for each arm of the trial in the intention-to-treat analyses. While not statistically significant, the consistency and magnitude of the changes suggested that the education did affect clinician behaviour up to six months following the intervention, and this effect could be detected in the cohort even when participants who did not complete the education were included in the data. The effects were most evident in the pathology education arm. In the intention-to-treat analyses, by the end of the follow-up period the pathology education arm showed on average $95.09 (95% CI -$229.45, $39.27) lower pathology costs than the medication arm. The imaging education arm showed on average $8.73 (95% CI -$33.18, $15.72) lower imaging costs than the medication arm and $10.18 (95% CI -$30.84, $10.48) lower imaging costs than the pathology arm (p=0.796). With the outlier removed, the prescribing arm showed on average $23.10 (95% CI -$56.37, $10.15) lower medication costs than the pathology arm, and $36.13 (95% CI -$66.89, -$5.36) lower medication costs than the imaging arm.

The per-protocol analyses excluded randomised participants who did not meet eligibility criteria, and those who did not complete all the education modules. These analyses reflected the same overall trends as the intention-to-treat analyses. However, in this group, there were statistically significant differences in costs noted in the pathology intervention analyses. Pathology costs were $186.52 (95% CI -$340.28, -$32.77) less in the pathology education arm compared with the medication arm, and $8.62 (95% CI -$127.64, $110.39) less than the imaging arm (p=0.03).

The per-protocol analysis also suggested some parallel movement in pathology and imaging outcomes, relative to the prescribing arm. This is consistent with the suggestion of overlap of intervention effects across arms, with possibly greater potential for educational effect overlap to occur in clinical decision making for test ordering, in comparison with prescribing decisions.

Health economic outcomes

Assessed in the cohort of 44 GPs who completed the education sessions, the savings in imaging amounted to 42%, in prescribing to 16% and in pathology to 13% compared with baseline costs. This amounted to a saving of $91,021.89 (estimated between -$203,188.18 and $21,140.36) among those 44 GPs over the course of the trial.

It should be noted that the effect of each of the intervention arms is only measured on a selected set of medications, pathology, and imaging orders. While these were the ones targeted by the education intervention, there is some evidence from the interviews that the learnings were applied much more broadly. Therefore, the savings determined above likely underestimate the true effect in two ways; (a) through applying the learnings more widely in daily routine the savings may be accrued more broadly and (b) the savings are only measured relative to the combined control arms who through the same effect may have applied their learnings more broadly and thus diminished the effect.

COMPARISON OF FINDINGS WITH THE LITERATURE

Our findings of the usability of MHR are in agreement with previous research, that there is increasing potential for using eHealth data to facilitate primary care audit and reflective practice (27, 28). However, there are also challenges such as time constraints and the need for software to be more user friendly (49). Comparison of our findings with those of other studies confirms the effectiveness of multifaceted approaches (10). Intervention participants found the interactive education (including guidelines and drug usage advice), clinical audit activity and reflective practice a motivator to change prescribing and test ordering behaviour (11-16). It appears that participants could also benefit from being able to compare ordering and prescribing statistics (22).

There are relatively few robust RCTs of educational interventions to reduce potentially inappropriate pathology test ordering. The most recent systematic review of educational interventions to change primary

care physicians' test ordering could identify just six qualifying studies that aimed to reduce groups of pathology tests (10). Of the four trials relevant to this study, three demonstrated some significant changes in test reductions, though not across all tests included in the education sessions, in the order of 7.9-13%. All four studies used a combination of education and regular feedback to GPs on their ordering behaviours (50-53). Health economic analysis was not commonly reported in these studies. One study compared education and feedback and feedback alone, and concluded education and feedback were more effective and more cost effective than feedback strategies in isolation (54). No studies in this review used online education modalities.

The literature concerning interventions to reduce inappropriate imaging for low back pain is also limited. The most recent systematic review identified five RCTs. The review did not find any evidence in change in ordering behaviour from practitioner education or from guideline dissemination. Audit and feedback provided weak evidence for effect, with most effect seen with clinical decision support and targeted reminders (40). None of the studies included in the review used online education methods or provided economic analyses.

Reducing inappropriate prescribing has received relatively more attention in the literature and is often referred to as 'deprescribing'. Ideally, deprescribing takes into account changes in an individual's treatment goals, their level of functioning, life expectancy, values and preferences (37). A number of deprescribing processes, guides and algorithms have been developed to assist with reducing inappropriate medications (55). However, again, there is a paucity of RCTs of educational interventions in primary care. A recent 'umbrella review' synthesised data from all systematic reviews of interventions for deprescribing in primary care (56). The review highlighted that deprescribing was a complex process, requiring communication and support for the patient by the health professional as well as attention to the risk-benefit balance in stopping medications, patient preferences, and comorbidities (56). The effects of physician education interventions on prescribing rates are modest (57). An RCT of primary care physician education directed to patients residing in nursing homes reported a statistically significant reduction of 0.5 potentially inappropriate medications per patient participant by the end of the study (58). We were not able to identify any RCTs of an online deprescribing education intervention.

LIMITATIONS

The findings from this study should be interpreted considering the study's limitations. The acceptance rate of GPs into the study was very low. This does raise concerns about recruitment bias, and the possibility that the cohort was particularly motivated regarding the interventions or otherwise differed from the Australian GP population. There is also some evidence in the findings that there were overlapping effects of the education across arms. This has the potential to reduce the relative effects of education specific to each arm. The education session completion rate was suboptimal, which likely reduced the overall effect of interventions in the cohort. We also note that there was no suitable objective method for assessing overall MHR usage by participants. We were able to measure uploads of SHS. However, this did not account for page views, which we anticipate would have been the main effect of the education sessions. It is also possible that Practice Incentive Payments linked to SHS uploads relatively inflated the baseline data. Our denominator for assessing rates of medications and tests for GP participants was patient 'surgery visits' coded in the EHR. This provided a systematic indicator of clinical activity for participants within the trial and permitted internally consistent comparisons of resource usage across study arms. However, due to data privacy safeguards, we were unable to correlate this indicator with verified clinical encounters recorded in the EHRs. Finally, we note that the recruitment and intervention occurred in the context of the COVID-19 pandemic. This is expected to have had an impact on uptake of the trial and completion rates for the education sessions.

CONCLUSIONS

The CHIME-GP study makes an important contribution to the healthcare quality improvement literature. There are few randomised controlled trials of quality improvement education interventions in primary care, and very few that assess economic outcomes. We were not able to identify any randomised controlled studies that used online education modalities, nor any that were designed in the context of a centralised health record such as MHR. Our findings suggested that modest, though not statistically significant, reductions in costs for potentially inappropriate medicines and low-back imaging are attainable with multi-faceted online education. This is consistent with the literature regarding traditional educational techniques. Substantial, though still not statistically significant, changes were noted with reductions in potentially unnecessary pathology ordering costs on intention-to-treat analysis. These changes were statistically significant in the cohort completing the education. There were significantly lower pathology costs by $186.52 (95% CI -$340.28, -$32.77) in the pathology arm compared with the medication arm. Potentially, decision making in pathology ordering is more amenable to changes in doctors' knowledge, attitudes and routines, with less complexity arising from patient factors. It may also be that pathology records in MHR provide more assistance to doctors in reducing pathology orders, than medication records for deprescribing or imaging records do for reducing low-back imaging orders. The study suggests that substantial relative health system savings may be achieved by the intervention, with the pathology education component providing the most confidence in savings projections.

FUTURE RESEARCH DIRECTIONS

The outcomes of the CHIME-GP trial provide guidance for future directions in the development and evaluation of scalable quality improvement activities incorporating MHR. The trial demonstrated substantial reductions in costs for potentially low-value pathology testing among participants who completed the relevant education modules. There were consistent trends towards reductions in potentially inappropriate prescribing and low-value imaging. While being cognisant of the context of the COVID-19 pandemic on the trial, the effectiveness of the intervention was impaired by slow uptake and low completion. Participants also noted user-related barriers concerning the ease of use of MHR and format of the education itself. The trial tested a multi-faceted education intervention in isolation, without ancillary or follow-up reinforcement activities, such as feedback on performance. We also note that the pragmatic randomised trial design is very conservative and rigorous, but not efficient for evaluating a large-scale real-world roll-out. Even within the confines of this trial, analysis was challenged by the volume of data preparation required to render the EHR extracts usable. Future directions for development and evaluation include: 1. exploring avenues for improving the ease of use of MHR and the education modules; 2. linking the education to motivators within the professional environment of GPs to encourage uptake and completion, such as professional accreditation; 3. incorporating study designs that are compatible with large-scale interventions, for example quasi-experimental designs; 4. incorporating reinforcing activities such as real-time feedback of performance; and 5. investment in developing robust automated data extraction and management capacity.

KEY FINDINGS

- The combined evaluation results indicated that the education positively influenced GP behaviour in reducing selected potentially inappropriate medicines and tests.
- Participants reported increased confidence and frequency of use of MHR as a result of the education.
- With an extreme outlier removed, there were consistent trends towards relative reductions in costs appropriate for each education arm of the trial. When assessed regardless of completion status of the education by participants, these trends were not statistically significant.

- In the cohort that completed the education modules, the relative reduction in selected pathology ordering costs was statistically significant.
- In the context of the COVID-19 pandemic, uptake of the trial was slow and approximately 60% of enrolled participants did not complete all education modules.
- The study suggests that substantial relative health system savings may be achieved by the intervention, with most confidence placed in the effect of the pathology education component.

RECOMMENDATIONS

- The pathology education intervention should be a particular focus of future intervention development, with an emphasis on the integration of the use of MHR and rational pathology ordering.
- The effect of the test ordering education interventions may be enhanced by combining the education with real-time audit and feedback of test-ordering behaviour, and we recommend testing the addition of audit and feedback in future developments.
- To improve recruitment and retention in future similar interventions, we recommend designing them to support practitioners with their professional accreditation requirements.
- Any such large-scale rollouts should be robustly evaluated. We recommend real-time evaluation during a staged roll-out, using pragmatic, efficient evaluation designs.
- Timely and accurate data collection will be crucial to the success of such a program of evaluation. If this evaluation was to be undertaken, we recommend significant investment in development of automated data collection tools and data analysis capacity.

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Appendices

APPENDIX A: PRE/POST TRAINING QUIZ QUESTIONS

Rational prescribing pre/post training quiz

1. I am confident using MyHR with patients as part of my clinical practice.
    a. 1 - not confident
    b. 2
    c. 3
    d. 4
    e. 5 - extremely confident

2. In the last 3 months, how many times you have you used MyHR during patient consultations?
    a. 0 times
    b. 1-10 times
    c. 11-20 times
    d. 21-30 times
    e. 31+ times

3. Please indicate your level of confidence in deprescribing medications in the elderly?
    a. 1 - not confident
    b. 2
    c. 3
    d. 4
    e. 5 - extremely confident

4. In the last 3 months, how often have you discussed deprescribing with a patient?
    a. 0 times
    b. 1-5 times
    c. 6-10 times
    d. 11-15 times
    e. 16+ times

5. In the last 3 months, how often have you stopped a medication that you deemed no longer necessary?
    a. 0 times
    b. 1-5 times
    c. 6-10 times
    d. 11-15 times
    e. 16+ times

6. Do you have a particular approach to deprescribing? Y/N

7. If you have answered yes, please describe your approach. (free text)

Diagnostic imaging pre/post training quiz

1. I am confident using MHR with patients as part of my clinical practice.
    a. 1 - not confident
    b. 2
    c. 3
    d. 4
    e. 5 - extremely confident

2. In the last 3 months, how many times you have you used MHR during patient consultations?
    a. 0 times
    b. 1-10 times
    c. 11-20 times
    d. 21-30 times
    e. 31+ times

3. Please indicate your level of confidence in ordering diagnostic imaging according to evidence-based guidelines.
    a. 1 - not confident
    b. 2
    c. 3
    d. 4
    e. 5 - extremely confident

4. In the last 3 months, how often have you referred to a guideline when deciding whether to order imaging for a patient with back pain?
    a. 0 times
    b. 1-5 times
    c. 6-10 times
    d. 11-15 times
    e. 16+ times

5. In the last 3 months, how often have you discussed the rationale for not ordering or declining imaging with a patient?
    a. 0 times
    b. 1-5 times
    c. 6-10 times
    d. 11-15 times
    e. 16+ times

Pathology pre/post training quiz

1. I am confident using MyHR with patients as part of my clinical practice.
    a. 1 - not confident
    b. 2
    c. 3
    d. 4
    e. 5 - extremely confident

2. In the last 3 months, how many times you have you used MyHR during patient consultations?
    a. 0 times
    b. 1-10 times
    c. 11-20 times
    d. 21-30 times
    e. 31+ times

3. In the last 3 months, how often have you reviewed a patient's regular pathology to make sure it is evidence-based?
    a. 0 times
    b. 1-5 times
    c. 6-10 times
    d. 11-15 times
    e. 16+ times

4. In the last 3 months, how often have you made changes to a patient's pathology testing schedule, or recalls and reminders?
    a. 0 times
    b. 1-5 times
    c. 6-10 times
    d. 11-15 times
    e. 16+ times

5. Are you aware of any commonly requested 'low value' pathology tests? (Y/N)

6. If you have answered yes, please describe the commonly requested 'low value' pathology tests that you are aware of. (free text)

Question in the Post-survey only (pathology)

7. Please give examples of reductions you have made to patients pathology ordering. I.e. Include brief description of patient and tests that were not ordered or removed from a schedule.

    a. Example 1 (free text)

    b. Example 2 (free text)

    c. Example 3 (free text)

    d. Example 4 (free text)

APPENDIX B: SEMI-STRUCTURED INTERVIEW GUIDES

Baseline interview guide

This evaluation is reviewing Medcast's education intervention using MyHR.

1. *What are you hoping to achieve/learn? How are you hoping to achieve that?*

Prompts

i. Learn how to use MyHR (skills)
ii. Improve clinical practice
iii. Learn about de-prescribing/pathology/radiology
iv. Improve use of MyHR
v. CPD

2. *Can you tell me about your current engagement with MyHR?*

Prompts

i. No engagement- I'm interested to understand why you haven't engaged with MyHR?
ii. Attitude? Patient and GP.
iii. Is it useful?
iv. Acceptability?
v. Sustainability?
vi. Concerns?
vii. Benefits? Shared records across healthcare providers

3. *How do you think this intervention will change how you currently use MyHR?*

Prompts

i. Impact on clinical practice/work efficiency
ii. Impact on ordering of pathology/radiology
iii. Impact on prescribing
iv. It won't change anything - can you explain why you think this is the case?

This education intervention will involve several learning modules including case based webinars, an online learning module and an audit of five patients as a way to apply the skills learnt in the other workshops (NB: audit only for interviewees participating in prescribing and pathology intervention)

4. *Can you tell me what you think of this format to support CPD?*

Prompts

i. Usefulness?
ii. Acceptability?
iii. Sustainable way for GP CPD?

a. What would you see as being barriers to this format?
b. What are the benefits of this format?

Post-trial interview guide

In the baseline interview we talked about what you thought you would achieve/learn in this education program and your current engagement with MyHR.

1. Now that you have participated in the program, was it what you expected? What do you feel (if anything) you have learnt? Will it change your practice in any way?

Prompts

i. Learn how to use MyHR (skills)
ii. Improve clinical practice
iii. Prescribing/pathology/radiology ordering
iv. Use of MyHR
v. CPD purposes

2. *Has this intervention changed how you use MyHR?*
    a. Do you plan to make or have you already made any changes to your practice?
    b. Did the education program allow you to identify how you might introduce these changes?

Prompts

i. Do you think will have an Impact on clinical practice/work efficiency
ii. Do you think will have an Impact on Ordering of pathology/radiology
iii. Do you think will have an Impact on Prescribing
iv. It hasn't- can you explain why you think this is the case?

This education intervention involved several learning modules including case based webinars, an online learning module and an audit of five patients as a way to apply the skills learnt in the other workshops

3. Can you tell me what you thought of this format to support CPD?

Prompts

i. Usefulness?
ii. Acceptability?
iii. Sustainable way for GP CPD? Or learn about MyHR?

a. What were the barriers to this format?
b. What were the benefits of this format?

APPENDIX C: LIST OF SPECIFIED PRESCRIPTIONS, PATHOLOGY AND RADIOLOGY ITEMS

Prescribing

Selected item	PBS item	Cost
Benzodiazepines	11186R	$20.67
	11187T	$19.69
	11205R	$18.75
	11520H	$17.72
	1805B	$23.42
	1806C	$33.44
	2088X	$14.44
	2089Y	$13.23
	2723H	$13.73
	2732T	$15.44
	3132W	$13.55
	3133X	$13.23
	3135B	$14.44
	3161J	$13.66
	3162K	$13.72
	4150K	$32.08
	4151L	$37.82
	4216X	$21.88
Diuretics	1004W	$25.55
	12222G	$13.01
	1484D	$22.49
	1486F	$18.18
	1585K	$19.90
	2339D	$15.93
	2340E	$26.83
	2412Y	$13.99
	2414C	$13.99
	2415D	$21.83
	2436F	$17.34
	8532C	$19.73
	8879H	$63.53
Inhaled corticosteroids (ICS)	11719T	$28.85
	11729H	$42.99
	8147T	$19.43
	8148W	$28.85
	8149X	$42.99
	8345F	$28.85
	8346G	$42.99
	8516F	$19.43
Nonsteroidal anti-inflammatory drugs (NSAIDS)	1299J	$15.18
	1300K	$14.34
	1302M	$28.44

Selected item	PBS item	Cost
	1590Q	$23.05
	1614Y	$17.01
	1659H	$16.85
	1674D	$21.52
	1795L	$17.56
	1824B	$20.32
	1895R	$17.11
	1896T	$16.88
	2454E	$17.64
	2757D	$26.00
	3190X	$16.95
	3192B	$13.66
	8439E	$17.03
	8440F	$17.03
	8561N	$15.03
	8562P	$16.23
Opiates	10091D	$48.67
	10092E	$54.04
	10094G	$35.14
	10096J	$27.67
	10100N	$42.32
	10601Y	$165.36
	10602B	$472.44
	10607G	$472.44
	10948F	$60.74
	10957Q	$41.20
	11754P	$369.60
	11761B	$30.63
	11768J	$369.60
	11773P	$92.40
	11987X	$369.60
	11990C	$369.60
	12008B	$15.32
	12023T	$20.09
	12031F	$21.63
	12045Y	$22.80
	12054K	$22.13
	1214X	$22.32
	12473L	$80.50
	12476P	$43.08
	12477Q	$56.38
	12492L	$31.56
	12500X	$63.36
	12510K	$55.78
	12515Q	$51.36

Selected item	PBS item	Cost
	12518W	$38.82
	12525F	$85.24
	12527H	$129.52
	12539Y	$44.44
	12547J	$35.80
	1609Q	$22.12
	1653B	$26.31
	1654C	$40.09
	1655D	$57.67
	1656E	$74.44
	2481N	$49.17
	2527B	$15.36
	2622B	$19.04
	5115F	$23.41
	5197M	$21.51
	5232J	$14.29
	5393W	$21.42
	5401G	$99.07
	6307Y	$5.85
	6308B	$9.98
	6309C	$28.60
	8000C	$34.42
	8035X	$24.19
	8385H	$27.82
	8386J	$36.30
	8387K	$51.03
	8388L	$72.87
	8489T	$29.95
	8491X	$29.94
	8492Y	$40.07
	8502L	$24.86
	8523N	$14.67
	8524P	$15.43
	8525Q	$16.09
	9299K	$32.23
	9399Q	$36.06
	9400R	$49.64
	9406C	$36.09
	9407D	$48.66
	9408E	$75.58
	9409F	$120.56
	9749D	$46.20
Proton pump inhibitors (PPIs)	11670F	$15.06
	11677N	$16.45
	11681T	$14.60

Selected item	PBS item	Cost
	11683X	$16.45
	11692J	$18.33
	11697P	$17.65
	12270T	$20.88
	12277E	$17.18
	12283L	$33.46
	12286P	$18.10
	12287Q	$24.64
	3401B	$22.74
	8198L	$15.56
	8332M	$15.80
	8399C	$13.59
	8507R	$15.26
	9331D	$15.35

Pathology ordering

Selected item	MBS item	Cost	Search term[3]
Full blood count (FBC)	65070	$14.12	/fbc|fbe|fbp|full blood/
Liver function test (LFT)	66512	$14.74	/lft|liver function|mba|biochemistry profile/
Midstream urine (MSU)	69333	$17.38	(/urin|urien/ AND /micro[[:^alnum:]]{0,}culture|m([[:^alnum:]]{0,}[cs]){2}|c([[:^alnum:]]{0,}[ms]){2}|s([[:^alnum:]]{0,}[mc]){2}/) OR /u[[:^alnum:]]{0,}mcs|msu|urine[[:^alnum:]]{0,}clean[[:^alnum:]]{0,}catch/
Thyroid function test (TFT)	66719	$29.56	/t3|t4|tsh|tft|thyroid function/
Urea, creatinine and electrolytes (UCE)	66512	$14.74	(/e[[:^alnum:]]{0,}lft|electrolytes|mba|biochemistry profile/ OR /^u[[:^alnum:]]{1,}e[[:^alpha:]]|[[:^alpha:]]u[[:^alnum:]]{1,}e[[:^alpha:]]|[[:^alpha:]]u[[:^alnum:]]{1,}e$/ OR /^e[[:^alnum:]]{1,}u[[:^alpha:]]\|[[:^alpha:]]e[[:^alnum:]]{1,}u[[:^alpha:]]\|[[:^alpha:]]e[[:^alnum:]]{1,}u$/ OR /^(cue|euc|eucs|ue|uec|uecr|uecs|ues)[[:^alpha:]]|[[:^alpha:]](cue|euc|eucs|ue|uec|uecr|uecs|ues)[[:^alpha:]]|[[:^alpha:]](cue|euc|eucs|ue|uec|uecr|uecs|ues)$/) AND NOT /leucocyte/
Vitamin D	66833	$25.59	/vit[[:^alpha:]]{0,1}d|vitamin[[:^alpha:]]{0,1}d/

[3] Further details about regular expressions in SAS can be found at https://documentation.sas.com/doc/en/pgmsascdc/9.4_3.5/lefunctionsref/p0s9ilagexmjl8n1u7e1t1jfnzlk.htm

Diagnostic imaging

Selected item	MBS item	Cost	Search term
CT	56223	$228.88	/^ct[[:^alpha:]]|[[:^alpha:]]ct[[:^alpha:]]|[[:^alpha:]]ct$/ AND (/lumb|back/ OR /^l([[:^alnum:]]{0,}[st]){0,2}.spine|[^a]l([[:^alnum:]]{0,}[st]){0,2}.spine/)
X-ray	58106	$72.83	/xr|x-r|x ra/ AND (/lumb|back/ OR /^l([[:^alnum:]]{0,}[st]){0,2}.spine|[^a]l([[:^alnum:]]{0,}[st]){0,2}.spine/)

APPENDIX D: INTENTION-TO-TREAT ANALYSIS

Table D1. CHIME-GP participant sample characteristics

Sample characteristic	Prescribing arm	Pathology arm	Imaging arm
GPs, n	33	32	32
GP age*			
≤ 45, %	41.9	38.7	37.5
≥ 46, %	58.1	61.3	62.5
GP sex			
female, %	39.4	31.3	37.5
male, %	60.6	68.8	62.5
Practice size			
Small (≤ 5 GPs), %	39.4	37.5	37.5
Large (≥ 6 GPs), %	60.6	62.5	62.5
Rural, Remote and Metropolitan Area (RRMA)			
Metropolitan (RA 1-2), %	75.8	62.5	68.8
Rural (RA 3-5), %	24.2	34.4	31.3
Remote (RA 6-7), %	0.0	3.1	0.0
Socioeconomic Indexes For Areas (SEIFA)**			
Quintile 1 (lowest 20 %), %	24.2	31.3	31.3
Quintile 2, %	3.0	15.6	12.5
Quintile 3, %	24.2	18.8	9.4
Quintile 4, %	12.1	21.9	18.8
Quintile 5 (highest 20 %), %	36.4	12.5	28.1
Education wave			
Wave 1, %	51.5	56.3	46.9
Wave 2, %	48.5	43.8	53.1
Visits***			
Patient age, mean (SD)	48.3 (24.0)	48.5 (24.1)	50.4 (24.9)
Patient gender			
female, %	59.6	58.5	55.8
male, %	40.4	41.5	44.2
Baseline visits, mean (SD)	3,182.5 (2,661.2)	3,514.7 (3,904.0)	2,613.3 (1,940.3)
Follow-up visits, mean (SD)	3,165.8 (2,646.5)	3,393.9 (4,203.6)	2,474.8 (1,989.4)

* Missing data for age n=3

** SEIFA quintiles of advantage and disadvantage with 5 being the most advantaged and 1 being the least.

*** Patient data were missing for 0.8%.

Table D2. Costs at baseline and follow-up by study arm

	Prescribing arm		Pathology arm		Imaging arm	
Costs per 100 visits	Baseline (N = 32)	Follow-up (N = 33)	Baseline (N = 32)	Follow-up (N = 32)	Baseline (N = 31)	Follow-up (N = 31)
	mean (SD)	mean (SD)	mean (SD)	mean (SD)	mean (SD)	mean (SD)
Prescribing	208.54 (101.87)	181.25 (80.75)	238.62 (259.48)	186.90 (80.28)	160.32 (76.09)	164.61 (105.31)
Pathology	706.02 (341.47)	865.72 (472.19)	740.76 (453.83)	807.39 (340.97)	714.98 (376.70)	803.31 (413.51)
Imaging	54.32 (42.21)	75.46 (61.29)	43.79 (47.71)	68.00 (65.96)	56.59 (60.92)	69.31 (69.14)

Table D3. Secondary outcomes at baseline and follow-up by study arm

	Prescribing arm		Pathology arm		Imaging arm	
Rates per 100 visits	Baseline (N = 32)	Follow-up (N = 33)	Baseline (N = 32)	Follow-up (N = 32)	Baseline (N = 31)	Follow-up (N = 31)
	mean (SD)	mean (SD)	mean (SD)	mean (SD)	mean (SD)	mean (SD)
Prescribing						
Benzodiazepines	0.88 (0.66)	0.80 (0.48)	0.98 (0.99)	0.74 (0.51)	0.68 (0.64)	0.73 (0.72)
Diuretics	0.66 (0.54)	0.59 (0.58)	0.77 (0.90)	0.79 (0.56)	0.53 (0.43)	0.66 (0.63)
ICS	0.61 (0.66)	0.42 (0.62)	0.53 (0.60)	0.32 (0.48)	0.56 (0.84)	0.46 (0.72)
NSAIDs	2.47 (1.35)	2.99 (1.61)	2.92 (3.21)	2.73 (2.17)	1.89 (1.35)	2.46 (1.93)
Opiates	1.15 (0.94)	1.01 (0.78)	1.23 (1.83)	1.03 (0.57)	0.97 (0.91)	1.07 (1.07)
PPI	5.53 (3.23)	4.27 (2.25)	6.96 (10.51)	4.26 (2.18)	4.26 (2.48)	3.62 (2.59)
Pathology						
FBC	10.24 (4.47)	12.40 (6.00)	10.37 (5.89)	11.30 (4.91)	9.96 (5.18)	10.98 (5.33)
LFT	9.37 (4.63)	11.09 (5.59)	9.28 (5.77)	9.97 (4.80)	9.89 (4.69)	10.86 (4.85)
TFT	5.76 (4.10)	7.34 (5.35)	6.33 (4.24)	6.81 (3.35)	5.40 (3.67)	6.13 (3.90)
Vitamin D	2.38 (2.67)	3.37 (4.43)	3.22 (3.54)	4.14 (3.81)	3.21 (3.15)	4.14 (3.76)
MSU	2.78 (2.17)	3.00 (2.42)	2.82 (2.95)	2.50 (2.36)	2.28 (1.93)	2.41 (2.16)
UCE	9.75 (4.19)	11.65 (5.18)	9.43 (5.95)	10.21 (4.72)	9.99 (4.71)	10.80 (4.81)
Imaging						
X-ray	0.17 (0.27)	0.22 (0.34)	0.14 (0.18)	0.18 (0.20)	0.13 (0.12)	0.19 (0.23)
CT scan	0.18 (0.16)	0.26 (0.24)	0.15 (0.18)	0.24 (0.26)	0.21 (0.25)	0.24 (0.26)

APPENDIX E: INTENTION-TO-TREAT ANALYSIS OF PRESCRIBING ARM WITHOUT OUTLIER

Table E1. Costs and prescribing rates at baseline and follow-up by study arm (without outlier)

	Prescribing arm		Pathology arm		Imaging arm	
Costs / rates per 100 visits	Baseline (N = 32)	Follow-up (N = 33)	Baseline (N = 32)	Follow-up (N = 32)	Baseline (N = 31)	Follow-up (N = 31)
	mean (SD)	mean (SD)	mean (SD)	mean (SD)	mean (SD)	mean (SD)
Costs	208.54 (101.87)	181.25 (80.75)	195.12 (83.61)	189.43 (80.30)	160.32 (76.09)	164.61 (105.31)
Benzodiazepines	0.88 (0.66)	0.80 (0.48)	0.84 (0.58)	0.69 (0.43)	0.68 (0.64)	0.73 (0.72)
Diuretics	0.66 (0.54)	0.59 (0.58)	0.79 (0.91)	0.80 (0.56)	0.53 (0.43)	0.66 (0.63)
ICS	0.61 (0.66)	0.42 (0.62)	0.55 (0.60)	0.33 (0.49)	0.56 (0.84)	0.46 (0.72)
NSAIDs	2.47 (1.35)	2.99 (1.61)	2.40 (1.35)	2.76 (2.20)	1.89 (1.34)	2.46 (1.93)
Opiates	1.15 (0.94)	1.01 (0.78)	0.92 (0.56)	1.02 (0.57)	0.97 (0.91)	1.07 (1.07)
PPI	5.53 (3.23)	4.27 (2.25)	5.18 (3.05)	4.31 (2.20)	4.26 (2.48)	3.62 (2.59)

APPENDIX F: PER-PROTOCOL ANALYSIS

Table F1. CHIME-GP participant sample characteristics (per-protocol)

Sample characteristic	Prescribing arm	Pathology arm	Imaging arm
GPs, n	15	15	14
GP age*			
≤ 45, %	53.3	35.7	28.6
≥ 46, %	46.7	64.3	71.4
GP sex			
female, %	40.0	33.3	35.7
male, %	60.0	66.7	64.3
Practice size			
Small (≤ 5 GPs), %	26.7	33.3	64.3
Large (≥ 6 GPs), %	73.3	66.7	35.7
Rural, Remote and Metropolitan Area (RRMA)			
Metropolitan (RA 1-2), %	73.3	53.3	64.3
Rural (RA 3-5), %	26.7	40.0	35.7
Remote (RA 6-7), %	0.0	6.7	0.0
Socioeconomic Indexes For Areas (SEIFA)**			
Quintile 1 (lowest 20 %), %	13.3	33.3	35.7
Quintile 2, %	0.0	6.7	14.3
Quintile 3, %	26.7	33.3	7.1
Quintile 4, %	20.0	13.3	14.3
Quintile 5 (highest 20 %), %	40.0	13.3	28.6
Education wave			
Wave 1, %	46.7	73.3	64.3
Wave 2, %	53.3	26.7	35.7
Visits***			
Patient age, mean (SD)	49.7 (24.0)	47.4 (24.2)	47.7 (24.6)
Patient gender			
female, %	57.9	60.3	54.4
male, %	42.1	39.7	45.6
Baseline visits, mean (SD)	3,439.8 (3,204.6)	4,956.9 (5,157.9)	2,194.1 (1,841.9)
Follow-up visits, mean (SD)	3,380.0 (3,076.1)	4,704.7 (5,695.0)	2,165.2 (1,878.6)

* Missing data for age n=1

** SEIFA quintiles of advantage and disadvantage with 5 being the most advantaged and 1 being the least.

*** Patient data were missing for less than 0.1%

Table F2. Primary and secondary outcomes at baseline and follow-up by study arm (per-protocol)

	Prescribing arm		Pathology arm		Imaging arm	
Costs per 100 visits	Baseline (N = 15)	Follow-up (N = 15)	Baseline (N = 15)	Follow-up (N = 15)	Baseline (N = 14)	Follow-up (N = 13)
	mean (SD)	mean (SD)	mean (SD)	mean (SD)	mean (SD)	mean (SD)
Prescribing	230.89 (98.98)	203.67 (80.74)	213.63 (103.66)	218.81 (75.94)	160.62 (61.85)	166.10 (85.87)
Pathology	666.40 (288.83)	882.32 (483.38)	812.25 (322.79)	841.65 (354.56)	764.38 (305.53)	809.24 (292.85)
Imaging	46.41 (38.45)	79.60 (55.03)	43.94 (51.20)	67.36 (71.43)	55.04 (52.17)	63.68 (54.98)

Table F3. Secondary outcomes at baseline and follow-up by study arm (per-protocol)

	Prescribing arm		Pathology arm		Imaging arm	
Per 100 visits	Baseline (N = 15)	Follow-up (N = 15)	Baseline (N = 15)	Follow-up (N = 15)	Baseline (N = 14)	Follow-up (N = 13)
	mean (SD)	mean (SD)	mean (SD)	mean (SD)	mean (SD)	mean (SD)
Prescribing						
Benzodiazepines	1.00 (0.76)	1.02 (0.54)	0.89 (0.52)	0.82 (0.49)	0.61 (0.46)	0.62 (0.56)
Diuretics	0.77 (0.50)	0.57 (0.47)	0.86 (0.80)	0.95 (0.53)	0.61 (0.35)	0.81 (0.67)
ICS	0.64 (0.73)	0.46 (0.40)	0.57 (0.66)	0.31 (0.36)	0.67 (1.05)	0.33 (0.46)
NSAIDs	2.75 (1.29)	3.42 (1.40)	2.64 (1.49)	3.07 (2.15)	1.70 (0.98)	2.47 (1.73)
Opiates	1.33 (0.89)	1.14 (0.73)	1.09 (0.62)	1.17 (0.73)	0.89 (0.73)	0.97 (0.62)
PPI	6.11 (3.12)	4.67 (2.25)	5.94 (3.66)	4.82 (2.52)	4.41 (2.64)	3.78 (2.58)
Pathology						
FBC	9.64 (3.88)	12.87 (6.56)	11.54 (4.32)	12.70 (5.59)	11.00 (5.21)	11.14 (5.04)
LFT	8.81 (3.84)	11.22 (5.61)	9.49 (4.69)	10.04 (5.65)	11.19 (4.08)	11.69 (3.70)
TFT	5.61 (3.26)	7.62 (5.57)	7.21 (2.65)	6.90 (3.44)	5.64 (3.15)	6.07 (2.76)
Vitamin D	2.01 (2.43)	3.23 (3.70)	3.67 (4.04)	3.86 (3.33)	2.73 (2.91)	3.51 (3.18)
MSU	2.83 (1.72)	3.11 (2.28)	3.43 (3.41)	3.20 (3.19)	2.15 (1.09)	2.28 (1.25)
UCE	9.07 (3.50)	11.76 (5.11)	9.70 (4.60)	10.59 (5.65)	11.55 (3.99)	11.58 (3.80)
Imaging						
X-ray	0.14 (0.18)	0.24 (0.24)	0.13 (0.18)	0.11 (0.17)	0.16 (0.12)	0.19 (0.19)
CT scan	0.16 (0.17)	0.27 (0.25)	0.15 (0.19)	0.26 (0.29)	0.19 (0.22)	0.22 (0.23)

APPENDIX G: SELECTED INDIRECT COST SAVINGS

Table G1. Selected list of additional indirect cost savings

Category	Association	Cost
Cancer	CT scans are associated with an absolute excess incidence rate of 9.38 per 100,000 person-years at risk in Australian children and adolescents[4]	$33,944 healthcare cost during the first year after diagnosis in 2013[5]
Diabetes	Inhaled corticosteroids are associated with an increased rate of diabetes, adjusted rate ratios ranged from 1.18 for low doses to 1.64 for high doses[6]	Annual healthcare cost for type 2 diabetes ranges from $4,025 (without complications) up to $9,645 (with complications) in 2001/2002[7]
Cataracts	Inhaled corticosteroids are associated with an increased risk of cataracts of approx. 25% for each 1,000 mcg per daily dose[8]	Cataract hospitalisations typically cost $3,030 in 2018/19[9]
Osteoporosis	Inhaled corticosteroids at high doses are associated with osteoporosis and osteopenia[10]	Annual direct healthcare costs are $545.42 per person with osteoporosis or osteopenia over the age of 50 years in 2017[11]
Falls/hip fractures	Benzodiazepines increase the risk of hip fracture by 2.55 times in those older than 65 years[12]	Hip fracture hospitalisations typically cost between $4,981 and $11,803 in 2018/19[13]

[4] Mathews JD, Forsythe AV, Brady Z, Butler MW, Goergen SK, Byrnes GB et al. Cancer risk in 680 000 people exposed to computed tomography scans in childhood or adolescence: Data linkage study of 11 million Australians BMJ. 2013;346:f2360.
[5] Goldsbury DE, Yap S, Weber MF, Veerman L, Rankin N, Banks E et al. Health services costs for cancer care in Australia: Estimates from the 45 and Up Study. PloS One. 2018;13(7):e0201552.
[6] Suissa S, Kezouh A, Ernst P. Inhaled corticosteroids and the risks of diabetes onset and progression. The American Journal of Medicine. 2010;123(11):1001-6.
[7] Colagiuri S, Colagiuri R, Conway B, Davey P, Grainger D. DiabCo$t Australia: Assessing the burden of Type 2 diabetes in Australia. Canberra: Diabetes Australia; 2003.
[8] Weatherall M, Jennifer C, James K, Perrin K, Shirtcliffe P, Beasley R. Dose–response relationship of inhaled corticosteroids and cataracts: A systematic review and meta-analysis. Respirology. 2009;14(7):983-90.
[9] Independent Hospital Pricing Authority. AR-DRG Lens Procedures C16Z. National Hospital Cost Data Collection Report: Public Sector, Round 23 (Financial Year 2018-19). 2021; Sydney.
[10] Chee C, Sellahewa L, Pappachan JM. Inhaled corticosteroids and bone health. Open Respir Med J. 2014;8:85-92.
[11] Watts J, Abimanyi-Ochom J, Sanders K. Osteoporosis costing all Australians. A new burden of disease analysis - 2012-2022. Sydney: Osteoporosis Australia; 2013.
[12] Finkle WD, Der JS, Greenland S, Adams JL, Ridgeway G, Blaschke T et al. Risk of fractures requiring hospitalization after an initial prescription for zolpidem, alprazolam, lorazepam, or diazepam in older adults. J Am Geriatr Soc. 2011;59(10):1883-1890.
[13] Independent Hospital Pricing Authority. AR-DRG Fractures of Neck of Femur, Minor Complexity (I78B) or Fractures of Neck of Femur, Major Complexity (I78A). National Hospital Cost Data Collection Report: Public Sector, Round 23 (Financial Year 2018-19). 2021; Sydney.

Falls/hip fractures	Opioids increase the risk of falls, fall injuries, and fractures (effect size between 0.15 and 0.71) among older persons[14]	Hip fracture hospitalisations typically cost between $4,981 and $11,803 in 2018/19[15]
Falls/hip fractures	PPI use is significantly associated with an increased risk of hip fracture development[16]	Hip fracture hospitalisations typically cost between $4,981 and $11,803 in 2018/19[17]

[14] Yoshikawa A, Ramirez G, Smith ML, Foster M, Nabil AK, Jani SN et al. Opioid Use and the Risk of Falls, Fall Injuries and Fractures among Older Adults: A Systematic Review and Meta-Analysis. The Journals of Gerontology: Series A. 2020;75(10):1989-1995.
[15] Independent Hospital Pricing Authority. op. cite.
[16] Thong BKS, Ima-Nirwana S, Chin KY. Proton pump inhibitors and fracture risk: A review of current evidence and mechanisms involved. Int J Environ Res Public Health. 2019;16:1571.
[17] Independent Hospital Pricing Authority. op. cite.

APPENDIX H: TABLES FROM QUIZ RESULTS

Table H1. Quiz respondent demographics and MHR responses

Characteristic	**Baseline**, N = 60[1]	**End**, N = 37[1]
Sex		
Male	38 (64%)	25 (69%)
Female	21 (36%)	11 (31%)
Unknown	1	1
Age in years	49 (41, 60)	51 (40, 60)
Unknown	1	1
Education completed		
Complete	39 (65%)	37 (100%)
Not complete	21 (35%)	0 (0%)
Study arm		
Imaging	18 (30%)	14 (38%)
Pathology	20 (33%)	12 (32%)
Prescribing	22 (37%)	11 (30%)
MHR confidence		
1 - not confident	14 (23%)	0 (0%)
2	14 (23%)	0 (0%)
3	8 (13%)	4 (11%)
4	19 (32%)	20 (54%)
5 - extremely confident	5 (8.3%)	13 (35%)
MHR use		
0 times	16 (27%)	0 (0%)
1-10 times	32 (53%)	16 (43%)
11-20 times	7 (12%)	13 (35%)
21-30 times	4 (6.7%)	5 (14%)
31+ times	1 (1.7%)	3 (8.1%)
Appropriate MHR record		
Event Summary	5 (8.3%)	3 (8.1%)
Medicines View Summary	20 (33%)	11 (30%)
Shared Health Summary	35 (58%)	23 (62%)

[1] n (%); Median (IQR)

Table H2. Deprescribing quiz summary results

Characteristic	Prescribing arm		Pathology arm		Imaging arm	
	Baseline, N = 22[1]	**End**, N = 11[1]	**Baseline**, N = 20[1]	**End**, N = 12[1]	**Baseline**, N = 18[1]	**End**, N = 14[1]
Deprescribing confidence						
1 - not confident, no formal approach	2 (9.1%)	0 (0%)	0 (0%)	0 (0%)	1 (5.6%)	0 (0%)
2	4 (18%)	0 (0%)	4 (20%)	0 (0%)	1 (5.6%)	0 (0%)
3	10 (45%)	1 (9.1%)	9 (45%)	4 (33%)	9 (50%)	5 (36%)
4	5 (23%)	7 (64%)	5 (25%)	6 (50%)	7 (39%)	6 (43%)
5 - extremely confident	1 (4.5%)	3 (27%)	2 (10%)	2 (17%)	0 (0%)	3 (21%)
Deprescribing discussions						
0 times	0 (0%)	0 (0%)	1 (5.0%)	0 (0%)	1 (5.6%)	0 (0%)
1-5 times	10 (45%)	0 (0%)	6 (30%)	3 (25%)	5 (28%)	2 (14%)
6-10 times	8 (36%)	5 (45%)	8 (40%)	3 (25%)	7 (39%)	7 (50%)
11-15 times	2 (9.1%)	3 (27%)	4 (20%)	3 (25%)	3 (17%)	3 (21%)
16+ times	2 (9.1%)	3 (27%)	1 (5.0%)	3 (25%)	2 (11%)	2 (14%)
Deprescribing frequency						
0 times	2 (9.1%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
1-5 times	8 (36%)	2 (18%)	11 (55%)	2 (17%)	7 (39%)	3 (21%)
6-10 times	7 (32%)	5 (45%)	4 (20%)	7 (58%)	4 (22%)	6 (43%)
11-15 times	3 (14%)	3 (27%)	2 (10%)	0 (0%)	5 (28%)	2 (14%)
16+ times	2 (9.1%)	1 (9.1%)	3 (15%)	3 (25%)	2 (11%)	3 (21%)
Has deprescribing approach	12 (55%)	8 (73%)	5 (25%)	9 (75%)	8 (44%)	7 (50%)
Estimate of all scripts inappropriate						
Up to 10%	5 (23%)	1 (9.1%)	5 (25%)	2 (17%)	2 (11%)	0 (0%)
Up to 25%	4 (18%)	2 (18%)	6 (30%)	3 (25%)	7 (39%)	3 (21%)
Up to 40%	8 (36%)	4 (36%)	5 (25%)	4 (33%)	4 (22%)	4 (29%)
Up to 60%	5 (23%)	3 (27%)	3 (15%)	1 (8.3%)	4 (22%)	5 (36%)
Up to 75%	0 (0%)	1 (9.1%)	1 (5.0%)	2 (17%)	1 (5.6%)	2 (14%)
Appropriate MHR record						
Event Summary	3 (14%)	1 (9.1%)	1 (5.0%)	1 (8.3%)	1 (5.6%)	1 (7.1%)
Medicines View Summary	7 (32%)	5 (45%)	6 (30%)	2 (17%)	7 (39%)	4 (29%)
Shared Health Summary	12 (55%)	5 (45%)	13 (65%)	9 (75%)	10 (56%)	9 (64%)
Drugs with evidence for deprescribing						
BZD	1 (4.5%)	0 (0%)	1 (5.0%)	0 (0%)	1 (5.6%)	0 (0%)
BZD, Opiates	5 (23%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Opiates	0 (0%)	0 (0%)	1 (5.0%)	0 (0%)	1 (5.6%)	0 (0%)
PPIs	0 (0%)	0 (0%)	1 (5.0%)	0 (0%)	1 (5.6%)	0 (0%)
PPIs, BZD	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (5.6%)	0 (0%)
PPIs, BZD, Opiates	7 (32%)	2 (18%)	4 (20%)	3 (25%)	5 (28%)	6 (43%)
PPIs, ICS, BZD, Opiates	9 (41%)	9 (82%)	13 (65%)	9 (75%)	9 (50%)	8 (57%)
Education completed						
Complete	12 (55%)	11 (100%)	14 (70%)	12 (100%)	13 (72%)	14 (100%)
Not complete	10 (45%)	0 (0%)	6 (30%)	0 (0%)	5 (28%)	0 (0%)

[1] n (%)

Table H3. Pathology quiz summary results

Characteristic	Prescribing arm		Pathology arm		Imaging arm	
	Baseline N = 21[1]	**End** N = 6[1]	**Baseline** N = 16[1]	**End** N = 9[1]	**Baseline** N = 18[1]	**End** N = 11[1]
Confidence in evidence-based pathology ordering						
1 - not confident	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
2	3 (14%)	1 (17%)	2 (12%)	0 (0%)	2 (11%)	0 (0%)
3	9 (43%)	3 (50%)	7 (44%)	1 (11%)	8 (44%)	4 (36%)
4	8 (38%)	2 (33%)	7 (44%)	6 (67%)	8 (44%)	6 (55%)
5 - extremely confident	1 (4.8%)	0 (0%)	0 (0%)	2 (22%)	0 (0%)	1 (9.1%)
Pathology review frequency						
0 times	6 (29%)	3 (50%)	2 (12%)	0 (0%)	1 (5.6%)	1 (9.1%)
1-5 times	8 (38%)	3 (50%)	9 (56%)	5 (56%)	10 (56%)	5 (45%)
6-10 times	5 (24%)	0 (0%)	2 (12%)	2 (22%)	5 (28%)	3 (27%)
11-15 times	2 (9.5%)	0 (0%)	2 (12%)	1 (11%)	1 (5.6%)	1 (9.1%)
16+ times	0 (0%)	0 (0%)	1 (6.2%)	1 (11%)	1 (5.6%)	1 (9.1%)
Pathology regimen change frequency						
0 times	1 (4.8%)	0 (0%)	0 (0%)	1 (11%)	0 (0%)	0 (0%)
1-5 times	6 (29%)	3 (50%)	5 (31%)	1 (11%)	6 (33%)	7 (64%)
6-10 times	10 (48%)	0 (0%)	1 (6.2%)	2 (22%)	7 (39%)	2 (18%)
11-15 times	0 (0%)	1 (17%)	4 (25%)	2 (22%)	1 (5.6%)	1 (9.1%)
16+ times	4 (19%)	2 (33%)	6 (38%)	3 (33%)	4 (22%)	1 (9.1%)
Aware of low value tests						
Aware	13 (62%)	6 (100%)	9 (56%)	9 (100%)	14 (78%)	10 (91%)
Not aware	8 (38%)	0 (0%)	7 (44%)	0 (0%)	4 (22%)	1 (9.1%)

[1] n (%)

Table H4. Imaging quiz summary results

Characteristic	Prescribing arm		Pathology arm		Imaging arm	
	Baseline N = 21[1]	End N = 6[1]	Baseline N = 16[1]	End N = 9[1]	Baseline N = 18[1]	End N = 11[1]
Confidence in evidence-based imaging						
1 - not confident	0 (0%)	1 (17%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
2	3 (14%)	0 (0%)	2 (12%)	3 (33%)	2 (11%)	0 (0%)
3	10 (48%)	1 (17%)	8 (50%)	3 (33%)	7 (39%)	3 (27%)
4	8 (38%)	4 (67%)	6 (38%)	2 (22%)	8 (44%)	5 (45%)
5 - extremely confident	0 (0%)	0 (0%)	0 (0%)	1 (11%)	1 (5.6%)	3 (27%)
Frequency guideline use in back pain imaging						
0 times	7 (33%)	2 (33%)	2 (12%)	4 (44%)	5 (28%)	0 (0%)
1-5 times	8 (38%)	3 (50%)	11 (69%)	3 (33%)	8 (44%)	5 (45%)
6-10 times	5 (24%)	0 (0%)	3 (19%)	1 (11%)	3 (17%)	3 (27%)
11-15 times	1 (4.8%)	1 (17%)	0 (0%)	0 (0%)	2 (11%)	3 (27%)
16+ times	0 (0%)	0 (0%)	0 (0%)	1 (11%)	0 (0%)	0 (0%)
Frequency discussed why not ordering imaging						
0 times	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
1-5 times	12 (57%)	1 (17%)	9 (56%)	2 (22%)	9 (50%)	3 (27%)
6-10 times	5 (24%)	3 (50%)	5 (31%)	6 (67%)	4 (22%)	2 (18%)
11-15 times	1 (4.8%)	1 (17%)	1 (6.2%)	0 (0%)	2 (11%)	4 (36%)
16+ times	3 (14%)	1 (17%)	1 (6.2%)	1 (11%)	3 (17%)	2 (18%)

[1] n (%)

Table H5. MHR models

Characteristic	Logistic regression for MHR confidence			Logistic regression for MHR use		
	log(OR)[1]	95% CI[1]	p-value	log(OR)[1]	95% CI[1]	p-value
Time						
Post vs. pre	2.1	1.2, 2.9	<0.001	1.6	0.84, 2.4	<0.001

[1] OR = Odds Ratio, CI = Confidence Interval

Table H6. Deprescribing models

Variable	Logistic regression for deprescribing confidence			Logistic regression for deprescribing frequency			Logistic regression for deprescribing approach		
	log(OR)[1]	95% CI[1]	p-value	log(OR)[1]	95% CI[1]	p-value	log(OR)[1]	95% CI[1]	p-value
Time									
Post vs. pre	1.8	0.51, 3.1	0.006	0.35	-0.62, 1.3	0.5	0.25	-0.88, 1.4	0.7
Study arm									
Imaging	—	—		—	—		—	—	
Pathology	-0.15	-1.8, 1.6	0.9	-0.43	-1.7, 0.83	0.5	0.08	-1.3, 1.4	>0.9
Prescribing	-0.27	-2.0, 1.5	0.8	-0.52	-1.8, 0.76	0.4	0.72	-0.59, 2.0	0.3
Time * Study arm									
Post * Pathology	-0.45	-2.1, 1.2	0.6	0.37	-1.0, 1.8	0.6	1.6	-0.18, 3.4	0.078
Post * Prescribing	0.83	-0.79, 2.4	0.3	0.23	-1.2, 1.6	0.7	0.39	-1.3, 2.1	0.6

[1] OR = Odds Ratio, CI = Confidence Interval

Table H7. Pathology regression models

Characteristic	Logistic regression for pathology confidence			Logistic regression for pathology review frequency			Logistic regression for pathology change frequency		
	log(OR)[1]	95% CI[1]	p-value	log(OR)[1]	95% CI[1]	p-value	log(OR)[1]	95% CI[1]	p-value
Time									
Post vs. pre	0.76	-0.34, 1.9	0.2	1.3	1.3, 1.3	<0.001	-0.74	-1.9, 0.40	0.2
Study arm									
Imaging	—	—		—	—		—	—	
Pathology	0.76	-0.52, 2.0	0.2	4.7	-0.29, 9.6	0.065	1.3	-0.38, 3.1	0.13
Prescribing	-0.87	-2.2, 0.47	0.2	-9.4	-9.4, -9.4	<0.001	0.06	-1.8, 1.9	>0.9
Time * Study arm									
Post * Pathology	1.1	-0.59, 2.8	0.2	5.8	2.8, 8.9	<0.001	0.67	-1.1, 2.5	0.5
Post * Prescribing	-1.2	-3.0, 0.62	0.2	-12	-12, -12	<0.001	0.78	-1.1, 2.7	0.4

[1] OR = Odds Ratio, CI = Confidence Interval

Table H8. Imaging regression models

Characteristic	Logistic regression for imaging confidence			Logistic regression for guideline use			Logistic regression for discussed not imaging		
	log(OR)[1]	95% CI[1]	p-value	log(OR)[1]	95% CI[1]	p-value	log(OR)[1]	95% CI[1]	p-value
Time									
Post vs. pre	3.6	3.6, 3.6	<0.001	1.1	0.00, 2.1	0.049	0.74	-0.40, 1.9	0.2
Study arm									
Imaging	—	—		—	—		—	—	
Pathology	-5.5	-8.3, -2.7	<0.001	-1.1	-2.4, 0.18	0.091	-0.79	-2.4, 0.78	0.3
Prescribing	-6.5	-6.5, -6.5	<0.001	-1.0	-2.4, 0.30	0.13	-0.48	-2.1, 1.1	0.6
Time * Study arm									
Post * Pathology	-3.2	-5.2, -1.2	0.001	-1.6	-3.2, 0.08	0.063	0.17	-1.6, 1.9	0.8
Post * Prescribing	-5.2	-5.2, -5.2	<0.001	-1.1	-2.8, 0.61	0.2	0.13	-1.7, 1.9	0.9

[1] OR = Odds Ratio, CI = Confidence Interval

APPENDIX I: PARTICIPANT PERCEPTIONS OF THE EDUCATION INTERVENTION FORMAT

ENABLERS
Webinars and online learning modules were thought to be flexible, convenient and accessible
I found that because it is actually quite informative I sometimes do go back, when I was going through the assignments and going through the slides on the Medcast, the website, to go through some of the things that they had text for, but I can sit down and look at the slides again… I did spend some time reading through the slides trying to get more out of it…It's good that it is uploaded, so actually you can go back and just the people or for other doctors who could not attend that webinar, they can still go back and actually watch through the video as well. (GP8 post, prescribing, male)
Satisfaction with the content of the webinars
I really liked the webinars. I found that they were useful for me as in reinforcing some things I knew, both teaching me things I didn't know. And then there was a discussion; some of the other participants mentioned their cases. So there was good discussion as well, which I found handy. (GP19 post, pathology, female) *Really, really enjoyed them [webinars]. Just simply, as I said, because of learning. Learning educationally, so it wasn't just about the health record, it was the reminding myself about what medications, what the potential side effects of medications were, and the interactions. They'd obviously done an awful lot of research on the case that was being presented; so very good. (GP12 post, prescribing, female)*
Satisfaction with the interactive format of the webinars and online discussions
It was really nice to hear other GPs input and that interaction was quite nice and going through those cases or other people's submitted cases, they were quite helpful, just to see different scenarios where it can be helpful. So that was nice. (GP14 post, pathology, female) *And I think the interactive format's a helpful thing and it, I guess, motivates – the participants to actually think a bit more thoroughly about what's going on, rather than just passively listening. It was a new thing to me, but I was able to do it and found that helpful. (GP16 post, imaging, female)* *Being isolated out here, my nearest centre is an hour and a quarter away, an hour and a half. So it's a delight to be able to interact on the screen. (GP11 post, pathology, male)*
The audit activity was helpful in facilitating discussion and translation into clinical practice
I think that without that activity, everything is very abstract, but having to do that activity, it makes you think, okay, how could I have – this patient that I'm seeing right now, how can I put what I've just learnt into action? (GP14 post, pathology, female) *I thought it was good bringing a case and talking about your case and that kind of thing 'cause it made you, even if you forgot to engage with the My Health Record study in your day-to-day practice, you then kind of had to because there was a form that you needed to fill out and you needed to submit it. (GP7 post, imaging, female)*
Desire for further access to the education
I was in the prescribing arm. There is the other arm that's the pathology arm, I think. Do we have access to the pathology webinars in that arm? I know that you can't be a part of the trial. That's fine. But just for knowledge sake, it would be nice if we could actually access the webinars. (GP23 post, prescribing, female) *Do you mind if I ask, just because I've got a few other GPs in the practice, I did mention it to them that I found it helpful, but is it still running? Like, can I still get other GPs in the practice to do the course? (GP14 post, pathology, female)*
Satisfaction with the amount of time allocated to the education
I actually really liked the way the second two webinars were only 45 minutes and they were a bit later in the evening. (GP21 post, pathology, female)

I thought it was a really good comprehensive program, and so I thought having that many CPD points attached to it was really useful and I thought it was worth the number of points that were allocated for it. (GP21 post, pathology, female)
Desire for further access to the education
I was in the prescribing arm. There is the other arm that's the pathology arm, I think. Do we have access to the pathology webinars in that arm? I know that you can't be a part of the trial. That's fine. But just for knowledge sake, it would be nice if we could actually access the webinars. (GP23 post, prescribing, female) *Do you mind if I ask, just because I've got a few other GPs in the practice, I did mention it to them that I found it helpful, but is it still running? Like, can I still get other GPs in the practice to do the course? (GP14 post, pathology, female)*
BARRIERS
Time was an issue, due to busyness especially during Covid, webinars scheduled in the school holidays and different time zones across Australia
I'm working at different time, I'm working in multiple clinics. Currently I'm working seven days…it's too hard with the time. And because it's crazy busy compared with before. (GP13 post, prescribing, male) *Unfortunately it [webinar] was scheduled right in the middle of school holidays so, I guess, that was one bit of feedback. That for GPs with families, the timing of that wasn't great. (GP16 post, imaging, female)* *I think the barrier that we have is our time difference…in Western Australia, I just can't take that length of time off work to do it live, and it's so much better live really I think, because then you get the interaction rather than the recorded versions of these things. (GP12 post, prescribing, female)*
Some participants felt a longer period of time was needed for the audit activity
I think the timeframes are all a bit short for an audit to really show much in the way of changes and I suppose it depends on having patients who are relevant to that task presenting in that period of time. It's good to reflect, and I suppose that's what we were doing in a way…so it wasn't a waste of time, but I find the timeframes a bit arbitrary and not as useful. (GP6 post, prescribing, female)
Challenges navigating the education program
I found that a bit clunky to use. It was a platform I wasn't familiar with, but I did find – it wasn't straight forward and I had to think it bit harder about things, and had to ask a few questions to the support team, to make sure I'd done things properly. Especially when it came to making sure I'd done everything, I did find the format really confusing. (GP16 post, imaging, female) *I also find the Medcast program, I find it really hard to navigate. (GP3 post, pathology, male)*
Online meeting challenges
When they were asked for feedback and things, there wasn't much people going – saying much. I suppose you'd have to be familiar with the Zoom meetings, and I think that first one probably was my first. And I did try and write some things in, only a couple of times. They were asking questions, and so they wanted everyone's answers. I don't think my answers got through, so I may have pressed the wrong button. (GP4 post, prescribing, male)
Challenges with uploading activities
There was an issue uploading the case. It didn't seem to work very well. So I had do it a different way, that's all. So you click on the upload button, it didn't work. So I had to do it a different way. (GP10 post, imaging, male) *I think when I had to upload something it took me a little while just to work out how to do that. I'm not the most IT savvy of people so it took me a while to work out how to actually put in the document and then upload it into the program. It just didn't seem, it just involved a couple of steps, I think filling the document in and then, I can't remember what I had to do, but save it and then upload it. So that was a bit more complicated and a bit annoying. (GP21 post, pathology, female)*

You would go to do something and then you need to upload, you weren't sure whether it's uploaded or not uploaded. It doesn't really tell you where you are at, and which one is the critical one's that you've got to do. Because there was one that's – I think either the first one where it says you need to upload your case studies, and I wasn't – I thought, oh do I need to do that. It's after someone has done it, and they say, oh it's uploaded something, how come I never did it. And so I went back and did it, so I completed it, but it was afterwards. (GP3 post, pathology, male)

There was one particularly frustrating one, I can't remember what it was titled but there were your cases in which we had to answer questions about each of the medications we'd been – and we had to type in potentially several sentence answers. That was my plan. When you hit the Enter button, rather than just going to a new line, it actually submitted your question and you couldn't go back. And even after I'd done it a couple of times. I did it two or three times. Actually I had a lot more to say. That was frustrating, yeah, and I mean, I was concerned that I was – I hadn't even answered half of what had been asked of us so in terms of not having done enough… that was annoying. (GP22 post, prescribing, male)

I'm a bit computer illiterate. So I had a bit of wading through finding ways to upload things, but got there. (GP11 post, pathology, male)

Challenges in communication

One of the things, when I was submitting the cases, I think because it wasn't very clear. I needed to contact them about the cases for some reason, and I found that a little bit cumbersome because I got an email back saying, you've sent this to my personal, not personal, but this email, but it should have been sent to the course emailer or whatever, because I'm not checking all the time or whatever. And so just to have that bit of information clearer I guess. (GP14 post, pathology, female)

More content/ different content was expected

I was hoping there would be more on the actual My Health Record, how to – well the setting itself took me a while. I had to play around with the configuration, there wasn't much presentation on that… so the instruction of how to set it up, how to link it what to click at to look at which view? Which tab because informatics are pretty complicated to compare, and sometimes its glitches or technical errors. (GP17 post, pathology, male)

One was more sort of an instructional bit about how to use the My Health Record side of things. I didn't find that that helpful to be honest. I guess because there are different EMRs, electronic medical softwares and things like that. The conversation felt very abstract in terms of – there is a thing called My Health Record. It's supposed to have this information but there wasn't very much hands on, this is how you actually – this is the functionality of it, this is what you can do with it, if that sort of makes sense. (GP14 post, pathology, female)

… the content, I think they're okay. They're not very new content, having just sat the exam last year. I think all the stuff that he's talking about, or the major presentations are very probably not entirely new. It's just a ready reminder for some known reflex actions that GPs do, it's such a big profession. (GP17 post, pathology, male)

Suggested improvements with communication and using online technology

The information was there but you had to wade through to find it. It would be useful to have the link to the website on all the emails, well not all of them, as a way in to help them. All those little things - it's nice to make it as simple as possible. Some of it is not so intuitive, the online stuff. (GP22 post, prescribing, male)

With regard to the webinars and stuff, I think we got an email at the very start of the whole program when things were happening and then I'd have to try and find that email to get into the webinar. It would have been nice to have like a reminder the day before or on the day or whatever with the link or whatnot to be able to go into it. (GP14 post, pathology, female)

I think everyone's gotten au fait with Zoom by now, but ask the question, whether everyone is confident before they start the course. And how about have a little link to some examples of what you might be expected to do, and have a little video for anyone who isn't confident. (GP4 post, prescribing, male)

I think it would have been good at the beginning and I think they actually did at the beginning of the second one, just at the very beginning to say there is a chat box and either have it set automatically that was viewable to everybody, or just point out that – because I guess there were some admin things that people were asking about.

But to point out that if you wanted to make a comment to the group, that you needed to select that it was visible to participants and facilitators. (GP21 post, pathology, female) *it will be perfect if it was just user specific, so that I logged in, and every tab was only relevant for me in my particular way…I guess they might come back and say, please make sure this needs to be submitted before August 2019, or whatever. Something like that, no, wait, that's not my date, my deadline. So there was those little things, wait a second, which stream am I at? Which one is my deadline? (GP25 post, prescribing, male)*
Suggestions for improvement of content
The unit modules were quite brief actually. That could have been padded out further. I would have liked to have seen what test we should be ordering. Should we be ordering other things like a complement? It would be interesting to know that I could click on something say, Dr [name] you haven't ordered a beta HCG for years. What's going on?" What sort of things my colleagues are ordering? For an example a good example is a lipase. Does anybody order an amylase anymore? That would just expand the education a bit. (GP11 post, pathology, male) *If I was to think about it from a practical point of view, it would be nice to say enroll people with – depending on which EMR they use, for instance if they use Best Practice. Then to go through this is the My Health Record but this is actually, on Best Practice, this is how you get into My Health Record. These are the sort of tabs that you can go into, to look for the various results or to find the bits of information that you need to – that you were looking for or this is how you would actually upload an event summary or a health summary or whatever, the really nuts and bolts practical how to use it. And because the groups that we had, like there were some questions but they weren't like – it's on your EMR but because your EMR is different to everyone else's, we can't really say anything about that. (GP14 post, pathology, female)* *It would be nice if the presenter used the actual Best Practice, the actually common software and teaching you how to activate it and troubleshoot and access it. There was a few slides on it on a slide, but that slide doesn't cover the trouble I had to even make it work, until say, half way through the course. So that component can be improved further by actually showing a user interface on My Health Record, using a common software…and troubleshoot how to actually link the patient file to My Health Record, and where to click to look at stuff but, as I said, instead of just jumping straight into the content because the technical side of things itself is a big barrier for doctors to even want to use it and this course should probably help educate a bit more on technical side of things, how to actually access the content because they're not very user friendly. (GP17 post, pathology, male)*