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Published in:
EMA - Emergency Medicine Australasia

DOI:
10.1111/1742-6723.12334

EMA Emergency Medicine Australasia

Emergency Medicine Australasia (2015) **27**, 47–54 doi: 10.1111/1742-6723.12334

ORIGINAL RESEARCH

Can a barcode scanner for blood collection improve patient identification integrity in the emergency department? A prospective before-and-after study

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Abstract

***Objective*:** To describe the effect of interventions designed to improve patient identification (PI) during pathology collection in the ED.

***Methods*:** A prospective before-and-after intervention study was conducted between June 2009 and June 2010 in a regional ED in Queensland, Australia. Interventions aimed to improve PI and specimen labelling, and consisted of: (i) education alone; and (ii) education plus an armband scanner that voice-prompted collector behaviour. Main outcomes measured included: frequency of correct key behaviours (KBs) during specimen collection, pathology integrity errors and cost of interventions.

***Results*:** Data from 282 ED pathology collections were analysed (before: $n = 115$, after with education: $n = 95$, after with education plus armband scanner: $n = 72$). KBs for PI and labelling improved significantly following education plus armband scanner use. Application of armbands before sample collection increased (36% *vs* 90%, $P < 0.001$), as did asking the patient to state their name (25% *vs* 93%, $P < 0.001$) and date of birth (22% *vs* 93%, $P < 0.001$). These results were similar, albeit less pronounced, when the effect of education only was assessed. No primary patient misidentification was detected in this small study. The annual costs for a hospital to adopt the education programme with and without the armband scanner were $104 045 and $5330 respectively.

***Conclusion*:** ED staff had poor behaviours for identifying patients and labelling pathology specimens before intervention. These safety behaviours were considered an assumed skill. Education alone improved critical KBs markedly that was further augmented by the armband scanner. The cost to adopt education alone is relatively low compared to the addition of armband scanner technology.

Key findings

- Emergency staff must confirm patient identification by eight key behaviours during pathology collection to ensure sample integrity.
- Key behaviours to ensure patient identification by emergency staff can be improved by education alone.
- Key behaviours to ensure patient identification by emergency staff who have received education can be reinforced by the addition of technology such as voice prompting bar code scanners.

Key words: *emergency department, patient identification system, safety, technology.*

Introduction

Poor patient identification (PI) in the hospital[1] and ED setting is a recognised safety risk.[2,3] Poor PI has been identified as a key issue by major international patient safety agencies, including the World Health Organization, National Patient Safety Agency in the UK, Joint Commission International Centre for Patient Safety and the

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Accepted 2 November 2014

TABLE 1. *Risk areas for pre-analytical identification failures (PAIF)*

Risk area	PAIF
1	Sample from patient where identity was not verified – might or might not be correct patient
2	Sample from identity-verified patient but insecure before labelled – sample received might or might not be correct patient
3	Sample from identity-verified patient, but labels not checked as consistent when applied – sample received might or might not be correct patient
4	Form printed but not verified – sample received might or might not be correct patient

National Patient Safety Centre in the USA as well as the Australian Commission on Safety and Quality in Healthcare.[4]

ED care can be impacted by poor PI during blood collection.[5] This can lead to pre-analytical identification failures (PAIFs). These are defined as present when the blood is either taken from the wrong patient or when the identity on labels or pathology forms are not consistent with the identity of the sample. They generally can occur in four major areas as indicated in Table 1.[6,7]

Scrutiny of the four factors indicates they require consistent human behavioural action to ensure accuracy. However, imprecise actions in one or more of these four areas might not lead to PAIF. Additionally, our current quality control systems only identify some of the PAIF. Actual or identified PAIFs have variable outcomes, including rejection of samples, recollections, misdiagnosis, failure to diagnose and incorrect therapeutic interventions. These errors are largely preventable.[3] The reported incidence of identified PAIF, such as these, range from 0.092%[3] to 1%.[5,8] However, an unknown number of PAIF are not detected by our normal systems.

The study site's clinical incident system identified the local PAIF rate as 1.01%, which raised concerns regarding our blood sample integrity. We hypothesised that novel technology in the form of an armband scanner that voice-prompted critical key behaviours (KBs) of PI by the specimen collector would be able to reduce PAIF.

The aims of the present study were to: (i) identify KBs that should reduce risk of PAIF; (ii) assess baseline compliance of KB; (iii) assess the effect of education on KB; (iv) assess any additional effect of voice-prompting armband scanners on KB; and (v) assess the cost of interventions.

Methods

Design

A prospective interventional study incorporating a before-and-after design was conducted between 22 June 2009 and 25 June 2010. Three arms were specified for the trial: Arm 1: Pre-intervention (22 June–30 October 2009); Arm 2: Post-intervention with education only (1 March–25 June 2010); and Arm 3: Post-intervention with education plus armband scanners (1 March–25 June 2010). The study was approved by the local Health District's Human Research Ethics Committee.

Setting and sample

The study was undertaken in a public ED in South East Queensland, Australia with over 65 000 attendances in 2010.

During times of study observation, data collection occurred when staff collected blood from patients placed in eight predetermined beds within the ED. The same beds were used in all three arms of the study. Half of the collection beds had an armband scanner in the post-intervention phase. To facilitate comparability of the three arms, we used computer-generated randomisation to choose in which bed the next patient–collector interaction would be observed.

The process of pathology collection and PI is summarised in Table 2. A behavioural failure was defined as an omission of any of the 11 predefined KBs. Eight critical KBs were identified to guarantee PI and that the sample was labelled correctly; three desired KBs would not effect the PI and labelling, but increased the chance of form and labelled sample matching. Labels for blood tubes at the study site were independently produced by clerks and placed with the medical files. After the intervention, the labels for blood tubes could also be created by a bedside printer initiated by correct armband scanner use. Labels were not used on the computer-generated request form created by clinician request. Sample size was based on departmental data, which showed a baseline error rate of 50% in any of the 11 KBs. A reduction to 30% (i.e. decrease of 20%) was assumed to be clinically important. Using an alpha of 5% and power of 80%, a sample size of 73 observations per arm was required.

Data collection

ED staff were observed during the patient's initial ED pathology collection for each of the three study arms by one embedded research nurse following specific training delivered by chief investigators (DS, GK). The embedded research nurse had independently identified the patient before study observation, and was an experienced nurse performing standard and usual nursing duties. This nurse usually worked in the same role, and as such their presence would not be considered unusual. ED staff and patients were unaware of the study and observation role of the embedded research nurse. Observation occurred between 11.00 and 17.00 hours from Monday to Friday. Pathology staff completed a separate data form for samples received. The completed form by the embedded research nurse and pathology were compared, and if discordant (mislabelling) a PAIF was recorded and the sample was not tested (i.e. no test).

Demographic data for collectors and patients were collected. Observations were excluded if: (i) the collector was a study investigator; (ii) the patient was unconscious or clearly unable to participate in

TABLE 2. *Key behaviours for correct patient identification, labelling and maintenance of sample integrity*

Criticality of key behaviour	Rationale for criticality	Key behaviour number	Key behaviour definition
Critical	Incorrect patient	1	Patient armband applied before specimen collection
Critical	Incorrect patient	2	Armband checked by staff before collection
Critical	Incorrect patient	3	Patient asked to state name
Critical	Incorrect patient	4	Patient asked to state date of birth
Critical	Blood tubes mix-up	5	Labels applied immediately (at bedside)
Critical	Blood tubes mix-up	6	Labels signed (at bedside)
Critical	Blood tubes mix-up	7	Specimen never left unattended before correct labelling (secure)
Critical	Suspected blood tubes mix-up by lab	8	'No test' recorded
Desired	Form mix-up	9	Pathology request form generated before specimen collection
Desired	Form mix-up	10	Request form taken to the bedside
Desired	Form mix-up	11	Patient label taken to, or printed at the bedside

In study Arms 1 and 2, key behaviours 1–10 comprised standard practice requirements; pathology collection would take place after key behaviour 2→ key behaviour 4; in study Arm 3, the armband scanner device voice-prompted the collector to perform key behaviours 3 and 4 and facilitated key behaviours 9, 10 and 11. 'No test' recorded refers to case where if the data collection form by the ERN and pathology staff did not match, this indicated PAIF (mislabelling). As a result, the lab would not process this blood for testing. When this occurs, staff would be informed and a new sample needed to be drawn with identification process intact.

identification; and (iii) pathology collection and PI occurred without observation.

Interventions

Pre-intervention data were collected from 22 June–30 October 2009. From 7 December 2009 to 25 February 2010, approximately 100 medical and nursing staff received education on new bar-coded armbands, armband scanner use, the required KBs in specimen collection and PI (Table 2). This included emphasis on the 'query system' of PI where the patient was asked to state name and date of birth. Staff were instructed to use this 'query system' regardless of armband scanner use. The education took place in normal ED education forums, lasted approximately 60 min and was delivered consistently by a senior ED medical staff member. Armband scanner devices and scanning procedure on armbands were demonstrated and practised. Data for Arm 2 and 3 were collected from 1 March to 25 June 2010. The bar-coded armbands (Laserband 2 advanced ID Band custom print label system by Zebra Technologies, Lincolnshire, IL, USA) and armband scanner (Metrologic OptimusS Portable Data Terminal, Metrologic Instruments, Blackwood, NJ, USA) were purchased from commercial vendors. These are shown in Figures 1a,b and 2, respectively. Armband scanners were placed at the bedside of four selected beds to scan the bar-coded armband of the patient. Armband scanner voice prompted the collector to use the 'query system' for PI, and printed labels at the bedside. A Daikin network router was required to enable communication between the scanner and printer.

Outcome measures

The frequency of the KBs during the identification process (Table 2) was compared between the three arms of the study. Primary outcomes were frequency of compliance to critical KBs required for correct PI, sample labelling and integrity. Secondary outcomes included compliance to desired KBs and healthcare costs.

Statistical analysis

Data collected were entered into SPSS v15.0 (SPSS Inc, Chicago, IL, USA). The statistician was blinded to arm (1, 2 or 3) allocation. Descriptive statistics were used to summarise data; inferential statistics were used for pre- and post-intervention comparisons. For dichotomous data, Chi-square tests were used and for smaller sample sizes Fisher's exact test was used.

A trial-based cost-analysis was performed from the perspective of costs to the hospital. Six 1 h education sessions were provided to 100 staff, with each attended by 15–20 clinical staff at a cost of $330 for the educator ($55 per h) and $5000 for the clinical staff ($50 per h per staff member).[9] The costs for armband scanners included education plus fixed costs of the armband scanner devices ($5000 each, annuatised at 5% over the expected 2 year life of the device), and variable costs of $1.00 per armband per patient plus $0.30 label cost for the 35% who require pathology (Gold Coast Hospital, pers. comm., 2011). A secondary analysis was undertaken to estimate the costs for a typical ED to implement education or education plus armband scanner. Outside of the trial, it was estimated that 10 armband scanner devices would be re-

Emergency Medicine Australasia published by Wiley Publishing Asia Pty Ltd on behalf of Australasian College for Emergency Medicine and Australasian Society for Emergency Medicine

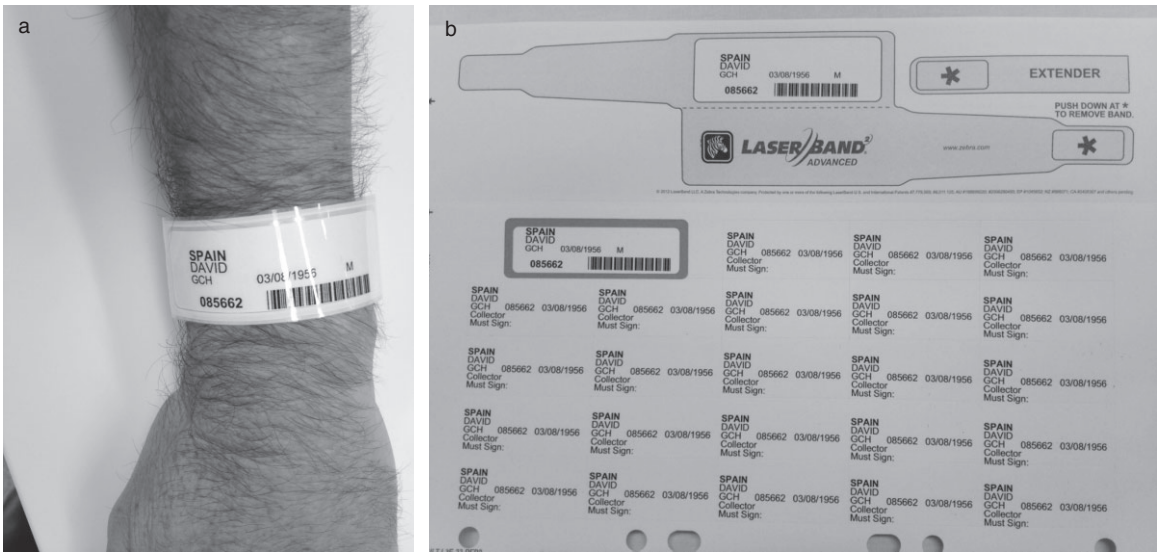

Figure 1. *(a) Laser printed armband. (b) Armband and labels for pathology.*

Figure 2. *Armband scanner.*

quired for an ED with an annual throughput of 65 000 patients. All costs are reported in 2010 Australian values.

Results

During the study period, 284 patient–collector pathology interactions were observed: 115 in the pre-intervention phase (Arm 1), 95 in the post-intervention education only (Arm 2), and 72 in the post-intervention using education plus armband scanner (Arm 3). Two interactions were excluded from analysis because of the inability of the embedded research nurse to adequately observe the interaction.

Patient and collector demographics

The baseline demographics of collectors and patients (Table 3) were similar in all three arms. The mean age of patients observed was 60 years (SD 20).

Primary outcome measures

The proportion of correctly performed critical KBs during the pathology collection process improved significantly between the pre- and post-intervention phases (Table 4), with improvement in every KB with education alone (Arm 2 *vs* Arm 1), and more so with education plus armband scanner (Arm 3 *vs* Arm 1). A secure collection process, where samples were in the possession of the collector until labelled – as judged by the embedded research nurse – was observed in 90.4% during the pre-intervention. This improved with education alone to 98.9% and to 100% in the education plus armband scanner group.

The laboratory data pertaining to specimen integrity and desirable information for laboratory use was similar for all three arms (Table 5). Labels on all samples received were cross-checked with embedded research nurse data. These confirmed patient identification and laboratory identification were congruent in all cases. The 'no tests' on review included three identified PAIFs and some other clerical deficiencies. These three cases were all labelled tubes not matching the request form and typical of detected PAIF. In all instances, the tube labels matched PI for the observed interaction, and the wrong form sent subsequently with the sample.

Secondary outcome measures

The proportions of correctly performed *desired* KBs during the pathology collection are displayed in Table 5. Education alone and education plus armband scanner did not achieve statistically significant improvements. The intervention costs per patient in the trial for education and education plus armband scanner groups were $56.11 and $149.83, respectively. The main cost driver for education was the cost for the staff attending sessions, whereas the main cost driver in the education plus armband scanner group was the cost of the armband scanner devices. Scaling these costs up for a typical hospital ED (i.e. 65 000 patients attending the ED annually, 10 armband scanner devices, 35% requiring a pathology test and labels, and 100 staff attending one of six education ses-

TABLE 3. *Patient and collector demographics*

Demographics	Pre-intervention	Post-intervention		*P* value
	Arm 1: *n* = 115 (%)	Arm 2: Education *n* = 95 (%)	Arm 3: Education + ABS *n* = 72 (%)	Arm 2 *versus* Arm 1, Arm 3 *versus* Arm 1, Arm 3 *versus* Arm 2
Patient sex				
Male	53.9	61.1	52.8	0.298, 0.88, 0.284
Mode of presentation				
Self-presented	29.6	26.3	28.9	0.602, 0.954, 0.683
Ambulance	70.4	73.7	66.7	0.602, 0.954, 0.683
Triage category				
1	0.0	2.1	1.4	0.118, 0.205, 0.73
2	56.5	55.8	66.7	0.915, 0.167, 0.154
3	41.7	38.9	30.6	0.682, 0.124, 0.261
4	1.7	3.2	1.4	0.502, 0.853, 0.459
5	0.0	0.0	0.0	1.000, 1.000, 1.000
Presenting LOC				
Alert	90.4	89.4	95.8	0.817, 0.172, 0.129
Confused/demented	9.6	10.6	4.2	0.817, 0.172, 0.129
Organisation problems				
No	97.4	98.9	98.6	0.412, 0.575, 0.843
Yes, fatigue	0.0	1.1	0.0	0.27, 1.000, 0.383
Yes, cultural barrier	2.6	0.0	0.0	0.113, 0.167, 1.000
Yes, other	0.0	0.0	1.4	1.000, 0.205, 0.249
Collector sex				
Male	34.8	34.0	29.6	0.867, 0.425, 0.534
Collector				
Medical student	0.0	3.2	0.0	0.055, 1.000, 0.128
Intern	7.8	8.4	4.2	0.875, 0.32, 0.272
Resident medical officer	13.9	14.7	22.2	0.865, 0.142, 0.212
Registrar	7.0	10.5	5.6	0.358, 0.704, 0.251
Consultant	0.9	3.2	0.0	0.227, 0.428, 0.128
Nurse	70.4	60	68.1	0.113, 0.731, 0.284

Data presented as % within intervention period. ABS, armband scanner; LOC, level of consciousness.

sions lasting 1 h), the total annual costs to implement education alone or education plus armband scanner would be approximately $5330 and $104 045, respectively, resulting in a cost per patient of $0.08 and $1.60 for the respective interventions.

Discussion

The present study found that all eight critical KBs in the identification process during specimen collection in ED can be improved by education alone and augmented further by combining this education with the use of armband scanner. The pre-intervention phase (Arm 1) of the present study revealed clear deficiencies in staff practices in PI, sample labelling and integrity. Staff adequacy in performing these is often perceived as an assumed skill. Encouragingly, the present study shows that behaviour can be improved.

The suboptimal behaviours for PI and sample labelling during pre-intervention suggest that the laboratory was at risk of unknowingly accepting and processing samples without guaranteed identification integrity. However, as predicted by Reason's 'swiss-cheese' error model,[10] such behavioural lapses often do not lead to actual PAIF and might not lead to major harm. The most frequent outcome from an identified PAIF is an avoidable additional pathology collection. The bigger issue is unidentified PAIF and the actual number of these is likely low but unknown. However, not all are harmless, as studies on actual transfusion AEs have demonstrated misidentification as a high-risk theme in ED.[11,12]

An increasing number of hospitals is implementing bar-coding systems to prevent errors in patient identification.[13] A bar code is no panacea; it guarantees only that the information recorded on the wristband is transmitted electronically, but does not ensure that the information on the wristband is correct. A case study demonstrated a potentially fatal mix-up between two patients inadvertently labelled with the other's armband.[14] Another study investigating complications while transferring patients to the ICU reported the application of an incorrect patient identification band to a preoperative patient.[15] Clearly, if only a single line of defence (i.e. technology alone) is relied on for identifica-

TABLE 4. *Primary outcome measures for pathology collection*

Outcome	Pre-intervention	Post-intervention		*P* value
	Arm 1: *n* = 115 (%)	Arm 2: Education *n* = 95 (%)	Arm 3: Education + ABS *n* = 72 (%)	Arm 2 *versus* Arm 1, Arm 3 *versus* Arm 1, Arm 3 *versus* Arm 2
Armband present before taking sample				
Yes	41 (35.7)	58 (61.1)	61 (89.7)	<0.001, <0.001, <0.001
Armband checked before taking sample				
Yes	13 (11.3)	32 (33.7)	40 (58.0)	<0.001, <0.001, 0.004
Patient asked to state name				
No	82 (73.2)	38 (40.0)	4 (5.8)	<0.001, <0.001, <0.001
Yes	28 (25.0)	50 (52.6)	64 (92.8)	<0.001, <0.001, <0.001
Unable to because of patient condition	2 (1.8)	4 (4.2)	0 (0.0)	0.413, 0.524, 0.135
Unclear	0 (0.0)	3 (3.2)	1 (1.4)	0.091, 0.385, 0.635
Patient asked to state date of birth				
No	88 (77.2)	40 (42.1)	4 (5.8)	<0.001, <0.001, <0.001
Yes	25 (21.9)	47 (49.5)	64 (92.8)	<0.001, <0.001, <0.001
Unable to because of patient condition	1 (0.9)	4 (4.2)	0 (0.0)	0.178, 1.000, 0.135
Unclear	0 (0.0)	4 (4.2)	1 (1.4)	0.040, 0.385, 0.392
Sample labelled				
No	0 (0.0)	0 (0.0)	0 (0.0)	
Yes, at bedside	47 (41.6)	69 (72.6)	48 (70.6)	<0.001, <0.001, 0.405
Yes, away from bedside	66 (58.4)	26 (27.4)	20 (29.4)	<0.001, <0.001, 0.953
Sample signed				
No	2 (1.7)	0 (0.0)	0 (0.0)	0.502, 0.524, 1.000
Yes, at bedside	46 (40.0)	69 (72.6)	46 (67.6)	<0.001, 0.001, 0.227
Yes, away from bedside	67 (58.3)	26 (27.4)	22 (32.4)	<0.001, <0.001, 0.652
Sampling process secure				
Yes	103 (90.4)	94 (98.9)	67 (100.0)	0.005, 0.004, 1.000
Form and sample sent together				
Yes	108 (100.0)	95 (100.0)	56 (96.6)	1.000, 0.121, 0.142
No test recorded				
Yes	9 (8.0)	0 (0.0)	3 (4.2)	0.005, 0.376, 0.078

Percentages displayed are the percentage of responses excluding missing data. ABS, armband scanner.

tion, errors still occur. All technology needs to operate within an environment of safety awareness and on its own cannot replace best practice in these processes.[13] Taking this into account, the technology we used in our study has the added advantage of encouraging best practice human behaviour where the collector independently verifies the patient's identity with the patient.

In the United States, it has been estimated that specimen-related errors can cost hospitals $200–$400 million per year.[16] The technology used in our study had significant set-up, maintenance and replacement costs. We used the technology as an adjunct to education and not as a stand-alone solution. Within the short time frames of our study, education alone improved outcomes significantly. We believe that this was partly because of the poor rate of compliance with PI seen during the pre-intervention phase, as well as the effectiveness of the education. Education alone appeared to be cost-effective during the brief course of the study. However, there is a large staff with high turnover in ED that would require ongoing education. Moreover, education alone has not been found to provide sustained effect in the longer term.[17] More significant improvements are seen when education is used in conjunction with a change in work practices.[18] Thus, armband scanner with education might be the more effective intervention for longer term, although we cannot demonstrate it as cost-effective by this study.

Limitations

Performance bias might have had an impact on our study. We minimised this by not informing staff and patients that their interactions were being observed. Second, blinding of staff to the embedded research nurse undertaking observations in the field might have been incomplete, but there were no instances of evident detection of the embedded research nurse by staff. Data for two patients were incomplete and discarded as the embedded research nurse was unable to witness all actions while undertaking other necessary nursing duties.

Third, data collection was limited to weekdays, 11.00 to 17.00 hours. Thus, some patient and staff factors might have been underrepresented. Outside

TABLE 5. *Laboratory data and secondary outcomes for pathology specimens received during study*

Outcome	Pre-intervention	Post-intervention		*P* value
	Arm 1 %	Arm 2 Education %	Arm 3 Education + ABS %	Arm 2 *versus* Arm 1, Arm 3 *versus* Arm 1, Arm 3 *versus* Arm 2
Laboratory data for pathology specimens received during study				
Form and sample arrive together				
Yes	109 (96.5)	94 (100.0)	71 (98.6)	0.128, 0.650, 0.434
Labels signed				
Yes	107 (97.3)	94 (100.0)	71 (98.6)	0.251, 1.000, 0.434
Request form signed				
Yes	108 (99.1)	94 (100.0)	71 (100.0)	1.000, 1.000, 1.000
Time and date on form				
No	5 (4.5)	1 (1.1)	1 (1.4)	0.151, 0.262, 0.841
Yes, date only	8 (7.1)	2 (2.1)	3 (4.2)	0.098, 0.427, 0.436
Yes, time only	2 (1.8)	1 (1.1)	0 (0.0)	1.000, 0.520, 1.000
Yes, time and date	97 (86.6)	90 (95.7)	67 (94.4)	0.016, 0.071, 0.683
Labelled tubes match request form				
Yes	110 (98.2)	94 (100.0)	68 (97.1)	0.501, 0.639, 0.181
Secondary outcome measures for pathology collection				
Form generated before sampling				
No	89 (78.1)	62 (65.3)	47 (69.1)	0.052, 0.070, 0.998
Yes, manual	6 (5.3)	5 (5.3)	4 (5.9)	0.988, 0.920, 0.933
Yes, electronic	19 (16.7)	28 (29.5)	17 (25.0)	0.025, 0.232, 0.398
Form taken to bedside				
Yes	31 (27.2)	33 (34.7)	29 (42.6)	0.223, 0.058, 0.463
Labels taken to bedside				
Yes	100 (88.5)	85 (90.4)	65 (95.6)	0.575, 0.493, 0.865
Costs				
Total costs†	$0	$5,330	$10,788	N/A
Cost per patient	$0	$56.11	$149.83	N/A

Percentages displayed are the percentage of responses excluding missing data. ABS, armband scanner. †In Australian dollars; based on two armband scanner devices, 35% requiring pathology test and thus a label cost, and 100 staff attending one of six education sessions lasting 1 h.

of these hours, increased presentations of intoxicated, uncooperative or aggressive patients compounded by fewer staff with fatigue and distraction might have increased the incidence of KBs. However, our randomisation process resulted in comparable demographics in each arm. The embedded research nurse collected data, and as such was not blinded, but formal blinding would have been logistically challenging and taken more resources than we had available.

Furthermore, we focused on failure rates in KBs of the identification process, and failure in one or more KBs might not lead to a PAIF. However, we would have required a massive study to have appropriate power to detect any significant differences in mislabelling and primary patient misidentification rates, as the baseline error rate was very low.

Although we excluded patients who were clearly confused or unconscious, six patients were randomised who could not state their name or date of birth because of their condition. We have chosen to keep these patients in the analysis, because: (i) it represents real-world practice where patient identification might be problematic; and (ii) by analysing these patients, we adhere to the intention to treat principle.

Another limitation was the variation in sample size between the arms. The difference in patient flow in different pre-allocated areas made data collection quite variable. Also, Arm 3 did not reach the pre-specified sample required (72 instead of 73). The differences in outcomes between the arms were quite pronounced, and as such this would have been a more serious concern if no differences were found and the study could have been viewed as potentially underpowered.

Lastly, all staff–patient interactions were unique, with no duplication of interactions. However, we did not collect information on individual clinician involvement (only their type and seniority). As such, we cannot comment on the effect that individual practice might have had.

Future implications

The pre-intervention phase demonstrates a pressing need to change our culture in the way our ED identifies patients and label specimens. ED staff need to recognise that this is not an assumed skill. This moderate size study indicates that there is potential for improved safety in the ED setting. A

short-term benefit on KBs has been demonstrated by the present study with education alone or when education and technology have been combined. The expected cost of $1.60 for education plus arm-banding is relatively large compared with the cost of $0.08 per patient for education alone; however, arm-banding might still provide value for money depending on the potential consequences of a primary patient misidentification error and the value from avoiding an error.

Although we can significantly reduce failures in the KBs of patient identification, larger studies would be required to fully assess impact on the integrity of pathology samples received at the laboratory. In addition, further alignment of the PAIF identified for the present study with the National Safety and Quality Health Service Standards[19] that were published after our study was undertaken is recommended.

Conclusion

The present study demonstrates that ED staff have suboptimal PI behaviours and poorly follow critical steps to correctly label pathology specimens. Many of these PI failures are undetected in an environment that assumes PI and specimen integrity. Improvements are possible with intervention by an education programme alone and augmented with additional use of an armband bedside scanner that prompts PI behaviour. The costs for both interventions are estimated.

Acknowledgements

We wish to acknowledge funding received from the Queensland Emergency Medicine Research Foundation to undertake the present study. We also wish to acknowledge Tony Ghent (Supervising Scientist, Pathology Queensland), emergency and pathology department staff, and data collectors involved in the present study.

Author contributions

Each member contributed to the manuscript in the following manner: planning – DS, JP, GK, JC, MS; conduct – DS, JP, GK; Reporting of work – DS, JP, GK, JC, MS, PS; and responsible for overall content as guarantor(s) – DS, GK, JC, JP, MS, PS.

Competing interests

GK is a section editor for *Emergency Medicine Australasia*.

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