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# Effectiveness of a multifaceted intervention to improve emergency department care of low back pain: a stepped-wedge, cluster-randomised trial

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► Additional material is published online only. To view please visit the journal online (http://dx.doi.org/10.1136/bmjqs-2020-012337).

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Received 7 September 2020
Revised 26 January 2021
Accepted 4 February 2021
Published Online First 10 March 2021



**To cite:** Coombs DM, Machado GC, Richards B, *et al*. *BMJ Qual Saf* 2021;**30**:825–835.

## ABSTRACT

**Background** Overuse of lumbar imaging is common in the emergency department (ED). Few trials have examined interventions to address this. We evaluated the effectiveness of a multifaceted intervention to implement guideline recommendations for low back pain in the emergency department.

**Methods** We conducted a stepped-wedge, cluster-randomised trial in four EDs in New South Wales, Australia. After a 13-month control phase of usual care, the EDs received a multifaceted intervention to support guideline-endorsed care in a random order, based on a computer-generated random sequence, every 4 weeks over a 4-month period. All sites were followed up for at least 3 months. The primary outcome was the proportion of low back pain presentations receiving lumbar imaging. Secondary healthcare utilisation outcomes included prescriptions of opioid and non-opioid pain medicines, inpatient admissions, length of ED stay, specialist referrals and re-presentations. Clinician beliefs and knowledge about low back pain care were measured before and after the intervention. Patient-reported pain, disability, quality of life and satisfaction were measured at 1, 2 and 4 weeks post ED presentation.

**Results** A total of 269 ED clinicians and 4625 episodes of care for low back pain (4491 patients) were included. The data did not provide clear evidence that the intervention reduced lumbar imaging (OR 0.77; 95% CI 0.47 to 1.26; p=0.29). It did reduce opioid use (OR 0.57; 95% CI 0.38 to 0.85; p=0.006) and improved clinicians' beliefs (mean difference (MD), 2.85; 95% CI 1.85 to 3.85; p<0.001; on a scale from 9 to 45) and knowledge about low back pain care (MD, 0.48; 95% CI 0.13 to 0.83; p<0.01; on a scale from 0 to 11). There was no difference in pain scores at 1-week follow-up (MD, 0.04; 95% CI −1.00 to 1.08; p=0.94; on a scale from 0 to 10). A similar trend was observed for all other patient-reported outcomes and time points. This study found no effect on the other secondary healthcare utilisation outcomes.

**Conclusion** It is uncertain if a multifaceted intervention to implement guideline recommendations for low back pain care decreased lumbar imaging in the ED; however, it did reduce opioid prescriptions without adversely affecting patient outcomes.

**Trial registration number** ACTRN12617001160325.

## INTRODUCTION

The huge problem of low back pain has not yet been adequately addressed, as it continues to hold the lead for burden of disease globally.[1] It is also a leading reason for presentation to the emergency department in the United States, with over four million presentations per year.[2] Imaging, opioid medicines and hospital admissions are not recommended in guidelines for most cases of low back pain.[3] Only about 5% of patients with low back pain who present to emergency departments have serious spinal pathology requiring urgent medical care.[4] However, in the emergency department, about one-third of patients with low back pain are imaged,[5] two-thirds receive an opioid medicine[4 6] and up to one-third are admitted to hospital.[4 7]

These variations from best practice are wasteful of scarce health resources, lack evidence of benefits and can lead to patient harm.[8–10] Imaging in low back pain is costly, in most cases does not improve outcomes and may lead to unnecessary invasive treatments.[11 12] In some cases imaging can be considered iatrogenic and has been associated with increased disability in the future.[11] Opioids commenced in the emergency

department can be continued for prolonged periods[13] and contribute to the opioid crisis.[14] Admissions for low back pain are prevalent in Australia, with 664 per 100 000 population being admitted with low back pain in 2017–2018[15] even though hospital admissions incur significant economic cost and many patients could be adequately followed up as outpatients. The *Lancet* low back pain series outlined the urgent need for action to reduce these harmful practices for low back pain.[9] As the initial site of care and the hub of acute diagnostic and treatment modalities, the emergency department is well positioned to address these issues.

There have been a number of evidence-based guidelines and care models developed to improve care for low back pain worldwide.[3 16] At present, it is unclear if active implementation of these guidelines improves healthcare so that it better aligns with the evidence, without adversely affecting patient outcomes. In this trial, we aimed to test the effectiveness of a multifaceted intervention to implement a guideline-based model of care for low back pain in the emergency department, by reducing harmful practices, improving clinician knowledge and not adversely affecting patient outcomes.

## METHODS

### Study design and participants

The Sydney Health Partners Emergency Department (SHaPED) trial was an investigator-initiated, multicentre, pragmatic, stepped-wedge, cluster-randomised trial to evaluate the implementation of an evidence-based model of care for low back pain in emergency departments. [17] The SHaPED trial was coordinated by a steering committee and was funded by Sydney Health Partners and the New South Wales (NSW) Agency for Clinical Innovation. FlexEze Australia supplied the heat wraps used in the trial at no cost.

Sydney Local Health District hospitals and an affiliated rural hospital in NSW, Australia were eligible provided they had an emergency service and used the same electronic medical record system (Cerner PowerChart). These hospitals provide diversity with respect to patient ethnicity, demographic characteristics, hospital setting and clinical staffing models. We worked with local clinicians to develop a dashboard integrated into the electronic medical record system using Qlik Sense to quantitatively explore healthcare utilisation practices, such as lumbar imaging, pain medications and laboratory tests, and examine the problem locally. We used these data, as well as discussion with local clinicians, including rheumatologists, physiotherapists and emergency physicians, to determine whether active implementation of the model of care would be beneficial for quality improvement at each site. If so, the emergency department directors agreed to have their site participate in the study. Although these hospitals have a medical rotation programme for resident medical officers and registrars working in the emergency department, the trial's start date was planned to avoid contamination arising from rotation of medical staff during the intervention period. However, there may have been a small number of clinicians that worked at two sites simultaneously. After a 13-month control phase of usual care, each emergency department (cluster) randomly transitioned to the intervention phase every 4 weeks ('step') and were followed up for at least 3 months, for a total of 20 months (periods).

Participants were emergency department clinicians (physicians, nurses and physiotherapists) that manage patients with low back pain. The criteria to include low back pain presentations were age of 18 years or older with a diagnosis code of non-specific low back pain or radicular syndromes (ie, presentations that were given a diagnosis code associated with serious spinal conditions such as fracture, spinal infection, cauda equina syndrome, malignancy or trauma as a cause were excluded). We used all relevant diagnosis codes from the Systematized Nomenclature of Medicine-Clinical Terms-Australian Version-Emergency Department Reference Set to identify eligible low back pain presentations through the electronic medical records (diagnosis codes are described in online supplemental appendix 1).[18] If a patient re-presented within 48 hours, only the first presentation was included.

Emergency department clinicians and patients were invited to participate in this study and provided informed consent; electronic medical record data were analysed without individual patient consent in accordance with the Health Records and Information Privacy Act 2002 (NSW). The authors vouch for the accuracy and completeness of the data presented. We followed the Consolidated Standards of Reporting Trials extension for stepped-wedge, cluster-randomised trials[19] and published the trial protocol.[20]

### Randomisation and masking

In this trial, the hospital site was the unit of randomisation. We collected data retrospectively from 1 July 2017 to 30 June 2018, and prospectively from 1 July 2018 to 31 July 2018 for the control phase of usual care (periods 1–13). Then emergency departments crossed from the control phase to the intervention phase in a randomised order, with a new emergency department receiving the intervention every 4 weeks. The randomisation schedule, based on a computer-generated random sequence, was generated by a statistician blinded to the sites. This timing was concealed from clusters and site investigators until 2 months before the implementation date. It was not possible to blind the clinician participants, patients or investigators, but outcome measures were extracted from electronic medical records by the data provider of each hospital independently of the research team. The intervention phase began on 1 August 2018 and ended on 16 November 2018 (periods 14–17). The follow-up

phase ended on 17 February 2019 (periods 18–20). The core trial period was defined as periods 13–18 (ie, between 1 July 2018 and 16 December 2018).

### Procedure

The intervention was the implementation of the guideline-based NSW Agency for Clinical Innovation model of care for acute low back pain[16] using a multifaceted intervention strategy. The model of care was developed for primary care and the emergency department setting in collaboration with policymakers, clinicians, consumers and researchers and distils the high-quality evidence in this area to formulate key messages for practice. The key messages in the model are the following: (1) patients with non-serious low back pain do not require lumbar imaging; (2) where medicines are used, simple analgesics should be the first option; and (3) patients with non-serious low back pain should be managed as outpatients. The implementation intervention was guided by the Knowledge-to-Action framework[21] and incorporated evidence-based implementation strategies for targeting the behaviour of healthcare professionals.[22–25] We undertook barrier analyses, mapped locally developed treatment processes for low back pain, and met with local opinion leaders, key clinicians and patients to design an intervention to address identified barriers to uptake of recommendations in the model of care.

The multifaceted intervention was clinician-targeted. The clinicians included medical officers, nursing staff and physiotherapists that worked in the emergency departments. The intervention included five main components:

1. Education seminars: structured training from experienced rheumatologists and physiotherapists that focused on skills for assessing, managing, educating and referring patients according to the Agency for Clinical Innovation model of care for acute low back pain. These seminars were run on numerous occasions throughout the 4-week intervention period in protected teaching time, either in neighbouring teaching rooms or in the emergency department itself. Clinician participation in the education sessions was tracked through a logbook.
2. Educational materials: a hard copy of the model of care, a website and decision support tools for appropriate use of lumbar imaging and analgesic medicines were distributed to clinicians. Posters highlighting key messages about benefits and harms of lumbar imaging, opioid medicines and inpatient admission were displayed throughout the emergency departments and patient handouts were provided so that clinicians could use them to more easily educate patients.
3. Provision of non-opioid pain management strategies: non-opioid pain medicines and heat wraps were made more easily accessible to clinicians as an evidence-based alternative to opioid medicines.
4. Fast-track referral to outpatient services: clinicians were educated on referral pathways options to outpatient services such as specialist back clinics and physiotherapy follow-up.
5. Audit and feedback: clinicians were provided with structured real-time audit and feedback data on department-level imaging, opioid and inpatient admission rates through monthly email newsletters and real-time dashboard developed in Qlik Sense.

Further details on the intervention are provided in online supplemental appendix 2. Eligible low back pain presentations to the emergency departments during the control phase received care as usual.

### Outcomes

We measured the effects of the multifaceted intervention with respect to three outcome domains: healthcare utilisation, clinician-reported outcomes and patient-reported outcomes.

The primary healthcare utilisation outcome was the proportion of low back pain presentations referred for any lumbar imaging in the emergency department. Secondary healthcare utilisation outcomes were advanced lumbar imaging (ie, CT or MRI), prescription of any opioid medicine, prescription of any strong opioid medicine (ie, buprenorphine, fentanyl, hydromorphone, morphine, oxycodone, pethidine or tapentadol), prescription of any non-opioid pain medicine, length of emergency department stay, consultation by a specialist in the emergency department, admission to hospital ward, admission to short stay unit and re-presentation to the emergency department within 48 hours. In the published protocol,[20] we grouped pain medicines according to the Anatomical Therapeutic Chemical classification (ie, paracetamol, non-steroidal anti-inflammatory drugs, muscle relaxants, opioids and neuropathic pain medicines). In the statistical analysis plan,[26] however, opioid medicines were analysed separately and non-opioid pain medicines were grouped to better reflect our aims stated in the protocol.[20] We were unable to measure readmissions to hospital within 28 days, although this was a prespecified secondary outcome in the published protocol.[20]

Clinician-reported outcomes were beliefs about low back pain measured using the Back Beliefs Questionnaire (scores range from 9 to 45, with higher scores indicating more positive beliefs),[27] and knowledge and attitudes about low back pain management using the Knowledge and Attitudes Questionnaire—a set of 11 questions of which the correct answers are based on current evidence and expert opinion, with higher scores indicating more accurate knowledge and positive attitudes.[28] A mean difference (MD) greater than 2 points in the Back Beliefs Questionnaire has been considered clinically important in a population-based study,[29] but the equivalent difference for the Knowledge and Attitudes Questionnaire has not been established. These questionnaires and the scoring criteria are presented in online supplemental appendices 3 and 4.

Patient-reported outcomes were back pain intensity measured on a 0–10 Numeric Pain Rating Scale, with 0 indicating no pain and 10 the worst possible pain; disability as measured by PROMIS Physical Function-4a (scale range from 4 to 20, with higher scores indicating better function); quality of life as measured by PROMIS Global Health-item 1 (scale range from 1 to 5, with higher scores indicating better quality of life); and satisfaction with care as measured by the Emergency Department Patient Experiences with Care Survey-item 31 (scale range 0–10, with 0 indicating worst care possible and 10 the best care possible).[30]

Healthcare utilisation outcome data were extracted from each hospital's electronic medical record. At two sites where clinicians still used paper-based medication charts, pain medicine data were collected manually. Socioeconomic status was defined using patients' postcodes and the Socio-Economic Indexes for Areas, developed by the Australian Bureau of Statistics. Clinician-reported outcome data were collected by questionnaire before and after the intervention. We collected patient-reported outcome data using an automated text message and online survey system supplemented by telephone calls at 1, 2 and 4 weeks after emergency department discharge for patients who consented to participate during the core trial period (ie, periods 13–18).

### Statistical analysis

The statistical analysis plan was published in Open Science Framework Preprints after completion of the trial but prior to accessing the data.[26] We estimated that a total number of 1920 eligible low back pain presentations would provide the trial with 80% power to detect a 10% absolute difference for the primary outcome of lumbar imaging referrals (a difference in imaging frequency considered to be worth detecting), assuming an alpha of 0.05 and an intraclass correlation coefficient (ICC) of 0.1. Assuming an SD of 2.5 and an ICC of 0.05, 600 patients would provide 80% power to detect a non-inferiority difference of 1 point in back pain intensity on a 0–10 point scale (a difference in pain intensity deemed to be clinically important). The decision for a non-inferiority analysis of patient-reported outcomes (prespecified in the statistical analysis plan[26] but not in the published protocol[20]) was based on the rationale that implementation of the model of care should reduce the use of low-value care but not worsen health outcomes or satisfaction with care.

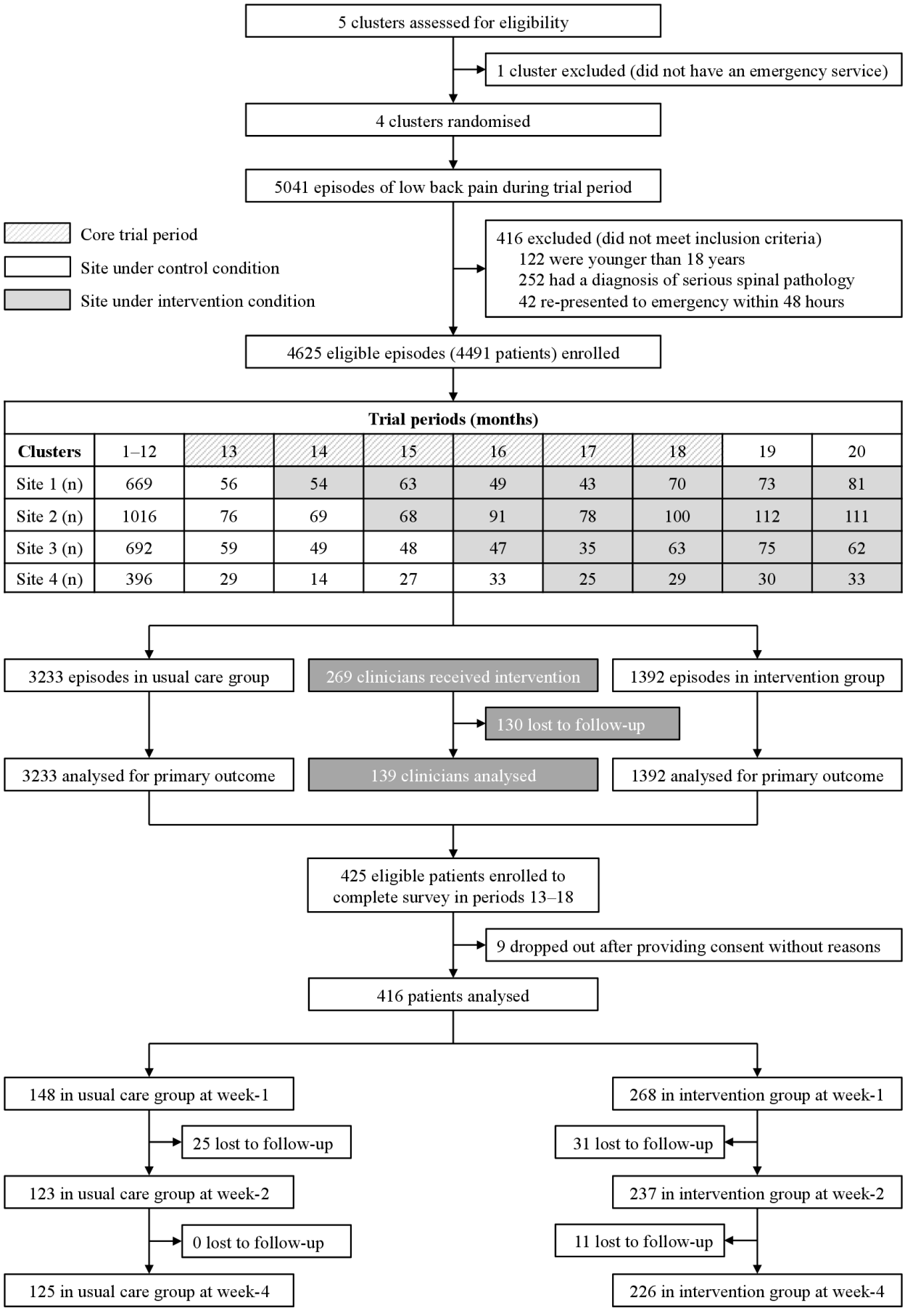
Data analyses were performed according to an intention-to-treat approach. All tests were two-sided with alpha set at 0.05. We conducted logistic (binary outcomes) and linear (continuous outcomes) regression analyses with a random effect for cluster (emergency department), a random effect for clinician nested within cluster, a fixed effect indicating the group assignment of each cluster at each step and a fixed effect of time. We investigated underlying temporal trends during the control phase (ie, periods 1–13) for all healthcare utilisation outcomes using visual inspection and by fitting a regression line to assess the significance of time slopes. Data collected during the intervention period were included in the intervention group, although we prespecified in the statistical analysis plan that these data would be excluded from the primary analysis.[26] Prespecified sensitivity analyses were conducted by adjusting the main model for potential confounders (age, gender, diagnosis, presenting day, mode of arrival and triage category) and by analysing data from the core trial period only (ie, periods 13–18). A prespecified subgroup analysis for the primary outcome was conducted by age, socioeconomic status, triage category, diagnosis and mode of arrival. A post-hoc sensitivity analysis for healthcare utilisation outcome data was conducted by omitting repeat visits to the emergency department by the same patient during the trial period (ie, analysis of 4491 unique patients). Post-hoc subgroup analyses were conducted by site and for any opioid prescribing. The effects of the intervention are presented as OR or MD with 95% CI. Analyses were conducted in SAS V.9.4 software. This trial was registered with the Australian New Zealand Clinical Trials Registry.

### Patient and public involvement

This study was completed with consumer involvement in study design, specifically with the patient-reported outcome measures. A consumer advisory group from the Australia & New Zealand Musculoskeletal Clinical Trials Network reviewed the protocol and gave feedback on the content of the intervention, the types of patient-reported outcome measures and time points for collecting the outcomes. Patients or the public were not invited to contribute to the writing or editing of this document for readability or accuracy.

## RESULTS

The trial profile is shown in figure 1. Four eligible emergency departments were randomised—one cluster did not have emergency services and was excluded. Between 1 August 2018 and 16 November 2018, all clinicians present in the participating emergency department during the multiple education session times that provided care for low back pain were invited to participate. This was estimated at 300 eligible emergency department clinicians. We estimated this retrospectively based on the number of individual clinicians that were recorded to have managed low back pain presentations during the intervention period. There were 269 clinicians enrolled in the trial. All 269 enrolled clinicians received the multifaceted intervention and completed the Back Beliefs Questionnaire and the Knowledge and Attitudes Questionnaire prior to receiving the intervention. The baseline characteristics of clinician participants are




| Trial periods (months) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Clusters** | 1–12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| Site 1 (n) | 669 | 56 | 54 | 63 | 49 | 43 | 70 | 73 | 81 |
| Site 2 (n) | 1016 | 76 | 69 | 68 | 91 | 78 | 100 | 112 | 111 |
| Site 3 (n) | 692 | 59 | 49 | 48 | 47 | 35 | 63 | 75 | 62 |
| Site 4 (n) | 396 | 29 | 14 | 27 | 33 | 25 | 29 | 30 | 33 |

**Figure 1** Study flowchart.

**Table 1** Baseline characteristics of clinicians

| | Clinicians (N=269) |
|---|---|
| Age, years | 34.5 (8.2) |
| Female sex | 160 (62.3) |
| Main profession | |
| Physician | 108 (40.6) |
| Nurse | 151 (56.8) |
| Other | 7 (2.6) |
| Country of professional training | |
| Australia | 212 (80.9) |
| Other | 50 (19.1) |
| Work in main profession, years | 8.6 (7.9) |
| Work in the emergency department, years | 5.8 (6.5) |
| Had postgraduate training in low back pain | 21 (8.1) |
| Number of patients with low back pain treated per week | 4.6 (4.7) |

Data are n (%) or mean (SD).
Data are missing for sex (12, 4.5%), main profession (3, 1.1%), country of professional training (7, 2.6%), and postgraduate training in low back pain (9, 3.3%).

shown in table 1. Only 139 clinicians completed the Back Beliefs Questionnaire and the Knowledge and Attitudes Questionnaire after the intervention period. The characteristics of the clinicians who completed the follow-up questionnaires (n=139) and clinicians who did not (n=130) were generally similar, with the exception of sex, main profession and mean number of patients seen per week. Female clinicians, nurses and those seeing more patients per week were more likely to complete the follow-up questionnaire (differences in clinicians' characteristics are described in online supplemental appendix 5).

Between 1 July 2017 and 17 February 2019, there were 5041 episodes of care for low back pain in the four emergency departments and 4625 eligible episodes (4491 unique patients) were included in the analysis of healthcare utilisation outcomes: 3233 in the usual care group and 1392 in the intervention group. Overall, the two groups were balanced with respect to baseline characteristics (table 2). The baseline characteristics of the low back pain presentations per emergency department are shown in online supplemental appendix 6. From 1 July 2018 to 16 December 2018 (ie, core trial periods 13–18), all patients who presented to the site emergency departments with diagnosis codes representing non-specific low back pain or radicular syndromes, who had mobile phone numbers (807 eligible patients), were invited to participate in the patient-reported outcome measure survey. A total of 425 patients consented to participate in the survey and were enrolled at week 1; 9 dropped out without reasons and 416 were included in the analysis of patient-reported outcomes. Of the 416 responders, 360 completed the follow-up survey at week 2 (86.5%) and 351 at week 4 (84.4%).

**Table 2** Baseline characteristics of low back pain presentations

| | Intervention (n=1392) | Control (n=3233) |
|---|---|---|
| Age, years | 53.4 (20.0) | 52.0 (20.3) |
| Female sex | 684 (49.1) | 1602 (49.6) |
| Primary diagnosis | | |
| Non-specific low back pain | 1249 (89.7) | 2909 (90.0) |
| Radicular low back pain | 143 (10.3) | 324 (10.0) |
| Socioeconomic status | | |
| SEIFA deciles 1–5 | 338 (25.6) | 1085 (35.3) |
| SEIFA deciles 6–10 | 980 (74.4) | 1988 (64.7) |
| Day of presentation | | |
| Weekday | 1008 (72.4) | 2316 (71.6) |
| Weekend | 384 (27.6) | 917 (28.4) |
| Hour of presentation | | |
| Working hours | 718 (51.6) | 1718 (53.1) |
| After hours | 674 (48.4) | 1515 (46.9) |
| Mode of arrival | | |
| Self-presented | 946 (68.1) | 2202 (68.1) |
| Ambulance | 434 (31.2) | 1018 (31.5) |
| Other | 10 (0.7) | 13 (0.4) |
| Triage category | | |
| 2 (emergency) | 31 (2.2) | 52 (1.6) |
| 3 (urgent) | 492 (35.3) | 1174 (36.3) |
| 4 (semiurgent) | 849 (61.0) | 1895 (58.6) |
| 5 (non-urgent) | 20 (1.4) | 112 (3.5) |
| Length of emergency stay, hours | 4.0 (2.8) | 4.1 (3.0) |

Data are n (%) or mean (SD).
Data are missing for socioeconomic status (234, 5.1%) and mode of arrival (2, 0.4%).
The primary diagnosis codes were categorised into non-specific back pain and radicular back pain. Lower numbers in socioeconomic status are more disadvantaged while higher numbers are less disadvantaged. Triage categories are based on the Australasian Triage Scale; there were no eligible low back pain presentations in triage category 1 (life-threatening).
SEIFA, Socio-Economic Indexes for Areas.

The regression analysis to assess the significance of time slopes revealed no underlying time trends in any healthcare utilisation outcome. This is represented in table 3 through the values listed for 'p for trend'. The results for the primary outcome of any lumbar imaging and other secondary healthcare utilisation outcomes are summarised in table 3. Our best estimate is that the intervention reduced the odds of lumbar imaging (OR=0.77), but the evidence is uncertain with a 95% CI of 0.47 to 1.26. The study found the intervention reduced the use of opioid medicines in the emergency department with an absolute reduction of 12.3%, from 62.8% to 50.5% of low back pain presentations (OR 0.57, 95% CI 0.38 to 0.85). The data did not provide clear evidence that the interventions had an effect on other secondary healthcare utilisation outcomes, including referrals for advanced lumbar imaging (OR 1.16, 95% CI 0.57 to 2.35), prescription of strong opioid medicines (OR 0.69,

**Table 3** Healthcare utilisation outcomes

| | ICC | P for trend | Intervention (n=1392) | Control (n=3233) | Effect of intervention (95% CI) | P value |
|---|---|---|---|---|---|---|
| Received any lumbar imaging | 0.016 | 0.744 | 327 (23.5) | 774 (23.9) | 0.77 (0.47 to 1.26) | 0.290 |
| Received advanced lumbar imaging | 0.002 | 0.281 | 157 (11.3) | 285 (8.8) | 1.16 (0.57 to 2.35) | 0.687 |
| Received any opioid medicine | 0.017 | 0.145 | 696 (50.5) | 1904 (62.8) | 0.57 (0.38 to 0.85) | 0.006 |
| Received any strong opioid medicine | 0.027 | 0.209 | 586 (42.5) | 1588 (52.4) | 0.69 (0.46 to 1.04) | 0.075 |
| Received non-opioid medicine | 0.003 | 0.106 | 992 (72.0) | 2095 (69.1) | 1.52 (0.98 to 2.35) | 0.063 |
| Admitted to hospital ward | 0.031 | 0.521 | 221 (15.9) | 498 (15.4) | 0.96 (0.54 to 1.71) | 0.887 |
| Admitted to short stay unit | 0.056 | 0.178 | 173 (12.4) | 382 (11.8) | 1.99 (0.91 to 4.37) | 0.086 |
| Consulted specialist in emergency | 0.037 | 0.995 | 52 (3.7) | 132 (4.1) | 2.50 (0.98 to 6.37) | 0.054 |
| Re-presented within 48 hours | 0.001 | 0.431 | 18 (1.3) | 38 (1.2) | 0.31 (0.06 to 1.57) | 0.159 |
| Length of emergency stay, hours | 0.012 | 0.333 | 4.05 (2.8) | 4.1 (3.0) | −0.28 (−0.84 to 0.28) | 0.332 |

Data are n (%) or mean (SD).
Data are missing for any opioid, strong opioid and non-opioid medicines (216, 4.8%).
The assessment of underlying temporal trends was conducted over the baseline control phase (periods 1–13) by fitting a regression line (logistic or linear) to assess the significance of time slopes. The effects of the intervention are presented as OR or MD and its 95% CI.
ICC, intraclass correlation coefficient.

95% CI 0.46 to 1.04), prescription of non-opioid pain medicines (OR 1.52, 95% CI 0.98 to 2.35), length of emergency department stay (MD −0.28, 95% CI −0.84 to 0.28), specialist consultations (OR 2.50, 95% CI 0.98 to 6.37), admission to hospital (OR 0.96, 95% CI 0.54 to 1.71), admission to short stay unit (OR 1.99, 95% CI 0.91 to 4.37) and re-presentation within 48 hours (OR 0.31, 95% CI 0.06 to 1.57).

The study showed that the intervention improved the accuracy of clinicians' beliefs and knowledge regarding low back pain and its management (table 4). After the intervention, the mean Back Beliefs Questionnaire score increased from 32.1 to 35.0 (MD 2.85, 95% CI 1.85 to 3.85) and the mean number of correct answers in the Knowledge and Attitudes Questionnaire also increased from 7.1 to 7.6 (MD 0.48, 95% CI 0.13 to 0.83). Patient-reported outcomes were not adversely affected by the intervention (table 5). At 1 week after emergency department discharge, there was no difference in pain intensity (MD 0.04, 95% CI −1.00 to 1.08), physical function (MD 0.96, 95% CI −0.92 to 2.83), quality of life (MD 0.17, 95% CI −0.25 to 0.58) or patient satisfaction with emergency care (MD 0.16, 95% CI −0.72 to 1.03) between the intervention and usual care groups. We observed similar results at 2 and 4 weeks following emergency department discharge (table 5).

The estimated effects of the intervention remained consistent in the prespecified sensitivity analyses (online supplemental appendices 7 and 8). Adjusting the main logistic regression model for potential confounders did not alter the effect of the intervention on the primary outcome of lumbar imaging referrals (OR 0.86, 95% CI 0.52 to 1.43) and continued to show significantly fewer opioid prescriptions after the intervention (OR 0.60, 95% CI 0.39 to 0.90), but revealed a significant increase in referrals for specialist consultations in the emergency department (OR 3.11, 95% CI 1.17 to 8.31) (online supplemental appendix 7). Restricting the analysis to the core trial period (ie, periods 13–18) also showed a reduction in opioid prescriptions in the emergency department (OR 0.61, 95% CI 0.39 to 0.97) and did not alter any other results (online supplemental appendix 8). A post-hoc sensitivity analysis omitting data from repeat visits by the same patient during the trial period (ie, analysis of 4491 unique patients) also showed similar results (see online supplemental appendix 9).

The prespecified subgroup analysis for the primary outcome of lumbar imaging referrals showed no interactions (online supplemental appendix 10). However, a post-hoc subgroup analysis revealed intervention-by-site interactions (p=0.0004) for use of any opioid in the emergency department (see online supplemental appendix 11). While the overall OR for use of any opioid was 0.57 (95% CI 0.38 to 0.85), the estimates at the four emergency departments were 0.46 (95% CI 0.30 to 0.73), 0.66 (95% CI 0.42 to 1.04), 0.40 (95% CI 0.24 to 0.66) and 1.09 (95% CI 0.61 to 1.93). The number and proportion of low back pain presentations

**Table 4** Clinician-reported outcomes

| | Intervention (n=139) | Control (n=139) | Mean difference (95% CI) | P value |
|---|---|---|---|---|
| BBQ score | 35.0 (5.9) | 32.1 (6.5) | 2.85 (1.85 to 3.85) | <0.001 |
| KAQ score | 7.6 (1.9) | 7.1 (1.9) | 0.48 (0.13 to 0.83) | 0.008 |

Data are mean (SD).
BBQ, Back Beliefs Questionnaire; KAQ, Knowledge and Attitudes Questionnaire.

**Table 5** Patient-reported outcomes

| | ICC | Intervention | Control | Mean difference (95% CI) | P value |
|---|---|---|---|---|---|
| Number of patients assessed (week 1) | | 268 | 148 | | |
| Pain intensity | 0.021 | 5.9 (2.7) | 6.0 (2.8) | 0.04 (−1.00 to 1.08) | 0.938 |
| Physical function | 0.016 | 11.4 (5.1) | 11.2 (5.0) | 0.96 (−0.92 to 2.83) | 0.316 |
| Quality of life | 0.006 | 2.9 (1.1) | 2.8 (1.2) | 0.17 (−0.25 to 0.58) | 0.427 |
| Satisfaction with care | 0.000 | 7.3 (2.5) | 7.0 (2.6) | 0.16 (−0.72 to 1.03) | 0.725 |
| Number of patients assessed (week 2) | | 237 | 123 | | |
| Pain intensity | 0.000 | 4.6 (2.8) | 4.3 (2.8) | −0.00 (−1.11 to 1.10) | 0.996 |
| Physical function | 0.025 | 12.8 (5.5) | 12.7 (5.3) | 1.00 (−1.26 to 3.25) | 0.385 |
| Quality of life | 0.006 | 2.9 (1.1) | 2.8 (1.1) | 0.24 (−0.20 to 0.69) | 0.281 |
| Number of patients assessed (week 4) | | 226 | 125 | | |
| Pain intensity | 0.008 | 3.7 (2.8) | 3.9 (3.0) | −0.12 (−1.25 to 1.01) | 0.833 |
| Physical function | 0.027 | 14.0 (5.4) | 13.9 (5.3) | 0.55 (−1.66 to 2.76) | 0.624 |
| Quality of life | 0.027 | 2.9 (1.1) | 2.9 (1.2) | 0.02 (−0.44 to 0.49) | 0.920 |

Data are mean (SD).
ICC, intraclass correlation coefficient.

receiving any lumbar imaging, any opioid medicine and admitted to hospital per period per emergency department are presented in online supplemental appendices 12, 13 and 14, respectively.

## DISCUSSION

### Statement of principal findings

This trial showed that there was no clear evidence that a multifaceted intervention targeting emergency department clinicians reduced rates of lumbar imaging. Similarly, there was no evidence of a reduction in prescriptions of non-opioid pain medicines, admissions, length of stay, specialist referrals and re-presentations. However, the data showed the intervention reduced use of opioids by 12.3% (from 62.8% to 50.5% of presentations) in the emergency department and improved the accuracy of clinicians' beliefs and knowledge. There were no adverse effects on patient-reported outcomes, such as pain and satisfaction with care despite the lower use of opioid medicines.

### Strengths and limitations of this study

This trial had several strengths. First, the use of routinely collected data extracted from the electronic medical record allowed us to efficiently collect healthcare data for 4625 episodes of care for low back pain and give timely clinical feedback of outcomes to the participating clinicians as part of the multifaceted intervention strategy. Second, we had negligible loss to follow-up in the healthcare and patient-reported outcomes, minimising the risk of bias. Finally, the use of a stepped-wedge, cluster-randomised design allowed us to pragmatically implement the care model across all sites and test the intervention in a real-world setting.

This trial had some limitations. SHaPED was conducted in four public hospital sites in NSW, Australia and so generalisability to other sites in Australia, including private hospital settings and other locations with different healthcare systems and cultures, is unclear. Further studies would be required to investigate if our results can be replicated in other settings. The limited number of sites and the short duration of the 'core trial period' also present limitations. Diagnostic coding is done by clinicians and hospital coders as part of standard practice. It is also possible that our intervention may not have long-term impact or may have a delayed impact, which highlights the need for investigation of more prolonged or ongoing strategies and measurement of longer-term outcomes. Another consideration is the lower imaging rates in the study hospitals when compared with imaging rates in the literature. There may not have been much room to move to allow for a reduction in imaging rates; however, without being able to judge the appropriateness of imaging, this remains unclear. We were also unable to track utilisation of the audit and feedback mechanisms. There may have been selection bias related to the clinicians who chose to participate in the intervention. Clinicians who participated in the education sessions and completed the follow-up surveys may be more likely to adhere to best practice and may be more interested in the topic. This may have impacted on the null primary outcome finding and the clinician-reported outcome results.

### Comparison with other studies

A systematic review on the effectiveness of interventions to reduce lumbar imaging in the emergency department has been published.[31] Five studies investigated the effects of implementation efforts to reduce lumbar imaging in the emergency department. The findings of these small studies suggested reduced referrals for specific imaging modalities, but they used non-randomised before-and-after study

designs associated with a high risk of bias. Before this study, the effect of a multifaceted strategy to implement contemporary guideline recommendations for low back pain in the emergency department has not been assessed within a randomised trial. Despite the success of previous before-and-after studies, our trial demonstrated no clear evidence that the implementation of an evidence-based model of care for low back pain reduced lumbar imaging referrals in the emergency department.

### Possible explanations and implications for clinicians, policymakers and future research

There may be several possible explanations for why we did not see change in imaging rates. One reason could be due to the limited alternatives to imaging offered by the intervention. Although the training emphasised the value of clinical assessment, rather than routine imaging in screening for serious spinal pathologies, there is evidence that patients' expectations, clinicians' concern for missing a serious pathology, fear of litigation, belief of minimal harm and time constraints contribute to overuse of lumbar imaging.[32] We developed a clinician website that provided decision support to clinicians during the trial; however, we were unable to implement a decision support system within the electronic medical record as part of the intervention. This may have also contributed to the result. Another reason could have been because we were measuring the utilisation of imaging and unable to assess the appropriateness of imaging. The preintervention imaging rates in the study sites (~25%) were also lower when compared with the average imaging rates in the literature (~35%),[5] which made reducing this further quite challenging. This may have made it difficult for clinicians to see a need for a change and therefore the audit and feedback mechanism may not have been as meaningful. Despite the lower baseline imaging rate, there were no previous efforts to attempt to reduce imaging at any of the sites, nor is lumbar imaging included in the Australasian College of Emergency Physicians Choosing Wisely recommendations.[33] In countries like Canada, where discouraging the use of lumbar imaging in atraumatic low back pain is included in the Canadian Association of Emergency Physicians Choosing Wisely recommendations,[34] emergency department imaging rates for non-serious low back pain are reported as low as 12%.[35] However, in the USA, a large national initiative to reduce avoidable imaging found no significant change in imaging rates for non-serious back pain.[36] It is evident that reducing imaging rates in low back pain is a complicated issue. Further studies assessing the appropriateness of imaging, implementing electronic medical record-based clinical decision tools and campaigns such as Choosing Wisely may be helpful in instilling behaviour change and reducing inappropriate lumbar imaging.

The trial's success in reducing emergency department use of opioid medicines can be explained by some subcomponents of the intervention. For example, we provided feasible, evidence-based alternatives such as non-opioid analgesics as first-line care and access to heat wrap therapy, making it easier for clinicians to change their prescribing behaviour. The audit and feedback showed a reduction in opioid prescription almost immediately, and this positive reinforcement may have contributed to the ongoing reduction in prescriptions. The high preintervention rate likely was another facilitator for change.

While we provided improved rapid access to outpatient services, this was not sufficient to reduce length of emergency department stay, re-presentations and admissions. Reasons for admissions for low back pain are often multifactorial. For example, severe pain may limit function and ability for patients to cope at home and patients who live alone may be fearful of being alone. Key performance indicators, such as restrictions put on emergency department length of stay, and competing clinical demands, such as critically ill patients, make it difficult for emergency department clinicians to adequately address these issues during the emergency department stay. Nonetheless, admissions rates vary around the world, and in some places it is less of a problem than others. For example, a Canadian study reported that only 2.5%[37] of patients with low back pain were being admitted from the emergency department, whereas an Australian study reported an admission rate of 34.1%.[7] Further research is required to not only fully understand reasons for admission, but also address the multiple factors contributing to high rates of admission.

We observed a difference in effects on use of opioid medicines between the sites in our post-hoc subgroup analysis, including no clear reduction in opioid use at the rural site. This suggests that local factors probably play a key role in enabling the success of the implementation of a model of care in the emergency department. However, the lack of influence of age, socioeconomic status, triage category, primary diagnosis or mode of arrival on the intervention's ability to reduce opioid use indicates that it is suitable for the broad range of patients with non-serious low back pain who present to the emergency department.

In this trial, there was no clear evidence that a multifaceted intervention to implement an evidence-based model of low back pain care in the emergency department reduced lumbar imaging referrals, but there was strong evidence that the intervention substantially reduced emergency department use of opioid medicines without adversely affecting patient outcomes and it also improved clinicians' beliefs and knowledge about low back pain care. While this trial

failed to show a definitive reduction in the rate of lumbar imaging (the trial's primary outcome), it did show important reductions in opioid prescribing in the emergency department and shows promise for addressing one aspect of the opioid crisis.

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**Correction notice** The licence to this article was updated to CC-BY-NC on the 09/09/2024.

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**Acknowledgements** We wish to thank all SHaPED trial investigators. FlexExe Australia supplied the heat wraps used in the trial at no cost. Qlik provided training and technical support in the development of the low back pain dashboard using Qlik Sense at no cost. The trial was sponsored by The University of Sydney (Sydney, Australia). We also acknowledge support from the Australia & New Zealand Musculoskeletal (ANZMUSC) Clinical Trials Network, NSW Agency for Clinical Innovation, NSW Emergency Care Institute and Sydney Local Health District. SHaPED investigators were entirely responsible for study design, conduct and data analysis.

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**Contributors** GM, BR, CN, RB, IAH, KH, KM, LB, JE, ER, RF and CM contributed to protocol development and design of the SHaPED trial. DC, GM, BR, CN and CM designed and delivered the SHaPED multifaceted intervention with input from JE, ER and RF. LB and QL led the statistical analysis with input from DC, GM, RB, IAH and CM. DC, GM, BR and CN were responsible for the conduct of the trial. GM and DC are the guarantors. All authors read and approved the final manuscript.

**Funding** This was an investigator-initiated study funded by Sydney Health Partners and the NSW Agency for Clinical Innovation. FlexEze™ Australia supplied the heat wraps used in the trial at no cost.

**Competing interests** GM, CM, RB and KM report grants from the Australian National Health and Medical Research Council during the conduct of this trial.

**Patient consent for publication** Not required.

**Ethics approval** The trial protocol was approved by the Sydney Local Health District Human Research Ethics Committee (protocol number X17-0043).

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** No data are available. Due to information governance restrictions imposed by organisations governing data access, we are unable to share the trial data unless applicants secure the relevant permissions.



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## Supplementary Appendix

**Supplement to: Effectiveness of a multifaceted intervention to improve emergency department care of low back pain: a stepped-wedge cluster-randomised trial**

**Content**





Coombs DM, *et al. BMJ Qual Saf* 2021;0:1–11. doi: 10.1136/bmjqs-2020-012337

**Appendix 1. SNOMED CT-AU (EDRS) codes and description**

| **Low back pain with non-specific cause** | **Codes** |
|---|---|
| Acute low back pain (finding) | 278862001 |
| Back pain complicating pregnancy (disorder) | 91957002 |
| Backache (finding) | 161891005 |
| Blunt injury to back (disorder) | 424270008 |
| Chronic back pain (finding) | 134407002 |
| Chronic low back pain (finding) | 278860009 |
| Coccyx sprain (disorder) | 209571002 |
| Complaining of low back pain (finding) | 161894002 |
| Degeneration of lumbar intervertebral disc (disorder) | 26538006 |
| Displacement of lumbar intervertebral disc without myelopathy (disorder) | 20021007 |
| Exacerbation of backache (finding) | 135860001 |
| Low back pain (finding) | 279039007 |
| Low back strain (disorder) | 300956001 |
| Lower back injury (disorder) | 282766005 |
| Lumbar spondylosis (disorder) | 239880009 |
| Lumbar sprain (disorder) | 209565008 |
| Mechanical low back pain (finding) | 279040009 |
| Pain in the coccyx (finding) | 34789001 |
| Sacral back pain (finding) | 61486003 |
| Spasm of back muscles (finding) | 203095000 |
| Sprain of ligament of lumbosacral joint (disorder) | 209548004 |
| Stiff back (finding) | 249921008 |
| Strain of back muscle (disorder) | 262965006 |
| Strain of tendon of back (disorder) | 262975009 |
| **Low back pain with neurological signs and symptoms** | |
| Acute back pain with sciatica (finding) | 247366003 |
| Acute sciatica (disorder) | 307176005 |
| Chronic sciatica (disorder) | 307177001 |
| Injury of lumbar nerve roots (disorder) | 24300005 |
| Injury of sciatic nerve (disorder) | 86269002 |
| Lumbago with sciatica (finding) | 202794004 |
| Lumbago-sciatica due to displacement of lumbar intervertebral disc (disorder) | 46960006 |
| Lumbar disc prolapse with radiculopathy (disorder) | 202735001 |
| Lumbar radiculopathy (disorder) | 128196005 |
| Sciatica (disorder) | 23056005 |
| Spinal stenosis of lumbar region (disorder) | 18347007 |
| **Low back pain due to serious pathology** | |
| Abscess of back (disorder) | 309083007 |
| Abscess of back, except buttock (disorder) | 19284003 |
| Cauda equina syndrome (disorder) | 192970008 |
| Closed fracture lumbar vertebra (disorder) | 207957008 |
| Collapse of lumbar vertebra (disorder) | 308758008 |
| Compression fracture of lumbar spine (disorder) | 426646004 |

| | |
|---|---|
| Concussion and edema of lumbar spinal cord (disorder) | 212360005 |
| Contusion of back (disorder) | 11437003 |
| Contusion of lower back (disorder) | 284062002 |
| Crush fracture of lumbar vertebra (disorder) | 281933002 |
| Disc prolapse with myelopathy (disorder) | 202728009 |
| Discitis (disorder) | 2304001 |
| Fracture of coccyx (disorder) | 125871005 |
| Fracture of lumbar spine (disorder) | 125608002 |
| Fracture of lumbar spine and/or pelvis (disorder) | 207986006 |
| Injury of cauda equina (disorder) | 230614002 |
| Lumbar disc prolapse with myelopathy (disorder) | 202731005 |
| Multiple fractures of lumbar spine and/or pelvis (disorder) | 207993005 |
| Open dislocation of coccyx (disorder) | 44237008 |
| Open fracture of lumbar vertebra with spinal cord injury (disorder) | 48956000 |
| Open fracture of sacrum AND/OR coccyx with spinal cord injury (disorder) | 65491009 |
| Traumatic dislocation of joint of lumbar vertebra (disorder) | 129166009 |
| Traumatic dislocation of lumbosacral joint (disorder) | 129161004 |

SNOMED CT-AU (EDRS)=Systematized Nomenclature of Medicine – Clinical Terms – Australian Version (Emergency Department Reference Set).

**Appendix 2. Multifaceted Intervention**

In the Sydney Health Partners Emergency Department (SHaPED) trial, we involved end-users throughout the entire implementation process. We obtained support from clinical leads and administration heads at the four emergency departments and formalised a partnership agreement between the institutions. We created a working group at each emergency department to provide oversight on the implementation progress.

We reviewed and discussed the existing local models of care for acute low back pain at the four emergency departments and recommended adaptation to facilitate adoption of the new model. We also conducted an environmental assessment to identify the typical pathway of care for a patient presenting with low back pain at each emergency department. This allowed us to identify practices and processes that would require development or change in order to support the implementation strategy.

We met with representatives from each site to plan how best to implement the New South Wales (NSW) Agency for Clinical Innovation (ACI) model of care for acute low back pain at their emergency department. We aimed to identify factors that would support practice change and factors that may create a barrier for implementation at each emergency department:

- Facilitators: facilitators for practice change identified included engagement of all potential stakeholders, scheduling champions and clinicians to enable attendance at meetings and face-to-face education sessions and conducting audits or monitor specific data indicators that would support practice change.

- Barriers: barriers to implementation were lack of clinician expertise/comfort to treat low back pain, time constraints in the busy emergency department setting, alternatives to the key behaviours we aimed to reduce (i.e. overuse of lumbar imaging, opioid medicines, and unnecessary hospital admissions), lack of clinical decision support tools and patient educational materials, and difficulty or inability to access local data on current management practices for low back pain.

Our multifaceted intervention strategy therefore aimed to address identified barriers and followed evidence-based approaches from the Cochrane Collaboration Effective Practice and Organisation of Care (EPOC) Group for changing practice by clinicians. The intervention involved five main components:

1. Education seminars

Educational seminars were delivered by an experienced clinician during the four weeks of the intervention phase. The format consisted of a mini-lecture (Fig. 1) and interactive group discussions lasting for 30 to 60 minutes. The included clinicians attended to at least one educational seminar. The seminars were conducted primarily during the existing regular clinical staff meetings or protected teaching times, but additional sessions were scheduled to reach most clinicians. During the educational seminars, clinicians were trained on history and physical examination of low back pain and encouraged to follow the recommendations in the NSW ACI model of care. They also learned about when to refer patients for diagnostic lumbar imaging, appropriate use of analgesic medicines, timely referral to specialist services, as well as other messages and principles outlined in the NSW ACI model of care. A 1-page patient handout (Fig. 6) was also developed based on the NSW ACI consumer information booklet. We translated the patient handout into six different languages. These materials were developed and reviewed by end-users and were well accepted.

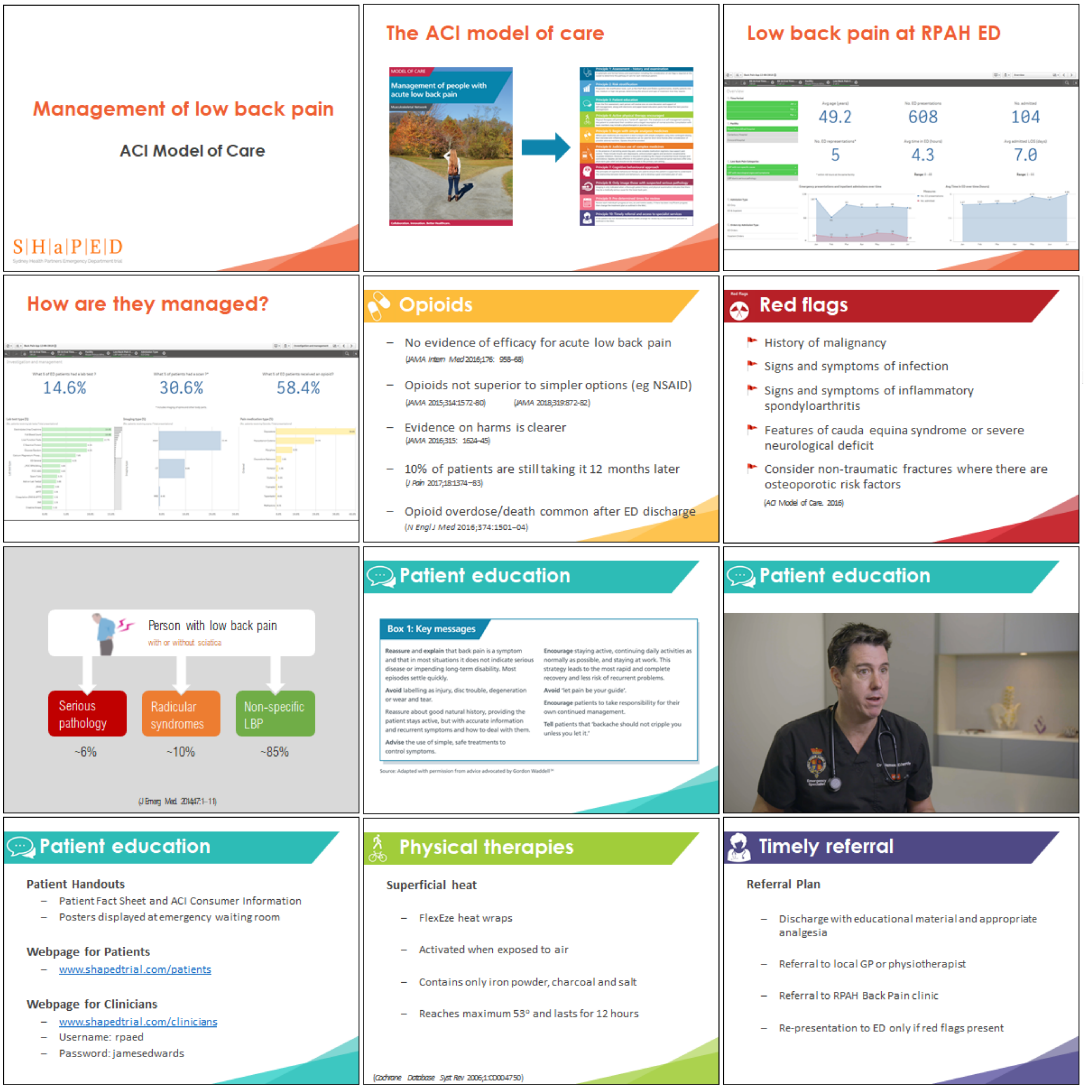



**Figure 1**. Example of lecture slides used during the education seminars.

2. Education materials

Clinician participants received a folder containing a copy of the NSW ACI model of care for acute low back pain and a 1-page summary of the recommendations (Fig. 2). Clinicians also received other clinical decision support tools, such as a diagnostic imaging decision flow chart adapted from the Royal Australian and New Zealand College of Radiologists (RANZCR) imaging guidelines (Fig. 3), and an emergency quick reference 'cheat sheets' outlining key points on history taking, physical examination, 'red flags' screening, education, diagnostic imaging, analgesia, and referrals that the clinicians could attached to their lanyards (Fig. 4). Posters (Fig. 5) outlining key messages from the NSW ACI model of care for acute low back pain were placed at the reception area of each emergency department. We have also developed a website with online versions of the above-mentioned tools, as well as patient education material. Patients received a factsheet (Fig. 6). There was also a patient website and a password protected clinician webpage (Fig. 7) containing educational resources.

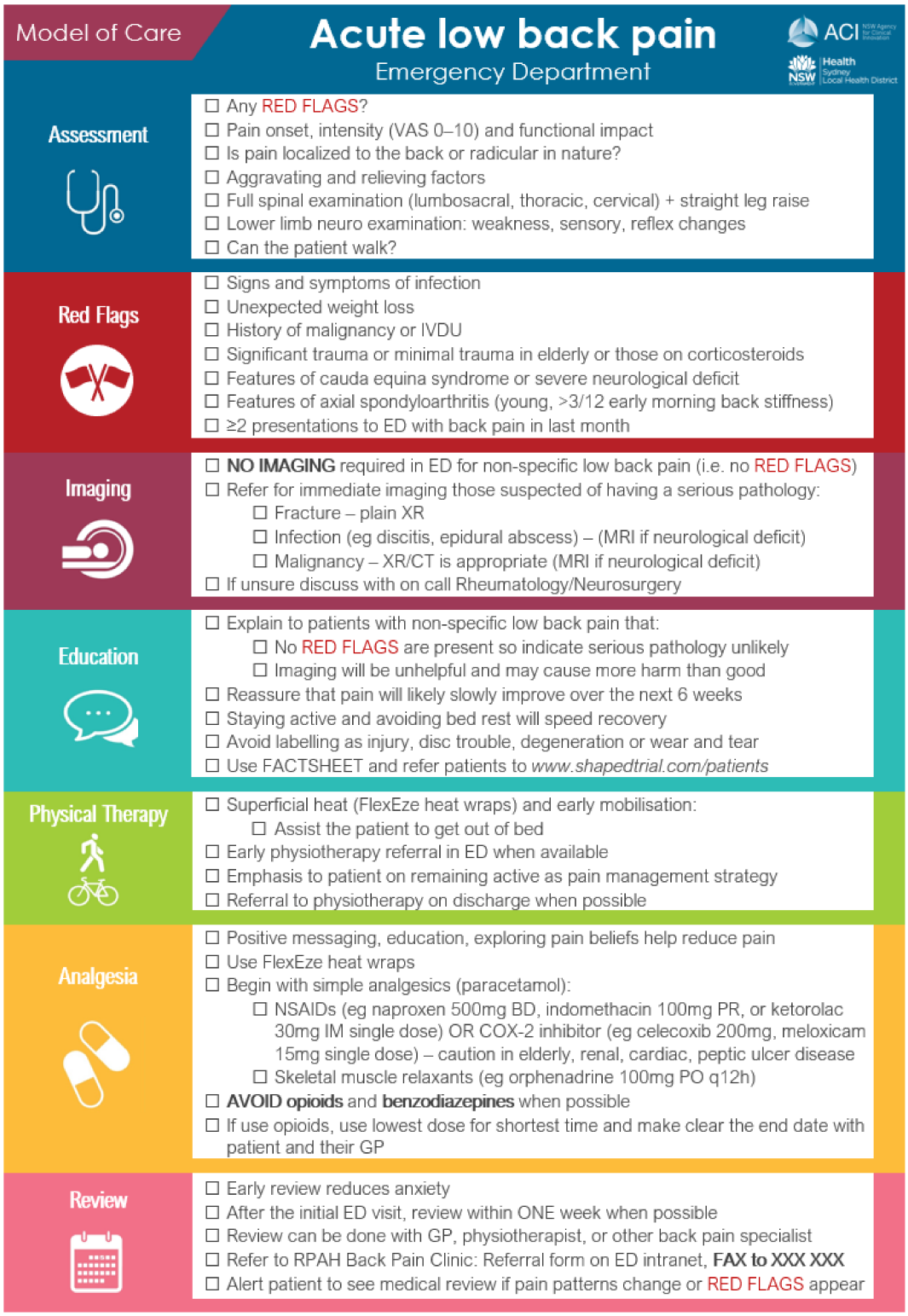



**Figure 2**. Summary of the care model recommendations (adapted from NSW ACI).

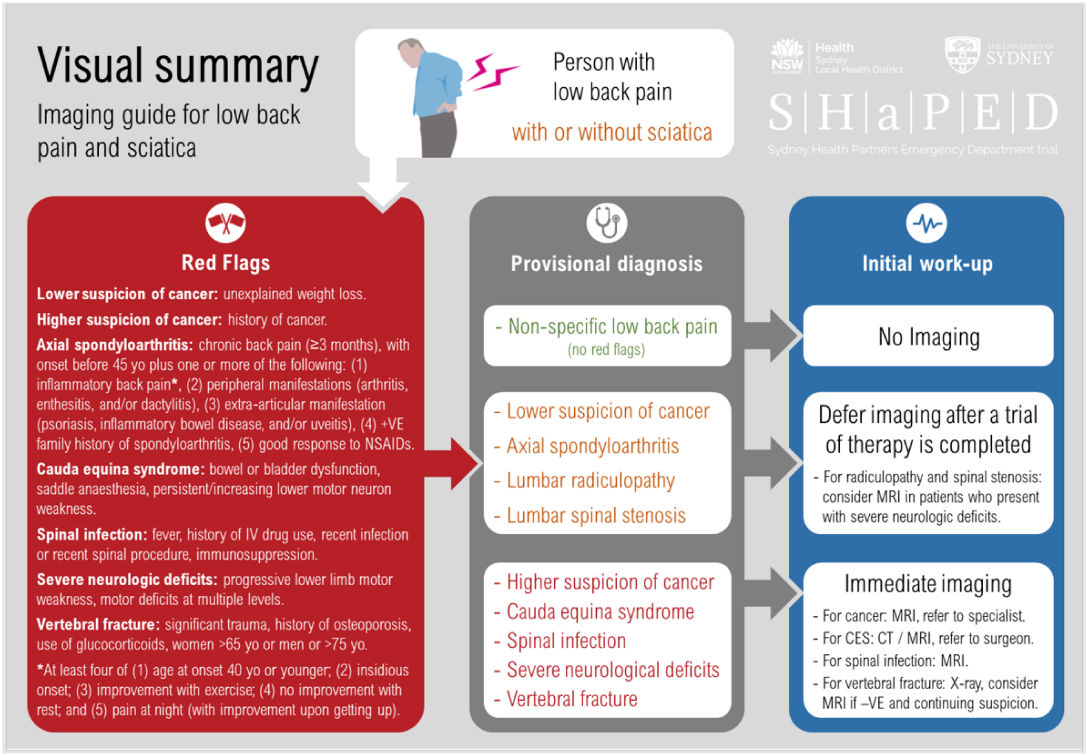



**Figure 3**. Lumbar imaging decision flow chart (adapted from The Royal Australian and New Zealand College of Radiologists guidelines).

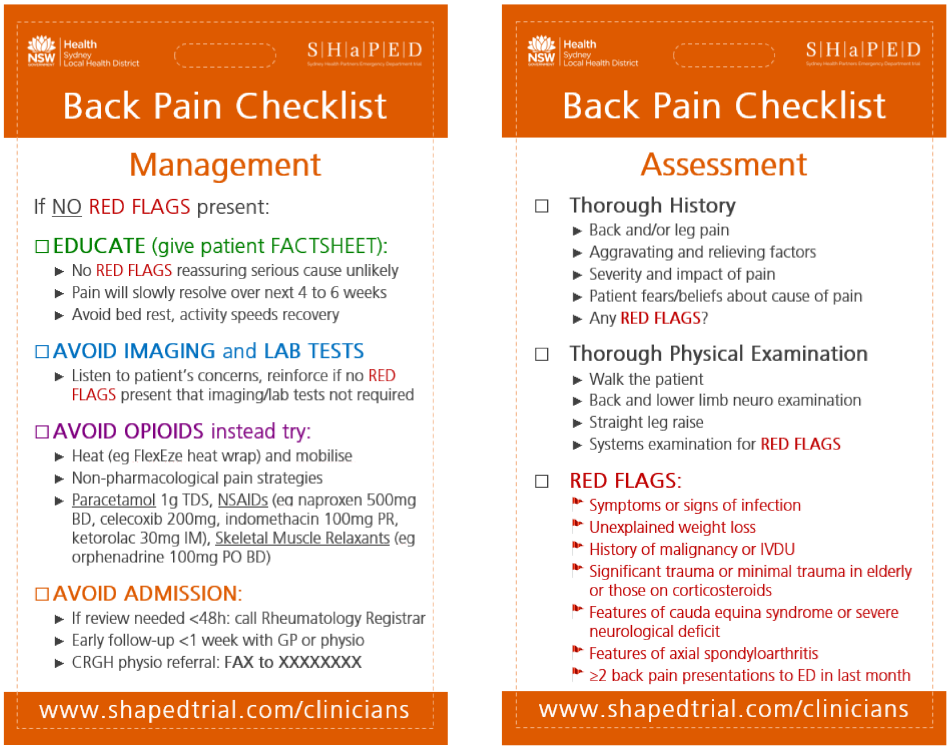



**Figure 4.** Emergency low back pain quick reference 'cheat sheets'.

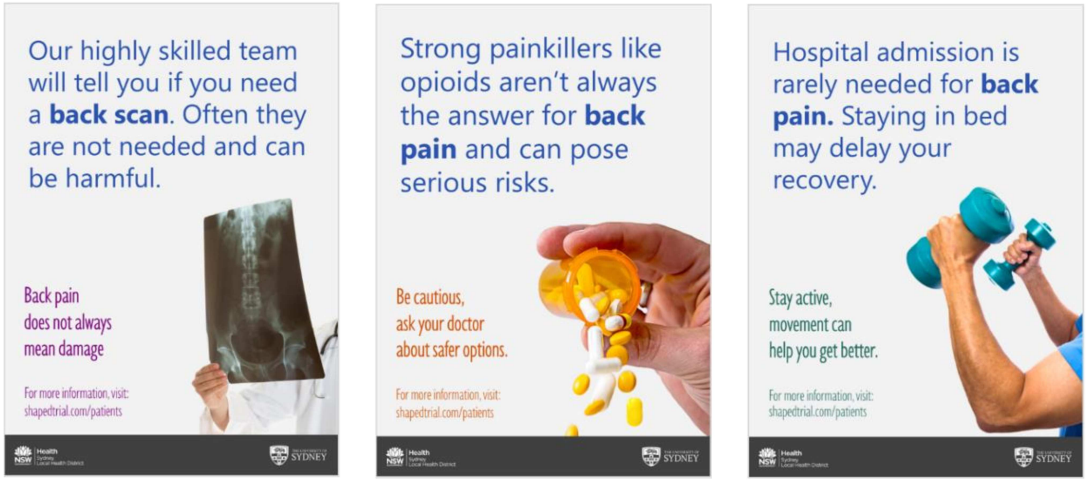



**Figure 5**. Three posters outlining key messages of the New South Wales Agency for Clinical Innovation model of care for low back pain.


**Figure 6**. One-page patient factsheet (double sided).

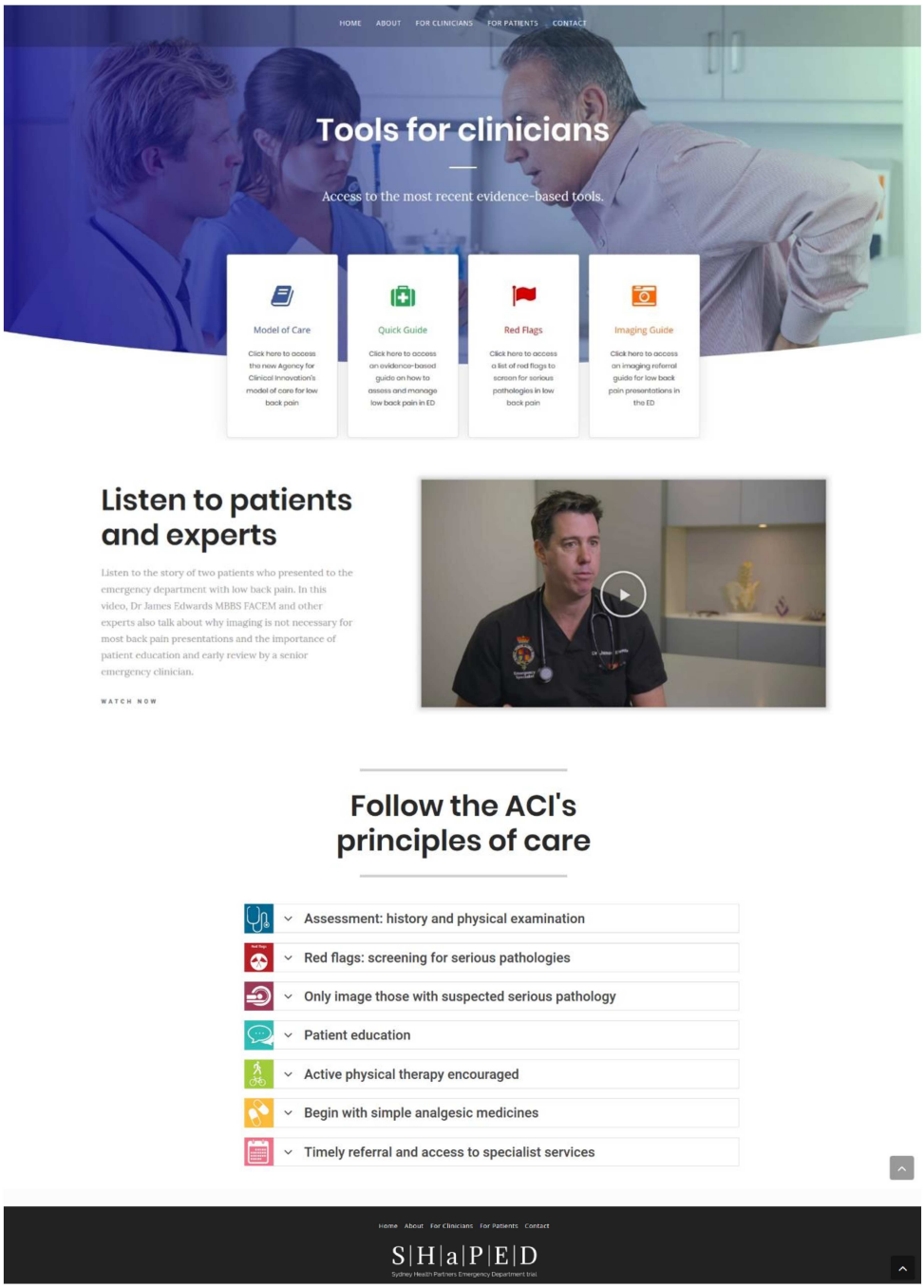



**Figure 7**. Examples of components of the clinician webpage.

3. Non-pharmacological pain management strategies

We instructed clinicians to provide reassurance and advice to patients about their low back pain as per recommendations in the NSW ACI model of care, as well as training on how to mobilise patients. Each emergency department was also supplied with FlexExe™ heat wraps as a first line option for non-pharmacological pain management. Clinicians were trained in the use of the heat wraps (Fig. 8).

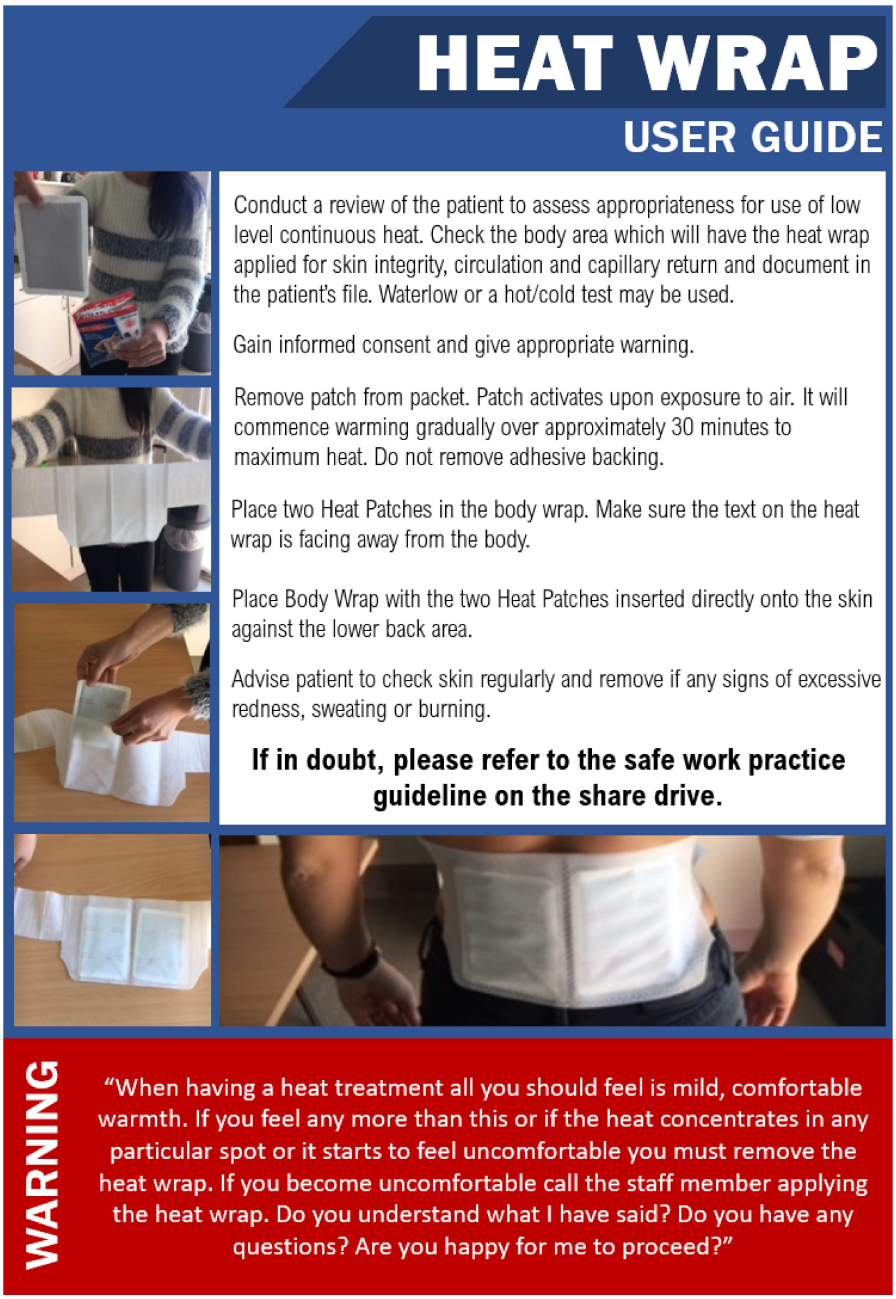



**Figure 8**. One-page heat wrap user guide.

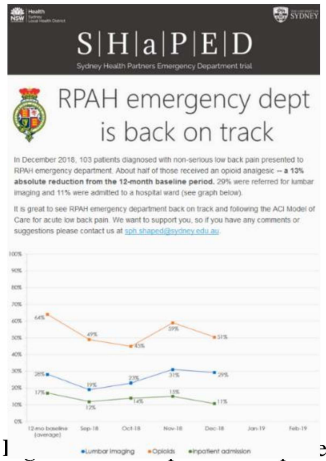
4. Pathway to early follow-up as outpatient

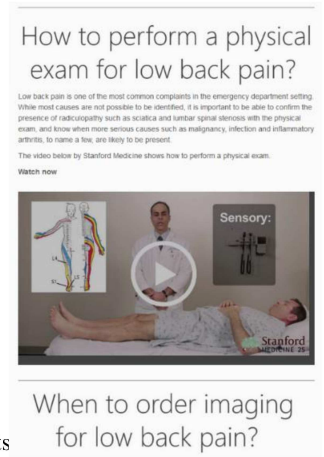
We liaised with local outpatient services at each of the hospitals. Physical therapy departments and back pain clinics agreed to prioritise patients and follow them up within 1 week of presentation to emergency department. Clinicians were informed on the outpatient services referral process during the training sessions and on it was written on the quick reference 'cheat sheets'.

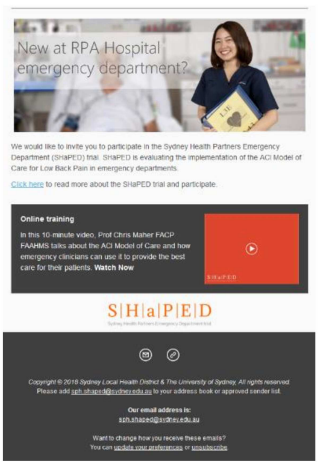
5. Audit and feedback

We developed a clinical care dashboard in Qlik Sense® to audit health care outcomes via the hospital's electronic medical records. The dashboard allowed us to identify our population and extract outcomes (Fig. 9). Each clinician participant received during the educational seminars emergency department level feedback on the 12-month retrospective data performance against the key outcomes of this study (i.e. lumbar imaging, opioid use, inpatient admission). Feedback was given to clinicians verbally during the seminars and in charts and graphs via monthly email newsletters (Fig. 10).


**Figure 9**. Examples of components of the data visualisation dashboard in Qlik Sense®.




l ents

**Appendix 3. Back-Beliefs Questionnaire**

We are trying to find out what people think about low back trouble. Please indicate your general views towards back trouble, *even if you have never had any*.

Please answer *ALL* statements and indicate whether you *agree* or *disagree* with each statement by circling the appropriate number on the scale. 1 = COMPLETELY DISAGREE, 5 = COMPLETELY AGREE.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| COMPLETELY DISAGREE | | | | COMPLETELY AGREE |

| | | Disagree | | | | Agree |
|---|---|---|---|---|---|---|
| 1 | There is no real treatment for back trouble. | 1 | 2 | 3 | 4 | 5 |
| 2 | Back trouble will eventually stop you from working. | 1 | 2 | 3 | 4 | 5 |
| 3 | Back trouble means periods of pain for the rest of one's life. | 1 | 2 | 3 | 4 | 5 |
| 4 | Doctors cannot do anything for back trouble. | 1 | 2 | 3 | 4 | 5 |
| 5 | A bad back should be exercised. | 1 | 2 | 3 | 4 | 5 |
| 6 | Back trouble makes everything in life worse. | 1 | 2 | 3 | 4 | 5 |
| 7 | Surgery is the most effective way to treat back trouble. | 1 | 2 | 3 | 4 | 5 |
| 8 | Back trouble may mean you end up in a wheelchair. | 1 | 2 | 3 | 4 | 5 |
| 9 | Alternative treatments are the answer to back trouble. | 1 | 2 | 3 | 4 | 5 |
| 10 | Back trouble means long periods of time off work. | 1 | 2 | 3 | 4 | 5 |
| 11 | Medication is the *only* way of relieving back trouble. | 1 | 2 | 3 | 4 | 5 |
| 12 | Once you have had back trouble there is *always* a weakness. | 1 | 2 | 3 | 4 | 5 |
| 13 | Back trouble *must* be rested. | 1 | 2 | 3 | 4 | 5 |
| 14 | Later in life back trouble gets progressively worse. | 1 | 2 | 3 | 4 | 5 |

From: Symonds TL, Burton AK, Tillotson KM, Main CJ. Do attitudes and beliefs influence work loss due to low back trouble? *Occupational Medicine*. 1996;46:25–32.

The inevitability measure comprises 1 scale using a sub-set of 9 items (items 1, 2, 3, 6, 8, 10, 12, 13, 14). The final score is calculated by reversing and summing the scores of these 9 core items with a total score ranging from 9 to 45.

**Appendix 4. Knowledge and Attitudes Questionnaire**

Please answer *ALL* statements and indicate whether you *agree* or *disagree* with each statement by circling the appropriate number on the scale. 1 = COMPLETELY DISAGREE, 5 = COMPLETELY AGREE.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| COMPLETELY DISAGREE | | | | COMPLETELY AGREE |

| | | Correct response |
|---|---|---|
| 1 | Patients with acute LBP should be prescribed complete bed rest until the pain goes away. | Disagree |
| 2 | Patients should not return to work until they are almost pain free. | Disagree |
| 3 | X-rays of the lumbar spine are useful in the work up of patients with acute LBP. | Disagree |
| 4 | Encouragement of physical activity is important in the recovery of LBP. | Agree |
| 5 | Interventions by doctors and other health care providers have very little positive impact on the natural history of acute LBP. | Disagree |
| 6 | I am likely to order X-rays for LBP because patients so often expect me to do so. | Disagree |
| 7 | There is nothing physically wrong with many patients with chronic back pain. | Agree |
| 8 | Well-motivated patients are unlikely to have long term problems with LBP. | Agree |
| 9 | I have no difficulty in assessing the motivation of my LBP patients | Agree |
| 10 | Practice guidelines are useful to help doctors in the management of medical conditions | Agree |
| 11 | They would find practice guidelines helpful in the management of LBP. | Agree |

From: Buchbinder R, Staples M, Jolley D. Doctors with a special interest in back pain have poorer knowledge about how to treat back pain. *Spine* 2009;34:1218–26.

The number of correct questions were determined by adding agree and strongly agree or disagree and strongly disagree depending on the wording of the question. A response of uncertain was coded as being incorrect.

**Appendix 5. Clinician characteristics, by assessment at follow-up**

| Characteristic | Follow-up completed* | Follow-up not completed* | Overall* | p value |
|---|---|---|---|---|
| Total no. | 139 | 130 | 269 | |
| Age† | 34.2±8.3 | 34.9±8.1 | 34.5±8.2 | 0.542 |
| Female sex – no. (%)‡ | 94 (68.6) | 66 (55.0) | 160 (62.3) | 0.025 |
| Main profession – no. (%)§ | | | | <0.001 |
| Physician | 43 (30.9) | 65 (51.2) | 108 (40.6) | |
| Nurse | 91 (65.5) | 60 (47.2) | 151 (56.8) | |
| Other | 5 (3.6) | 2 (1.6) | 7(2.6) | |
| Country of professional training – no. (%)¶ | | | | 0.462 |
| Australia | 114 (82.6) | 98 (79.0) | 212 (80.9) | |
| Other | 24 (17.4) | 26 (21.0) | 50 (19.1) | |
| Work years in main profession‖ | 8.5±7.4 | 8.7±8.4 | 8.6 ±7.9 | 0.850 |
| Work years in emergency department** | 5.8±6.7 | 5.9±6.2 | 5.8±6.5 | 0.916 |
| Had posgraduate training on low back pain – no. (%)†† | 13 (9.5) | 8 (6.5) | 21 (8.1) | 0.378 |
| No. low back pain patients treated per week‡‡ | 5.3 (5.3) | 3.8 (3.6) | 4.6 (4.7) | 0.021 |

* Plus–minus values are means ±SD. Percentages may not sum to 100 because of rounding or missing data.
† Data were missing for 24 in the follow up done group and 31 in the follow up not done group.
‡ Data were missing for 2 in the follow up done group and 10 in the follow up not done group.
§ Data were missing for 0 in the follow up done group and 3 in the follow up not done group.
¶ Data were missing for 1 in the follow up done group and 6 in the follow up not done group.
‖ Data were missing for 6 in the follow up done group and 9 in the follow up not done group.
** Data were missing for 7 in the follow up done group and 9 in the follow up not done group.
†† Data were missing for 2 in the follow up done group and 7 in the follow up not done group.
‡‡ Data were missing for 27 in the follow up done group and 29 in the follow up not done group.

**Appendix 6. Baseline characteristics of presentations, by cluster (periods 1–13)**

| Characteristic | Cluster* | | | |
|---|---|---|---|---|
| | Site 1 | Site 2 | Site 3 | Site 4 |
| Total no. | 725 | 1092 | 751 | 425 |
| Age – yr | 57.8±21.0 | 50.5±19.7 | 51.6±20.0 | 46.4±19.0 |
| Female sex – no. (%) | 381 (52.6) | 523 (47.9) | 371 (49.4) | 202 (47.5) |
| Primary diagnosis – no. (%)† | | | | |
| Non-specific low back pain | 616 (85.0) | 1017 (93.1) | 668 (88.9) | 394 (92.7) |
| Radicular low back pain | 109 (15.0) | 75 (6.9) | 83 (11.1) | 31 (7.3) |
| Socioeconomic status – no. (%)‡ | | | | |
| SEIFA Deciles 1-5 | 90 (12.8) | 76 (7.6) | 400 (55.0) | 393 (94.7) |
| SEIFA Deciles 6-10 | 611 (87.2) | 925 (92.4) | 327 (45.0) | 22 (5.3) |
| Day of presentation – no. (%) | | | | |
| Weekday | 523 (72.1) | 776 (71.1) | 526 (70.0) | 321 (75.5) |
| Weekend | 202 (27.9) | 316 (28.9) | 225 (30.0) | 104 (24.5) |
| Hour of presentation – no. (%) | | | | |
| Working hours | 405 (55.9) | 570 (52.2) | 371 (49.4) | 249 (58.6) |
| After hours | 320 (44.1) | 522 (47.8) | 380 (50.6) | 176 (41.4) |
| Mode of arrival – no. (%) | | | | |
| Self-presented | 482 (66.5) | 731 (66.9) | 513 (68.3) | 313 (73.6) |
| Ambulance | 239 (33.0%) | 360 (33.0%) | 238 (31.7%) | 104 (24.5%) |
| Other | 4 (0.6) | 1 (0.1) | 0 (0.0) | 8 (1.9) |
| Triage category – no. (%)§ | | | | |
| 2 (Emergency) | 9 (1.2%) | 26 (2.4%) | 6 (0.8%) | 2 (0.5%) |
| 3 (Urgent) | 232 (32.0%) | 587 (53.8%) | 169 (22.5%) | 111 (26.1%) |
| 4 (Semi-urgent) | 469 (64.7%) | 466 (42.7%) | 530 (70.6%) | 280 (65.9%) |
| 5 (Non-urgent) | 15 (2.1%) | 13 (1.2%) | 46 (6.1%) | 32 (7.5%) |
| Length of stay in emergency, hours | 4.0±2.5 | 4.3±2.9 | 3.7±2.4 | 3.9±3.8 |

* Plus–minus values are means ±SD. Percentages may not sum to 100 because of rounding or missing data.
† Primary diagnosis codes from the Systematised Nomenclature of Medicine–Clinical Terms–Australian Version–Emergency Department Reference Set were categorized into non-specific low back pain and radicular low back pain.
‡ Socio-economic status was defined using patient postcode based on the Socio-Economic Indexes for Areas (SEIFA), developed by the Australian Bureau of Statistics. Lower numbers are more disadvantaged, and higher numbers are less disadvantaged. Data were missing for 149 presentations.
§ Triage categories are based on the Australasian Triage Scale (ATS). There were no low back pain presentations in the ATS category 1 (life threatening).

**Appendix 7. Primary and adjusted analyses for healthcare utilisation outcomes (Periods 1–20)**

| | | | Study groups | | Primary analysis | | Adjusted analysis | |
|---|---|---|---|---|---|---|---|---|
| **Healthcare utilisation outcomes** | **ICC** | **p for time trend†** | **Control** | **Intervention** | **Estimated effect*** | **p value** | **Estimated effect*** | **p value** |
| No. of patients assessed | | | 3233 | 1392 | | | | |
| Received lumbar imaging – no. (%) | 0.0162 | 0.7441 | 774 (23.9) | 327 (23.5) | 0.77 (0.47, 1.26) | 0.2904 | 0.86 (0.52, 1.43) | 0.5570 |
| Received advanced imaging – no. (%) | 0.0022 | 0.2811 | 285 (8.8) | 157 (11.3) | 1.16 (0.57, 2.35) | 0.6868 | 1.32 (0.64, 2.70) | 0.4548 |
| Received any strong opioid – no. (%)‡ | 0.0271 | 0.1449 | 1588 (52.4) | 586 (42.5) | 0.69 (0.46, 1.04) | 0.0746 | 0.75 (0.49, 1.14) | 0.1718 |
| Received any opioid – no. (%)‡ | 0.0174 | 0.2086 | 1904 (62.8) | 696 (50.5) | 0.57 (0.38, 0.85) | 0.0061 | 0.60 (0.39, 0.90) | 0.0149 |
| Received other analgesic – no. (%)‡ | 0.0033 | 0.1060 | 2095 (69.1) | 992 (72.0) | 1.52 (0.98, 2.35) | 0.0633 | 1.54 (0.99, 2.40) | 0.0571 |
| Admitted to hospital ward – no. (%) | 0.0306 | 0.5208 | 498 (15.4) | 221 (15.9) | 0.96 (0.54, 1.71) | 0.8868 | 1.34 (0.72, 2.50) | 0.3612 |
| Admitted to EMU or EDSSU – no. (%) | 0.0561 | 0.1780 | 382 (11.8) | 173 (12.4) | 1.99 (0.91, 4.37) | 0.0862 | 2.18 (0.98, 4.87) | 0.0563 |
| Referred for a consultation – no. (%) | 0.0371 | 0.9945 | 132 (4.1) | 52 (3.7) | 2.50 (0.98, 6.37) | 0.0540 | 3.11 (1.17, 8.31) | 0.0232 |
| Re-presenting within 48 hours – no. (%) | 0.0007 | 0.4307 | 38 (1.2) | 18 (1.3) | 0.31 (0.06, 1.57) | 0.1588 | 0.33 (0.06, 1.72) | 0.1873 |
| Length of ED stay (hours) – mean (SD) | 0.0115 | 0.3332 | 4.1 (3.0) | 4.05 (2.8) | -0.28 (-0.84, 0.28) | 0.3321 | -0.17 (-0.70, 0.36) | 0.5341 |

* The effects of the intervention are presented as Odds Ratio (OR) or Mean Difference (MD) and its 95% confidence interval (CI). Percentages may not sum to 100 because of rounding or missing data.
† The assessment of underlying temporal trends over the baseline control phase (periods 1 to 13) was performed by fitting a regression line (logistic or linear) to assess the significance of time slopes.
‡ Due to missing data, total sample in the control group was 3031 and 1378 in the intervention group.

**Appendix 8. Sensitivity analysis of core trial period for healthcare utilisation outcomes (periods 13–18)**

| | | Study groups | | Primary analysis | |
|---|---|---|---|---|---|
| **Healthcare utilisation outcomes** | **ICC** | **Control** | **Intervention** | **Estimated effect*** | **p value** |
| No. of patients assessed | | 460 | 815 | | |
| Received lumbar imaging – no. (%) | 0.0000 | 108 (23.5) | 184 (22.6) | 1.19 (0.72, 1.95) | 0.4978 |
| Received advanced imaging – no. (%) | 0.0009 | 43 (9.3) | 90 (11.0) | 1.33 (0.65, 2.71) | 0.4330 |
| Received any strong opioid – no. (%)† | 0.0200 | 220 (48.2) | 326 (40.4) | 0.75 (0.47, 1.18) | 0.2079 |
| Received any opioid – no. (%)† | 0.0092 | 277 (60.7) | 393 (48.7) | 0.61 (0.39, 0.97) | 0.0351 |
| Received other analgesic – no. (%)† | 0.0000 | 311 (68.2) | 569 (70.5) | 1.45 (0.93, 2.25) | 0.1032 |
| Admitted to hospital ward – no. (%) | 0.0559 | 63 (13.7) | 135 (16.6) | 0.68 (0.35, 1.35) | 0.2747 |
| Admitted to short stay unit – no. (%) | 0.0812 | 45 (9.8) | 109 (13.4) | 1.92 (0.83, 4.44) | 0.1265 |
| Referred for a consultation – no. (%) | 0.0364 | 21 (4.6) | 30 (3.7) | 1.90 (0.63, 5.74) | 0.2578 |
| Re-presenting within 48 hours – no. (%) | 0.0004 | 8 (1.7) | 9 (1.1) | 0.32 (0.06, 1.62) | 0.1699 |
| Length of ED stay (hours) – mean (SD) | 0.0162 | 4.36 (3.90) | 4.00 (2.67) | -0.28 (-0.94, 0.38) | 0.4100 |

* The effects of the intervention are presented as Odds Ratio (OR) or Mean Difference (MD) and its 95% confidence interval (CI). Percentages may not sum to 100 because of rounding or missing data.

† Due to missing data, total sample in the control group was 456 and 807 in the intervention group.

**Appendix 9. Post-hoc sensitivity analysis omitting data from repeat visits by the same patient (periods 1–20)**

| | | Study groups | | Primary analysis | | Adjusted analysis | |
|---|---|---|---|---|---|---|---|
| **Healthcare utilisation outcomes** | **ICC** | **Control** | **Intervention** | **Estimated effect*** | **p value** | **Estimated effect*** | **p value** |
| No. Patients assessed | | 2983 | 1231 | | | | |
| Proportion receiving lumbar imaging – no. (%) | 0.0152 | 735 (24.6) | 297 (24.1) | 0.66 (0.39, 1.12) | 0.1226 | 0.72 (0.42, 1.24) | 0.2394 |
| Proportion receiving advanced imaging – no. (%) | 0.0012 | 269 (9.0) | 137 (11.1) | 0.74 (0.35, 1.57) | 0.4337 | 0.82 (0.38, 1.77) | 0.6166 |
| Proportion receiving any strong opioid medication – no. (%) ‡ | 0.0282 | 1436 (51.3) | 503 (41.3) | 0.64 (0.42, 1.00) | 0.0482 | 0.70 (0.45, 1.11) | 0.1280 |
| Proportion receiving any opioid medication – no. (%) ‡ | 0.0176 | 1738 (62.1) | 602 (49.5) | 0.51 (0.33, 0.79) | 0.0027 | 0.55 (0.35, 0.86) | 0.0081 |
| Proportion receiving other analgesic medication – no. (%) ‡ | 0.0048 | 1937 (69.2) | 878 (72.1) | 1.48 (0.93, 2.38) | 0.1018 | 1.52 (0.94, 2.45) | 0.0851 |
| Proportion admitted from ED to Hospital ward – no. (%) | 0.0279 | 438 (14.7) | 188 (15.3) | 0.91 (0.48, 1.73) | 0.7704 | 1.26 (0.63, 2.51) | 0.5153 |
| Proportion admitted from ED to EMU or EDSSU – no. (%) | 0.0555 | 354 (11.9) | 158 (12.8) | 2.12 (0.88, 5.11) | 0.0947 | 2.45 (1.00, 6.02) | 0.0500 |
| Proportion referred for a consultation in the ED – no. (%) | 0.0368 | 119 (4.0) | 48 (3.9) | 2.31 (0.86, 6.18) | 0.0964 | 2.99 (1.06, 8.45) | 0.0388 |
| Proportion re-presenting to the same ED within 48 hours – no. (%) | 0.0007 | 32 (1.1) | 11 (0.9) | N/A | | N/A | |
| Length of ED stay (hours) - mean (SD) | 0.0096 | 4.00 (2.95) | 3.98 (2.66) | -0.25 (-0.84, 0.34) | 0.4075 | -0.15 (-0.71, 0.41) | 0.5963 |

* The effects of the intervention are presented as Odds Ratio (OR) or Mean Difference (MD) and its 95% confidence interval (CI). Percentages may not sum to 100 because of rounding or missing data.
‡ Due to missing data, total sample in the control group was 2798 and 1217 in the intervention group.

**Appendix 10. Subgroup analysis for any lumbar imaging (periods 1–20)**

| Characteristics | Control, n/N (%) | Intervention, n/N (%) | OR (95% CI)* | p value | p for interaction |
|---|---|---|---|---|---|
| Overall | 774/3233 (23.9) | 327/1392 (23.5) | 0.77 (0.47, 1.26) | 0.2904 | |
| Age | | | | | 0.8357 |
| <65 years | 392/2267 (17.3) | 158/956 (16.5) | 0.83 (0.49, 1.41) | 0.4932 | |
| ≥65 years | 382/966 (39.5) | 169/436 (38.8) | 0.86 (0.51, 1.46) | 0.5764 | |
| Socioeconomic status† | | | | | 0.7317 |
| SEIFA Deciles 1–5 | 213/1085 (19.6) | 65/338 (19.2) | 0.70 (0.39, 1.25) | 0.2267 | |
| SEIFA Deciles 6–10 | 538/1988 (27.1) | 251/980 (25.6) | 0.75 (0.45, 1.24) | 0.2618 | |
| Triage category‡ | | | | | 0.0816 |
| 2 (Emergency) | 23/52 (44.2) | 7/31 (22.6) | 0.29 (0.09, 0.90) | 0.0325 | |
| 3 (Urgent) | 317/1174 (27.0) | 143/492 (29.1) | 0.90 (0.53, 1.53) | 0.6967 | |
| 4 (Semi-urgent)/5 (Non-urgent) | 434/2007 (21.6) | 177/869 (20.4) | 0.75 (0.45, 1.26) | 0.2756 | |
| Primary diagnosis§ | | | | | 0.7286 |
| Non-specific low back pain | 717/2909 (24.6) | 304/1249 (24.3) | 0.68 (0.33, 1.40) | 0.2988 | |
| Radicular low back pain | 57/324 (17.6) | 23/143 (16.1) | 0.76 (0.46, 1.25) | 0.2736 | |
| Mode of arrival | | | | | 0.8734 |
| Ambulance/transferred/other | 355/1031 (34.4) | 150/444 (33.8) | 0.78 (0.46,1.33) | 0.3691 | |
| Self-presented | 419/2202 (19.0) | 176/946 (18.6) | 0.76 (0.46, 1.28) | 0.3099 | |
| Cluster | | | | | 0.0956 |
| Site 1 | 229/725 (31.6) | 108/433 (24.9) | 0.60 (0.35, 1.03) | 0.0630 | |
| Site 2 | 280/1161 (24.1) | 131/560 (23.4) | 0.85 (0.49, 1.49) | 0.5786 | |
| Site 3 | 196/848 (23.1) | 63/282 (22.3) | 0.83(0.45, 1.52) | 0.5511 | |
| Site 4 | 69/499 (13.8) | 25/117 (21.4) | 1.23 (0.60, 2.53) | 0.5654 | |

* The model estimates are presented as Odds Ratio (OR) and its 95% confidence interval (CI). Percentages may not sum to 100 because of rounding or missing data. n = number of presentations with outcome, N = number of total presentations, excluding presentations where data were missing. ED = Emergency department

† Socio-economic status was defined using patient postcode based on the Socio-Economic Indexes for Areas (SEIFA), developed by the Australian Bureau of Statistics. Lower numbers are more disadvantaged, and higher numbers are less disadvantaged.

‡ Triage categories are based on the Australasian Triage Scale (ATS). There were no low back pain presentations in the ATS category 1 (life threatening).

§ Primary diagnosis codes from the Systematised Nomenclature of Medicine–Clinical Terms–Australian Version–Emergency Department Reference Set were categorized into non-specific low back pain and radicular low back pain.

**Appendix 11. Post-hoc subgroup analysis for any opioid medicine (periods 1–20)**

| Characteristics | Control, n/N (%) | Intervention, n/N (%) | OR (95%CI)* | p value | p for interaction |
|---|---|---|---|---|---|
| Overall | 1904/3031 (62.8) | 696/1378 (50.5) | 0.57 (0.38, 0.85) | 0.0061 | |
| Age | | | | | 0.6173 |
| <65 years | 1301/2132 (61.0) | 466/947 (49.2) | 0.59 (0.39, 0.90) | 0.0137 | |
| ≥65 years | 603/899 (67.1) | 230/431 (53.4) | 0.55 (0.35, 0.86) | 0.0086 | |
| Socioeconomic status† | | | | | 0.7990 |
| SEIFA Deciles 1–5 | 606/1038 (58.4) | 148/329 (45.0) | 0.50 (0.31, 0.80) | 0.0041 | |
| SEIFA Deciles 6–10 | 1231/1844 (66.8) | 517/975 (53.0) | 0.52 (0.34, 0.80) | 0.0025 | |
| Triage category‡ | | | | | 0.1948 |
| 2 (Emergency) | 35/49 (71.4) | 22/31 (71.0) | 1.01 (0.34, 3.02) | 0.9843 | |
| 3 (Urgent) | 802/1090 (73.6) | 318/491 (64.8) | 0.67 (0.43, 1.06) | 0.0870 | |
| 4 (Semi-urgent)/5 (Non-urgent) | 1067/1892 (56.4) | 356/856 (41.6) | 0.54 (0.35, 0.82) | 0.0042 | |
| Primary diagnosis§ | | | | | 0.3497 |
| Non-specific low back pain | 1691/2717 (62.2) | 623/1236 (50.4) | 0.48 (0.27, 0.83) | 0.0096 | |
| Radicular low back pain | 213/314 (67.8) | 73/142 (51.4) | 0.59 (0.39, 0.89) | 0.0111 | |
| Mode of arrival | | | | | 0.4575 |
| Ambulance/transferred/other | 696/962 (72.3) | 274/440 (62.3) | 0.61 (0.39, 0.97) | 0.0356 | |
| Self-presented | 1208/2069 (58.4) | 422/936 (45.1) | 0.55 (0.36, 0.84) | 0.0052 | |
| Cluster | | | | | 0.0004 |
| Site 1 | 509/725 (70.2) | 231/433 (53.3) | 0.46 (0.30, 0.73) | 0.0008 | |
| Site 2 | 683/1034 (66.1) | 306/560 (54.6) | 0.66 (0.42, 1.04) | 0.0728 | |
| Site 3 | 468/773 (60.5) | 99/268 (36.9) | 0.40 (0.24, 0.66) | 0.0004 | |
| Site 4 | 244/499 (48.9) | 60/117 (51.3) | 1.09 (0.61, 1.93) | 0.7693 | |

* The model estimates are presented as Odds Ratio (OR) and its 95% confidence interval (CI). Percentages may not sum to 100 because of rounding or missing data. n = number of presentations with outcome, N = number of total presentations, excluding presentations where data were missing. ED: Emergency department

† Socio-economic status was defined using patient postcode based on the Socio-Economic Indexes for Areas (SEIFA), developed by the Australian Bureau of Statistics. Lower numbers are more disadvantaged, and higher numbers are less disadvantaged.

‡ Triage categories are based on the Australasian Triage Scale (ATS). There were no low back pain presentations in the ATS category 1 (life threatening).

§ Primary diagnosis codes from the Systematised Nomenclature of Medicine–Clinical Terms–Australian Version–Emergency Department Reference Set were categorized into non-specific low back pain and radicular low back pain.

**Appendix 12. Number and proportion receiving any lumbar imaging per period, per site**

| Period | Site 1 | Site 2 | Site 3 | Site 4 |
|---|---|---|---|---|
| 1 | 17/62 (27.4%) | 22/84 (26.2%) | 11/51 (21.6%) | 2/39 (5.1%) |
| 2 | 31/66 (47.0%) | 24/81 (29.6%) | 17/63 (27.0%) | 3/34 (8.8%) |
| 3 | 12/55 (21.8%) | 19/73 (26.0%) | 15/48 (31.3%) | 3/29 (10.3%) |
| 4 | 11/51 (21.6%) | 26/88 (29.5%) | 15/60 (25.0%) | 4/25 (16.0%) |
| 5 | 16/51 (31.4%) | 18/93 (19.4%) | 12/51 (23.5%) | 5/36 (13.9%) |
| 6 | 15/53 (28.3%) | 18/94 (19.1%) | 12/49 (24.5%) | 6/34 (17.6%) |
| 7 | 23/62 (37.1%) | 21/104 (20.2%) | 17/74 (23.0%) | 4/32 (12.5%) |
| 8 | 16/44 (36.4%) | 9/57 (15.8%) | 9/56 (16.1%) | 5/30 (16.7%) |
| 9 | 16/59 (27.1%) | 26/90 (28.9%) | 16/54 (29.6%) | 7/26 (26.9%) |
| 10 | 21/60 (35.0%) | 18/82 (22.0%) | 12/63 (19.0%) | 2/48 (4.2%) |
| 11 | 18/47 (38.3%) | 16/84 (19.0%) | 12/52 (23.1%) | 3/24 (12.5%) |
| 12 | 15/59 (25.4%) | 24/86 (27.9%) | 16/71 (22.5%) | 6/39 (15.4%) |
| 13 | 18/56 (32.1%) | 19/76 (25.0%) | 13/59 (22.0%) | 8/29 (27.6%) |
| 14 | 14/54 (25.9%) | 20/69 (29.0%) | 9/49 (18.4%) | 3/14 (21.4%) |
| 15 | 13/63 (20.6%) | 14/68 (20.6%) | 10/48 (20.8%) | 6/27 (22.2%) |
| 16 | 7/49 (14.3%) | 15/91 (16.5%) | 9/47 (19.1%) | 2/33 (6.1%) |
| 17 | 12/43 (27.9%) | 19/78 (24.4%) | 4/35 (11.4%) ( | 4/25 (16.0%) |
| 18 | 17/70 (24.3%) | 26/100 (26.0%) | 22/63 (34.9%) | 8/29 (27.6%) |
| 19 | 25/73 (34.2%) | 30/112 (26.8%) | 16/75 (21.3%) | 3/30 (10.0%) |
| 20 | 20/81 (24.7%) | 27/111 (24.3%) | 12/62 (19.4%) | 10/33 (30.3%) |

ED: Emergency Department; No Color: Preintervention Period; Light Gray: Intervention Period; Dark Gray: Postintervention Period.

**Appendix 13. Number and proportion receiving any opioid medicine per period, per site**

| Period | Site 1 | Site 2 | Site 3 | Site 4 |
|---|---|---|---|---|
| 1 | 41/62 (66.1%) | 0/0 (0.0%) | 0/0 (0.0%) | 17/39 (43.6%) |
| 2 | 44/66 (66.7%) | 44/59 (74.6%) | 38/59 (64.4%) | 13/34 (38.2%) |
| 3 | 45/55 (81.8%) | 40/52 (76.9%) | 31/48 (64.6%) | 14/29 (48.3%) |
| 4 | 43/51 (84.3%) | 63/88 (71.6%) | 35/60 (58.3%) | 16/25 (64.0%) |
| 5 | 41/51 (80.4%) | 54/93 (58.1%) | 26/49 (53.1%) | 20/36 (55.6%) |
| 6 | 39/53 (73.6%) | 64/94 (68.1%) | 28/47 (59.6%) | 16/34 (47.1%) |
| 7 | 45/62 (72.6%) | 69/104 (66.3%) | 42/74 (56.8%) | 15/32 (46.9%) |
| 8 | 21/44 (47.7%) | 33/57 (57.9%) | 28/52 (53.8%) | 13/30 (43.3%) |
| 9 | 40/59 (67.8%) | 61/90 (67.8%) | 31/49 (63.3%) | 9/26 (34.6%) |
| 10 | 42/60 (70.0%) | 51/82 (62.2%) | 39/63 (61.9%) | 22/48 (45.8%) |
| 11 | 29/47 (61.7%) | 56/84 (66.7%) | 35/49 (71.4%) | 16/24 (66.7%) |
| 12 | 36/59 (61.0%) | 55/86 (64.0%) | 44/71 (62.0%) | 23/39 (59.0%) |
| 13 | 43/56 (76.8%) | 44/76 (57.9%) | 35/58 (60.3%) | 13/29 (44.8%) |
| 14 | 31/54 (57.4%) | 49/69 (71.0%) | 29/47 (61.7%) | 9/14 (64.3%) |
| 15 | 39/63 (61.9%) | 38/68 (55.9%) | 27/47 (57.4%) | 16/27 (59.3%) |
| 16 | 17/49 (34.7%) | 47/91 (51.6%) | 9/43 (20.9%) | 12/33 (36.4%) |
| 17 | 25/43 (58.1%) | 36/78 (46.2%) | 8/32 (25.0%) | 9/25 (36.0%) |
| 18 | 38/70 (54.3%) | 54/100 (54.0%) | 25/62 (40.3%) | 17/29 (58.6%) |
| 19 | 36/73 (49.3%) | 66/112 (58.9%) | 34/73 (46.6%) | 14/30 (46.7%) |
| 20 | 45/81 (55.6%) | 65/111 (58.6%) | 23/58 (39.7%) | 20/33 (60.6%) |

ED: Emergency Department; No Color: Preintervention Period; Light Gray: Intervention Period; Dark Gray: Postintervention Period.

**Appendix 14. Number and proportion admitted to hospital per period, per site**

| Period | Site 1 | Site 2 | Site 3 | Site 4 |
|---|---|---|---|---|
| 1 | 13/62 (21.0%) | 9/84 (10.7%) | 5/51 (9.8%) | 9/39 (23.1%) |
| 2 | 16/66 (24.2%) | 16/81 (19.8%) | 9/63 (14.3%) | 3/34 (8.8%) |
| 3 | 16/55 (29.1%) | 15/73 (20.5%) | 8/48 (16.7%) | 2/29 (6.9%) |
| 4 | 10/51 (19.6%) | 11/88 (12.5%) | 6/60 (10.0%) | 3/25 (12.0%) |
| 5 | 11/51 (21.6%) | 17/93 (18.3%) | 4/51 (7.8%) | 4/36 (11.1%) |
| 6 | 12/53 (22.6%) | 12/94 (12.8%) | 4/49 (8.2%) | 1/34 (2.9%) |
| 7 | 19/62 (30.6%) | 16/104 (15.4%) | 10/74 (13.5%) | 2/32 (6.3%) |
| 8 | 8/44 (18.2%) | 12/57 (21.1%) | 0/56 (0.0%) | 4/30 (13.3%) |
| 9 | 11/59 (18.6%) | 11/90 (12.2%) | 4/54 (7.4%) | 7/26 (26.9%) |
| 10 | 13/60 (21.7%) | 13/82 (15.9%) | 9/63 (14.3%) | 5/48 (10.4%) |
| 11 | 9/47 (19.1%) | 21/84 (25.0%) | 2/52 (3.8%) | 1/24 (4.2%) |
| 12 | 7/59 (11.9%) | 19/86 (22.1%) | 9/71 (12.7%) | 7/39 (17.9%) |
| 13 | 16/56 (28.6%) | 7/76 (9.2%) | 7/59 (11.9%) | 2/29 (6.9%) |
| 14 | 13/54 (24.1%) | 20/69 (29.0%) | 3/49 (6.1%) | 1/14 (7.1%) |
| 15 | 14/63 (22.2%) | 9/68 (13.2%) | 5/48 (10.4%) | 1/27 (3.7%) |
| 16 | 11/49 (22.4%) | 14/91 (15.4%) | 1/47 (2.1%) | 1/33 (3.0%) |
| 17 | 15/43 (34.9%) | 12/78 (15.4%) | 2/35 (5.7%) | 1/25 (4.0%) |
| 18 | 16/70 (22.9%) | 15/100 (15.0%) | 11/63 (17.5%) | 1/29 (3.4%) |
| 19 | 16/73 (21.9%) | 19/112 (17.0%) | 5/75 (6.7%) | 0/30 (0.0%) |
| 20 | 20/81 (24.7%) | 19/111 (17.1%) | 3/62 (4.8%) | 4/33 (12.1%) |

ED: Emergency Department; No Color: Preintervention Period; Light Gray: Intervention Period; Dark Gray: Postintervention Period.