

A clinical knowledge measurement tool to assess the ability of community pharmacists to detect drug-related problems

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Abstract

Introduction Drug-related problems (DRPs) are associated with significant morbidity and mortality, with most DRPs thought to be preventable. Community pharmacists can detect and either prevent or resolve many of these DRPs. A survey-based clinical knowledge measurement tool was designed and validated to estimate a community pharmacist's clinical knowledge and ability to detect and appropriately resolve DRPs.

Methods Nine clinical cases with seven multiple-choice statements (63 statements in total) were constructed, based on scenarios that were found to occur frequently in Australian community pharmacies. The statements aimed to assess a pharmacist's ability to identify, gather relevant information about and make appropriate recommendations to resolve, a DRP. The survey was pilot tested with 18 academics at three Australian pharmacy schools, resulting in the removal of 23 statements. The survey was then administered to undergraduate pharmacy students (28 fourth-year, 41 third-year and 42 first-year students) and to 433 Australian community pharmacists who were participating in an intervention documentation trial. The pharmacists' resultant survey scores were correlated against their actual rate of documenting clinical interventions.

Results The tool had relatively good internal consistency. Significant differences were seen between the three groups of students ($P < 0.01$). Community pharmacists with additional clinical qualifications had a significantly higher score than other participating pharmacists ($P < 0.01$). A moderate, but significant, correlation was seen between the pharmacists' survey score and their clinical intervention rate in practice during the trial ($P < 0.01$).

Conclusion The clinical knowledge measurement tool appeared to estimate a pharmacist's ability to detect and resolve DRPs within the community pharmacy environment.

Introduction

Drug-related problems (DRPs) are defined as 'undesirable events (either actual or potential) experienced by the patient thought to be due to drug therapy'^[1] and can broadly be related to errors, adverse effects or adherence issues that frequently contribute to morbidity, hospital admission and mortality.^[2–4] Many DRPs originate during the course of the patient's community-based care and a 2008 review reported that up to three quarters of hospital admissions due to DRPs were potentially preventable.^[3] A study conducted in the USA found that 25% (95% confidence interval 20–29%) of

patients in the community experienced an adverse drug event within 4 weeks of receiving a prescription,^[5] while an Australian study reported that 10% of patients visiting their general practitioner (GP) had experienced a DRP within the last 6 months.^[6] These findings highlight a need for improved detection and prevention of DRPs in the community, before hospital attendance or a GP visit is required.

Australian community pharmacists are considered to be well-placed to detect and either prevent or resolve DRPs during the course of their routine prescription-related

activities, such as dispensing and counselling.^[7] However, the pharmacist must possess adequate clinical knowledge in order to detect, and consequently resolve, the DRP. Despite the wealth of literature regarding DRPs and their preventability, there appears to be a lack of tools for assessing the clinical knowledge of pharmacists. One study conducted in Pittsburgh, USA, examined the ability of pharmacists to detect DRPs and make appropriate recommendations through the use of four case-based scenarios delivered by simulated patients (also known as 'mystery shoppers') within community pharmacies. The study showed that 33% of pharmacists did not make an adequate assessment of the patient prior to making a recommendation, and only 32% of recommendations were considered appropriate.^[8] This issue is of particular concern, given the logical link between a pharmacist's clinical knowledge and their ability to detect and resolve DRPs in practice.

A sub-study estimating the clinical knowledge level of pharmacists was conducted as part of the Pharmacy Recording Of Medication Incidents and Services electronic documentation system (PROMISE) trial, which aimed to determine the number and nature of DRPs detected, and clinical interventions performed, by Australian community pharmacists.^[9,10] The aim of the sub-study, and the focus of this article, was to develop and validate a survey-based clinical knowledge measurement tool. The tool was then used during the trial to determine any correlation between a pharmacist's clinical knowledge survey score and their ability to successfully detect and resolve DRPs within the community pharmacy environment.

Methods

Using clinical intervention data that were collected during a previous iteration of the PROMISE trial,^[11] a survey-based clinical knowledge measurement tool was developed by three clinical research pharmacists. The researchers constructed nine clinical cases with seven multiple-choice statements (63 statements in total) based on scenarios that were found, in the earlier study, to occur frequently in Australian community pharmacies.

The cases aimed to assess a pharmacist's ability to identify, gather relevant information about, and make appropriate recommendations to resolve, a DRP. Pharmacists were required to read the short scenario and select how relevant or appropriate they felt each of several proposed actions was to the scenario using a seven-point Likert scale. A seven-point scale was chosen as it was thought that more options would provide a more accurate representation of the pharmacist's abilities. The pharmacist was required to answer each statement before they could move on to the next case. All cases can be seen in full at the end of this Methods section.

The survey was administered through the online survey builder LimeSurvey v1.8 (www.limesurvey.org/) and an example screen layout can be seen in Figure 1. An online survey system was chosen to administer the tool, as it would greatly increase the number of pharmacists who could participate compared to a simulated patient study.

Eighteen academic pharmacists, consisting of researchers and teaching staff, within three Schools of Pharmacy in Australia (University of Tasmania, Monash University and Curtin University of Technology) were asked to pilot the survey to determine its suitability. Statements were to be removed if the academics' answers created standard deviations that were greater than two units above the mean, and this process eliminated 11 statements. For the remaining statements, the answers were analysed to determine if the academics gave similar answers to the writers' intentions. Any statements with responses that were too dissimilar to the writers' intentions were removed (for example, the statement was written with the intention of an 'irrelevant' response but the academics said it was 'relevant'). A further 12 statements were removed using this method, leaving nine clinical cases, each with between three and six multiple-choice statements, resulting in a total of 40 statements for analysis.

Reliability of the survey was assessed using the Cronbach's α and Fleiss' κ methods. Cronbach's α is a measure of the internal reliability of a scale^[12] and Fleiss' κ is a statistical measure for assessing the reliability of agreement between a fixed number of raters when assigning categorical ratings to a set number of items.^[13] Fleiss' κ was considered more relevant than Cronbach's α for this particular survey due to the use of the Likert scale categories; however, both methods were utilised. To ensure an accurate Cronbach's α value, negatively worded statements must first be reversed.^[12] This required reversal of the scores in statements 4.2, 4.5, 5.4, 5.6, 6.6, 7.1, 7.5, 7.6, 7.7, 8.1, 8.2, 8.5, 8.6 and 9.7.

From the 40 statements, scores were calculated where the correct answer was defined as the mode of the 18 academics' answers. Each statement received a score of 2, 1 or 0 depending on how far away the answer was from the mode. For example, if the academics agreed the answer was 'relevant', the participant would receive a score of 2 for answering 'relevant', 1 for 'very relevant' or 'slightly relevant' and 0 for any other answer. For this survey, the lowest possible total score was 0 and the highest was 80, with the intention that a higher score would signify a higher level of clinical knowledge.

The survey was then administered to Bachelor of Pharmacy undergraduate students at the University of Tasmania, including 28 fourth-year, 41 third-year and 42 first-year students to validate the survey. The students' level of clinical knowledge is expected to increase as they progress through each year of the pharmacy degree. That is, as seen in previous student knowledge questionnaires,^[14] it was expected that the

A slightly overweight, 51yo female patient who regularly visits your pharmacy presents a prescription for perindopril 5mg. The dispensing records indicate that the last antihypertensive agent prescribed for this patient was the perindopril/indapamide combination and it was last dispensed 3 months ago.

Please indicate how relevant each piece of additional information would be in this case.

	Very Relevant	Moderately Relevant	Only Slightly Relevant	Neutral	Only Slightly Irrelevant	Moderately Irrelevant	Totally Irrelevant
Discuss with the patient whether the medication change was intentional.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Discuss with the patient's doctor whether the medication change was intentional.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Obtain the patient's blood pressure to determine current efficacy of her antihypertensive treatment.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Determine the patient's smoking history.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Discuss with the patient their compliance with the antihypertensive agent.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Determine if the patient has had a cholesterol level done recently.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Discuss a weight management program with the patient.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

[Exit and clear survey] [Resume later] << Previous Next >>

Figure 1 The appearance of the cases in the online survey builder LimeSurvey (www.limesurvey.org/), version 1.8.

fourth-year students would have a higher mean score than the third-year students, who in turn would have a higher mean score than the first-year students. Second-year students did not complete the survey, as it was felt that the sample size would be large enough with three groups of students. The survey was administered to the students during selected tutorial sessions under the supervision of a tutor, therefore ensuring the students were unable to access additional resources, and all students within the class had to participate in the survey.

The final evaluation of the clinical knowledge measurement tool was performed by administering it to 433 Australian community pharmacists who were participating in the PROMISE trial.^[9,10] Additional information was collected from each pharmacist, including any post-graduate qualifications, which was used to identify pharmacists who may be considered to have 'above average' clinical knowledge. This included pharmacists who were Australian Association of Consultant Pharmacy accredited (AACPA) to perform medication reviews, as attaining accreditation requires further education on identifying and resolving DRPs. Pharmacists who had further university-level clinical training were also identified, such as Doctorates, Masters or Graduate Certificates in the area of clinical pharmacy.

The pharmacists' survey scores were used to determine whether there was a correlation between a pharmacist's

assessed clinical knowledge and their actual rate of documenting clinical interventions during the trial. Clinical interventions were defined as an actual or potential DRP identified by a pharmacist, who then made recommendations to resolve or prevent the DRP. The clinical intervention rate was calculated as the number of interventions divided by the number of prescriptions dispensed by the pharmacist.

Statistical calculations were completed using the PASW Statistics package (versions 17 and 18), with the Fleiss' κ calculation being performed in Microsoft Excel. Post-hoc analysis was performed using the Gabriel method when sample sizes were not equal and the Hochberg's method when sample sizes were very unequal for survey scores, as the population variance proved normal with the Levene's-test of equality.^[12] Spearman's correlation and Kruskal-Wallis tests were used for analysis of the intervention rate due to the non-parametric nature of the data. A multiple regression analysis was also performed on pharmacist demographics to determine additional factors influencing the survey score.

The overall PROMISE trial, including the utilisation of participant surveys and the use of students to pilot test the participant surveys, received ethics approval from the Tasmanian Health and Medical Human Research Ethics Committee (approval number H0010393).

Cases

Please note: statements appearing in *italics* were not included in the final 40 statements

For cases 1–3

- Very relevant = 7
- Moderately relevant = 6
- Only slightly relevant = 5
- Neutral = 4
- Only slightly irrelevant = 3
- Moderately irrelevant = 2
- Totally irrelevant = 1

Case 1

A slightly overweight, 51-year-old female patient who regularly visits your pharmacy presents a prescription for perindopril 5 mg. The dispensing records indicate that the last antihypertensive agent prescribed for this patient was the perindopril/indapamide combination and it was last dispensed 3 months ago. Please indicate how relevant each piece of additional information would be in this case.

	Academics			Writers' answer
	Mode	Mean	Standard deviation	
• Discuss with the patient whether the medication change was intentional.	7	6.89	0.32	7
• Discuss with the patient's doctor whether the medication change was intentional.	7	6.28	1.13	7
• Obtain the patient's blood pressure to determine current efficacy of her antihypertensive treatment.	5	5.11	1.53	1
• Determine the patient's smoking history.	5	4.67	1.64	1
• Discuss with the patient their compliance with the antihypertensive agent.	7	6.50	1.42	7
• Determine if the patient has had a cholesterol level done recently.	5	4.72	1.45	1
• Discuss a weight management programme with the patient.	5	5.06	1.55	1

Case 2

A frail 80-year-old male patient presents to collect his last repeat from his glyceryl trinitrate (GTN) sublingual spray prescription. On dispensing, the pharmacist notices that this is the third time this medication has been dispensed in the last 2 weeks. Please indicate how relevant each piece of additional information would be in this case.

	Academics			Writers' answer
	Mode	Mean	Standard deviation	
• Determine if the pain the patient is feeling is actually due to angina.	7	6.89	0.32	7
• Determine if the patient has any expired bottles of GTN spray at home.	5	4.56	1.98	1
• Ask the patient to demonstrate his administration technique.	7	6.67	0.59	7
• Establish whether the patient has a new script for GTN spray at home.	5	4.22	1.99	1
• Determine how long since the patient's general practitioner has reviewed his angina treatment.	7	6.94	0.24	7
• Determine how efficacious the GTN spray is.	7	6.44	1.54	7
• Determine if the patient has changed his diet in the last fortnight.	1	2.89	2.14	1

Case 3

A 58 kg, 35-year-old woman presents to the pharmacy to collect a prescription for methotrexate 10 mg weekly from her rheumatologist, which is a new medication for her. Please indicate how relevant each piece of additional information would be in this case.

	Academics			Writers' answer
	Mode	Mean	Standard deviation	
• Determine if the patient has had baseline liver function tests.	7	6.78	0.43	7
• Determine if the patient has had a negative pregnancy test and is currently taking/using adequate contraception.	7	7.00	0.00	7
• Determine if the side effects of methotrexate have been explained to the patient.	7	6.94	0.24	7
• Determine if the patient has been instructed to take folic acid.	7	6.39	0.85	7
• Determine if the patient is also taking regular paracetamol.	5	4.06	2.07	1
• Determine how often the patient drinks alcohol.	6	5.83	1.47	7
• Determine if the patient is currently taking any over-the-counter antacids.	2	3.89	2.25	1

For cases 4–6

- Highly likely = 7
- Moderately likely = 6
- Only slightly likely = 5
- Neutral = 4
- Only slightly unlikely = 3
- Moderately unlikely = 2
- Highly unlikely = 1

Case 4

A 65 kg, 45-year-old female patient comes into the pharmacy to enquire about possible side effects. She was commenced on paroxetine 20 mg daily a few days ago and has been experiencing increasing anxiety (which is the reason the paroxetine was initially started), sweating and tachycardia. She has a medical history of atrial fibrillation and severe lower back pain, and is also taking digoxin, ramipril, tramadol and methadone. Please indicate how likely each drug-related problem would be in this case.

	Academics			Writers' answer
	Mode	Mean	Standard deviation	
• The commencement of the paroxetine may have resulted in an increase in anxiety for the patient.	6	5.78	1.35	7
• This dose of paroxetine is unlikely to be controlling the patient's anxiety symptoms and an increase in her dose should be considered.	1	2.50	1.62	1
• The paroxetine may have interacted with the tramadol to cause the patient's symptoms.	7	6.61	0.78	7
• The paroxetine may have interacted with the methadone to cause the patient's symptoms.	7	4.50	2.23	7
• The paroxetine may have interacted with the digoxin to cause the patient's symptoms.	1	3.00	1.88	1
• The patient may be experiencing digoxin toxicity and should be referred back to her general practitioner.	1	2.89	2.19	1
• The patient's symptoms could be due to worsening atrial fibrillation and her digoxin dose should be increased.	1	3.00	2.00	1

Case 5

A slightly overweight, 78 year-old female patient with a history of hypertension and mild heart failure presents with prescription for frusemide 20 mg D to treat her swollen ankles. She is also currently taking lercanidipine 20 mg ramipril 2.5 mg D, plus amitriptyline 10 mg N for sleep. Please indicate how likely each drug-related problem would be in this case.

	Academics			Writers' answer
	Mode	Mean	Standard deviation	
• The patient's symptoms are likely to indicate a worsening of her heart failure.	6	6.50	0.51	7
• The swollen ankles may be due to an increased fluid intake caused by a dry mouth from the amitriptyline.	5	4.56	1.34	1
• Lercanidipine could be causing peripheral oedema.	7	6.67	0.59	7
• The swollen ankles may be due to an increased fluid intake resulting from hyperglycaemia.	2	3.22	1.70	1
• The patient may need to increase her level of exercise to improve blood flow in her ankles.	5	3.67	1.78	1
• The patient may have syndrome of inappropriate antidiuretic hormone secretion which has led to swollen ankles.	3	3.39	1.65	1
• The patient may have been experiencing an arrhythmia which has decreased her cardiac output and caused her swollen ankles.	4	4.11	1.53	1

Case 6

A woman comes into the pharmacy to collect her elderly husband's prescriptions for him while he is recuperating at home. She states there is a new prescription for 'Imdur 60 mg M' that was started in the hospital last week. The new medication doesn't seem to be working and her husband is still experiencing chest pain. The husband's history shows regular dispensing of Somac 40 mg N, Iscover 75 mg M, Lipitor 20 mg N, Duride 60 mg N, Coversyl 5 mg Spiriva 18mcg M and GTN spray p.r.n. Please indicate how likely each drug-related problem would be in this case.

	Academics			Writers' answer
	Mode	Mean	Standard deviation	
• Her husband may be experiencing a decrease in symptom control for his chronic obstructive pulmonary disease and his shortness of breath is causing the chest pain.	5	4.56	1.50	7
• Her husband may be experiencing nitrate tolerance if he has continued to take the Duride brand that he was initially prescribed, as well as the Imdur from the hospital.	7	6.61	0.70	7
• Her husband needs a higher dose of isosorbide mononitrate to control his symptoms.	1	3.72	2.27	7
• Her husband could be experiencing an interaction between clopidogrel and pantoprazole resulting in an exacerbation of coronary symptoms.	2	3.22	1.73	7
• Her husband needs to increase the use of his glyceryl trinitrate spray to improve his symptoms.	1	3.56	2.09	1
• Her husband should have aspirin added to decrease his chest pain symptoms.	1	2.83	1.82	1
• Her husband needs to increase his dose of pantoprazole because his chest pain may be due to worsening reflux.	5	4.56	1.72	1

For cases 7–9

- Very appropriate = 7
- Moderately appropriate = 6
- Only slightly appropriate = 5
- Neutral = 4
- Only slightly inappropriate = 3
- Moderately inappropriate = 2
- Totally inappropriate = 1

Case 7

A slightly overweight, 70-year-old male patient is currently taking warfarin (dose is 5 mg/4 mg on alternate days). He has a dental prescription for an abscess for amoxycillin 500 mg three times a day and metronidazole 400 mg three times a day. Please indicate how appropriate each recommendation would be in this case.

	Academics			Writers' answer
	Mode	Mean	Standard deviation	
• Cease the warfarin whilst taking the antibiotics.	1	1.78	1.52	1
• Discuss the interaction with the patient and recommend an increase in international normalised ratio (INR) monitoring whilst taking the antibiotics.	7	6.89	0.32	7
• Discuss the signs and symptoms of an increased INR with the patient.	7	6.83	0.38	7
• Recommend the dentist change the metronidazole to clindamycin.	2	3.89	2.37	1
• Recommend ibuprofen for pain relief for the dental abscess.	1	1.44	0.86	1
• Halve the warfarin dose whilst taking the antibiotics.	1	2.44	1.89	1
• Change the warfarin to aspirin whilst using the antibiotics.	1	1.11	0.32	1

Case 8

A 65 year-old female with airways disease has a recent dispensing history containing Seretide 250/25 (two puffs twice a day and Ventolin inhaler (1–2 p.r.n.). She presents a 3-month-old prescription to the pharmacist for prednisolone 25 mg, which reads '25 mg twice a day for three days, then 12.5 mg twice a day for three days'. On further discussion, the pharmacist determines that the patient is currently experiencing a worsening of the respiratory symptoms and is unsure what dose of prednisolone she should be taking. Please indicate how appropriate each recommendation would be in this case.

	Academics			Writers' answer
	Mode	Mean	Standard deviation	
• Advise the patient not to take the prednisolone 25 mg at all.	1	2.11	1.88	1
• Commence over-the-counter pantoprazole 20 mg daily to decrease the risk of gastrointestinal bleeds whilst taking the prednisolone.	1	2.28	1.41	1
• Dispense the prescription as written and instruct the patient to take it with food.	1	3.89	2.40	1
• Contact the patient's general practitioner and determine what prednisolone dose she should currently be taking.	7	6.67	0.84	7

	Academics			Writers' answer
	Mode	Mean	Standard deviation	
• Advise the patient to cease the Seretide whilst she is taking the prednisolone tablets.	1	1.06	0.24	1
• Advise the patient to increase the use of her Ventolin inhaler in preference to using the prednisolone.	1	1.89	1.28	1
• Advise the patient to discuss with her doctor about increasing the strength of her Seretide to the 500/50 Accuhaler.	6	4.78	2.07	7

Case 9

A 120 kg, 40-year-old male smoker with osteoarthritis is taking esomeprazole 40 mg daily, but currently has no gastrointestinal symptoms. The only other medication he is currently taking is regular paracetamol for his osteoarthritis pain that he buys over the counter, and his dispensing history shows ketoprofen and cephalexin dispensed several months ago. Please indicate how appropriate each recommendation would be in this case.

	Academics			Writers' answer
	Mode	Mean	Standard deviation	
• Dispense the prescription with dietary advice about avoiding reflux triggers.	5	4.17	1.79	1
• Recommend the patient return to the general practitioner to reduce his dose to 20 mg daily.	7	6.06	1.16	7
• Recommend the patient return to the general practitioner to trial using esomeprazole on a p.r.n. basis.	7	5.83	1.42	7
• Discuss a weight management programme with the patient.	6	6.33	0.59	7
• Discuss smoking cessation with the patient.	6	5.89	1.41	7
• Recommend the patient have his vitamin B ₁₂ levels checked.	4	3.67	1.85	4
• Recommend the patient stop the regular paracetamol and change back to ketoprofen to control his osteoarthritis pain.	1	1.22	0.73	1

Results

Reliability

A Cronbach's α value of 0.7 or higher is considered to show good correlation within the statements between subjects.^[12]

Table 1 Results of Cronbach's α statistical tests using various parameters

	Number of participants	Cronbach's α
Academics	18	0.620
Academics plus fourth years	46	0.630
Academics plus fourth and third years	87	0.704
Academics plus fourth, third and first years	129	0.843
Fourth, third and first years	111	0.828
All PROMISE	433	0.702
All academics, students and trial participants	562	0.802

PROMISE, Pharmacy Recording Of Medication Incidents and Services electronic documentation system trial dataset.

Analysis showed that the survey had moderate correlation for the final 40 statements ($\alpha = 0.62$) with 'α with the deletion of one item' ranging from 0.46–0.61, indicating that the statements had similar influence in the total score. When the analysis was performed on answers from additional groups (academics and fourth-year students, with and without third-year students), α was 0.63 and 0.70 respectively. Table 1 shows the reliability coefficients of various Cronbach's α tests using different parameters.

The Fleiss' κ statistical test was also run on the 40 answers given by the academics. The statistical test returned a value of $\kappa = 0.33$, which is considered a fair agreement between the raters.^[13]

Validation of the survey

The 40 statements were answered by 28 fourth-year, 41 third-year and 42 first-year undergraduate pharmacy students. The scoring system derived from the academics' answers was used to conduct an analysis of variance (ANOVA), which showed significant differences between the three groups of students ($P < 0.01$; Table 2). Post-hoc analysis using the Gabriel method showed significant differences between the first-years and the third- and fourth-years ($P < 0.001$ for both tests), with the difference between the third- and fourth-years approaching statistical significance ($P = 0.054$).

PROMISE pharmacist dataset

The PROMISE dataset was graded according to the scoring system outlined in the method and participating pharmacists were divided into three groups:

- Pharmacists with additional qualifications ($n = 26$)
- AACPA pharmacists ($n = 66$)
- Other pharmacists: control ($n = 341$)

Significant differences were seen between the three groups ($P = 0.003$), with post-hoc analysis using the Hochberg method showing a significant difference between the

Table 2 Descriptive statistics of the survey scores for the three groups of students

	Count	Mean	Standard deviation	Minimum	Maximum
Fourth years	28	52.36	6.62	42.00	68.00
Third years	41	48.20	6.59	33.00	58.00
First years	42	32.43	7.81	15.00	54.00
Total	111	43.28	11.14	15.00	68.00
Statistics	$F(2,108) = 82.14, P < 0.01$				

Table 3 Descriptive statistics of the survey scores for the three groups within the Pharmacy Recording Of Medication Incidents and Services electronic documentation system (PROMISE) trial dataset

	Count	Mean	Standard deviation	Minimum	Maximum
Other	26	56.42	6.71	40.00	65.00
AACPA	66	54.76	7.48	37.00	67.00
PROMISE	341	52.38	7.45	26.00	67.00
Total	433	52.98	7.50	26.00	67.00
Statistics	$F(2,430) = 5.82, P < 0.01$				

AACPA, Australian Association of Consultant Pharmacy accredited.

Table 4 Descriptive statistics of the survey scores for the two groups within the Pharmacy Recording Of Medication Incidents and Services electronic documentation system (PROMISE) trial dataset

	Count	Mean	Standard deviation	Minimum	Maximum
Other and AACPA	92	55.23	7.27	37.00	67.00
PROMISE	341	52.38	7.45	26.00	67.00
Total	433	52.98	7.50	26.00	67.00
Statistics	$t(431) = 3.27, P < 0.01$				

AACPA, Australian Association of Consultant Pharmacy accredited.

pharmacists with additional qualifications and the control PROMISE pharmacists ($P = 0.023$). The difference between AACPA pharmacists and the control PROMISE pharmacists was approaching significance ($P = 0.051$). There was no significant difference between the pharmacists with additional qualifications and the AACPA pharmacists ($P = 0.70$; Table 3), therefore these two groups of pharmacists were combined. An independent samples *t*-test was performed on the resulting two groups (pharmacists with additional qualifications or accreditation to perform medication reviews versus other pharmacists) and a significant difference was still detected ($P = 0.001$; Table 4).

The demographic comparisons between participating pharmacists and the average Australian pharmacist showed a similar gender distribution, however PROMISE pharmacists were significantly younger on average ($\chi^2 = 134.63$, $df = 4$, $P < 0.001$). Despite this, there was no correlation between the pharmacist's clinical knowledge survey score and their graduation year (Pearson's $r = 0.002$, $n = 427$, $P = 0.973$) or their age range (ANOVA; $F(4,427) = 1.02$, $P = 0.40$). Female pharmacists had a significantly higher mean clinical knowledge survey score than their male counterparts ($t(430) = -2.96$, $P = 0.003$). A multiple regression analysis

was performed, showing that pharmacists who were female or had additional qualifications were more likely to have a higher clinical knowledge score; however the resulting model was a poor fit ($R^2 = 0.045$).

Correlation with the pharmacist's intervention rate

Out of 433 pharmacists who completed the survey-based clinical knowledge measurement tool, 421 participated in the 12-week trial and therefore had an intervention rate calculated. There was a moderate, but statistically significant, positive correlation between the PROMISE participants' clinical knowledge survey score and their individual intervention rate in practice (Spearman's $\rho = 0.19$, $P < 0.001$). When the pharmacists' scores were split into quartiles, a Kruskal–Wallis analysis also showed significant differences between the average intervention rate of each quartile ($\chi^2 = 13.94$, $df = 3$, $P = 0.003$), with a post-hoc Jonckheere–Terpstra test showing a significant positive trend, so that as the survey score increased, so did the pharmacist's intervention rate ($t = 3.60$, $P = 0.001$).

Discussion

Major findings

The 40-item survey appeared to provide an accurate reflection of pharmacists' clinical knowledge and correlated with the pharmacist's clinical intervention documentation rate in practice, as measured during the PROMISE III trial.^[9] Those pharmacists with a higher survey score recorded, on average, a significantly higher number of clinical interventions. It seems reasonable to infer that pharmacists with a greater level of clinical knowledge tended to detect and resolve more DRPs than their less-knowledgeable colleagues.

Study limitations

The 40-item survey was considered to possess moderate internal consistency in the 18 academics with Cronbach's $\alpha = 0.62$ and a fair agreement between raters being shown with Fleiss' κ ($\kappa = 0.33$). A low Cronbach's α score does not always indicate an unreliable survey, as it can indicate that there may be subsets of questions within the survey affecting the results.^[15] Also, other studies have reported similar Cronbach's α scores; for example, a study examining the knowledge of chronic kidney disease guidelines amongst medical interns reported a Cronbach's $\alpha = 0.69$.^[16] The construction and purpose of this survey was similar to the clinical knowledge survey described within this article, therefore achieving a similar Cronbach's α was considered acceptable. As only moderate internal consistency was achieved, the assessment was trialled in a wider number of participants (the undergraduate students) to determine if it was still an appropriate tool to determine the ability to detect and resolve DRPs.

By making participation mandatory and removing access to any resources, the survey results obtained from the students were considered to be free from bias. This level of control was not achieved with the participating pharmacist group, as the pharmacists could access the survey online from any computer, and therefore could access additional resources despite being encouraged not to. In addition, only 433 pharmacists (out of a possible 531 participating in the PROMISE trial) answered the survey; therefore, it is possible that only the more enthusiastic and confident pharmacists may have participated. In this sense, the results from the students could be considered more accurate, as the influence of these factors remains largely unknown and is therefore a limitation that may have biased the pharmacist results.

Discussion of findings

The clinical knowledge survey score of the pharmacists correlated well with their intervention rate, and the survey also appeared to provide an accurate reflection of students'

clinical knowledge. It was assumed that students with more years of training should have, on average, better clinical knowledge than those with fewer. This expectation was met, with the fourth-year students achieving higher scores on the survey, followed by the third-year and first-year students. Interestingly, the abilities of the fourth-year students were on par with those of the community pharmacists involved in the trial, with no significant difference found between their scores.

The survey scores showed the main significant difference occurred between the pharmacists with additional qualifications and the control pharmacists. This again indicates that the survey may accurately reflect the clinical knowledge of the pharmacists, as it would be expected that pharmacists who had received additional clinical training (either through tertiary education or training and accreditation to perform medication reviews) would have a higher level of clinical knowledge than pharmacists who had not. This result is similar to a Swedish study that examined the differences between the abilities of pharmacists and pharmacy technicians in detecting DRPs, where the pharmacists (who had achieved a higher level of education) had a higher rate of DRP detection.^[17] It follows that by increasing the level of additional training that pharmacists receive, the number of DRPs detected and resolved within community pharmacy may be increased. Indeed, a recent study in the USA showed that pharmacists self-report that continuing education increases their clinical knowledge and the level of patient care they provide,^[18] which could lead to an increased number of DRPs detected. Such an increase would be reasonably expected to drive a reduction in hospital admissions and other morbidity caused by DRPs.^[19] Similar findings have occurred in studies examining the knowledge and performance of physicians, which have concluded that continuing education improved physician performance^[20–22] and, in some cases, health outcomes for patients.^[23]

It might be expected that a pharmacist's clinical knowledge would decrease as the number of years since leaving university increased, because knowledge may decline when not being consistently used. Interestingly, there appeared to be no correlation between the clinical knowledge survey score and the graduation year or age range of the pharmacist. This may again indicate that the clinical knowledge survey is a practical tool that identifies the pharmacist's current abilities in identifying and resolving DRPs, rather than just a novel measure of their clinical knowledge, as it would be expected that pharmacists using their skills regularly within community pharmacy would have more experience at managing DRPs, therefore resulting in a higher clinical knowledge survey score.

Female pharmacists had a significantly higher clinical knowledge survey score than their male counterparts. This could be partly due to the fact that male pharmacists tend to

work longer hours,^[24] and tend to be more business-focused, and therefore may have less time to effectively participate in online surveys. The gender of the students was not collected and therefore it is unknown whether this difference would be seen within the student groups (where classes also tend to have a higher proportion of females), or only seen within the pharmacist group.

Ultimately, the survey could also be used as a training tool for both students and pharmacists. For example, the survey could be used to assess a pharmacist's clinical knowledge and identify any areas of knowledge deficiency, thereby driving an increase in certain aspects of continuing education amongst pharmacists.

Conclusion

The survey-based clinical knowledge measurement tool that was developed appeared to estimate a pharmacist's ability to detect and resolve DRPs within the community pharmacy environment. The pharmacists' scores correlated with their rate of clinical interventions, which indicates that clinical

knowledge helps in the detection of DRPs and the performance of interventions. This tool could be used in the future to determine current levels of clinical knowledge amongst community pharmacists and also to identify areas for improvement to increase their abilities.

Declarations

Conflict of interest

The Authors declare that they have no conflicts of interest to disclose that may involve the subject matter of the manuscript and compromise its integrity.

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