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Factors influencing the successful implementation of a novel digital health application to streamline multidisciplinary communication across multiple organisations for emergency care

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Abstract

Rationale: Delivering optimal patient health care requires interdisciplinary clinician communication. A single communication tool across multiple pre-hospital and hospital settings, and between hospital departments is a novel solution to current systems. Fit-for-purpose, secure smartphone applications allow clinical information

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to be shared quickly between health providers. Little is known as to what underpins their successful implementation in an emergency care context.

Aims: To identify (a) whether implementing a single, digital health communication application across multiple health care organisations and hospital departments is feasible; (b) the barriers and facilitators to implementation; and (c) which factors are associated with clinicians' intentions to use the technology.

Methods: We used a multimethod design, evaluating the implementation of a secure, digital communication application (Pulsara™). The technology was trialled in two Australian regional hospitals and 25 Ambulance Victoria branches (AV). Post-training, clinicians involved in treating patients with suspected stroke or cardiac events were administered surveys measuring perceived organisational readiness (Organisational Readiness for Implementing Change), clinicians' intentions (Unified Theory of Acceptance and Use of Technology) and internal motivations (Self-Determination Theory) to use Pulsara™, and the perceived benefits and barriers of use. Quantitative data were descriptively summarised with multivariable associations between factors and intentions to use Pulsara™ examined with linear regression. Qualitative data responses were subjected to directed content analysis (two coders).

Results: Participants were paramedics ($n = 82$, median 44 years) or hospital-based clinicians ($n = 90$, median 37 years), with organisations perceived to be similarly ready. Regression results ($F(11, 136) = 21.28$, $p = <0.001$, Adj $R^2 = 0.60$) indicated Habit, Effort Expectancy, Perceived Organisational Readiness, Performance Expectancy and Organisation membership (AV) as predictors of intending to use Pulsara™. Themes relating to benefits (95% coder agreement) included improved communication, procedural efficiencies and faster patient care. Barriers (92% coder agreement) included network accessibility and remembering passwords. Pulsara™ was initiated 562 times.

Conclusion: Implementing multiorganisational, digital health communication applications is feasible, and facilitated when organisations are change-ready for an easy-to-use, effective solution. Developing habitual use is key, supported through implementation strategies (e.g., hands-on training). Benefits should be emphasised (e.g., during education sessions), including streamlining communication and patient flow, and barriers addressed (e.g., identify champions and local technical support) at project commencement.

KEYWORDS
communication barriers, disruptive technology, evaluation, health services research, implementation science, patient-centred care

1 | INTRODUCTION

Miscommunication is a common factor in adverse events in hospital.[1,2] Conversely, early communication of patient details as part of pre-notification of hospitals for time-critical conditions can improve door-to-treatment times[3] which are subsequently associated with improved patient outcomes.[4,5] For a range of medical conditions, multiple clinicians are involved in assessing, diagnosing and delivering treatment to each patient, and these clinicians are often dispersed across different organisations (e.g., emergency medical service, hospital, general practice) and multiple departments (e.g., emergency, radiology, specialist medical units). Communication of personal or clinical information often needs to be repeated each time about the same patient, creating inefficiencies that may contribute to delays in diagnosis or treatment decisions. For example, approximately 25% of information provided verbally by paramedics during handover was not included in hospital charts of 96 patients presenting with trauma.[6] Although functional, the use of different communication systems or processes (e.g., radio, phone, fax, numeric/text page, etc.) between and within organisations have been identified as confusing or frustrating,[7] as well as a major barrier for effective handover of patients to other health professionals[8] including from paramedics to emergency department (ED) staff.[8,9] Pen-and-paper standardised solutions have improved handovers within the ED,[10,11] but wider dissemination of information to specialist teams is also required.

In the absence of purpose-built solutions for health care, frustrated clinicians have resorted to generic technology solutions to expedite sharing of patient information. These include adopting informal processes such as the use of an unsecured short-messaging service (SMS) on personal phones[7,12,13] or general smartphone applications (or apps) such as WhatsApp Messenger (for a review see Giordano et al.[14]). A number of smartphone app solutions have been proposed to solve communication issues within health care,[15,16] but options compliant with the Health Insurance Portability and Accountability Act (HIPAA) are limited.[17] While many smartphone apps and technological solutions exist for information transfer between paramedic and hospital staff,[18] having one app which is a single communication tool that supports multidisciplinary communication across multiple organisations and different hospital departments is a novel solution. The clinical effectiveness of these apps is emerging with preliminary evidence indicating faster assessment, clinical decision making and patient treatment times.[19–21] However, it is unknown how these systems were effectively implemented, and if they were simultaneously implemented across multiple healthcare organisations.

Implementation of new communication systems in health settings is complex.[7,22] Successful programs depend on the availability of easy-to-use technology, the organisational and clinician acceptance and use of the technology, which can vary across departments[23,24] and hospitals,[22] as well as an effective implementation strategy. Although implementation considerations have been identified for digital mental health interventions,[25] evidence is urgently needed on what is required to best implement novel communication solutions for complex healthcare scenarios such as medical emergencies. Indeed, calls for objective data and the qualitative experience of clinicians involved in technology-based communication systems have been made.[17] To our knowledge, the prospective identification of factors associated with clinicians' intentions to use a new communication system across multiple healthcare organisations has not been reported. Such information can be used to tailor and support future implementation approaches.

The aims of the current study were to:

(a) determine if a single digital health technology-based communication app could be implemented across and within multiple emergency health care organisations,
(b) identify the perceived barriers and facilitators to implementation, and
(c) identify which factors were associated with clinicians' intentions to use the technology

2 | METHODS

2.1 | Design

We used a multimethod, pragmatic 'real-world' design, during the implementation period in two different regions located in Victoria, Australia. A 6-month feasibility pilot in region 1 (August 2016 to February 2017) was extended by a 12-month feasibility study in regions 1 and 2 (May 2017 to May 2018). Multiple methods included data from the Pulsara™ App administration dashboard; a survey comprising quantitative measures of each participant's demographics, smartphone use, perceived readiness for change of their organisation, individual acceptance, motivations and intentions to use Pulsara™; and open-ended questions for qualitative data about perceived barriers and facilitators.

2.2 | Setting

Our study was conducted, within two large rural hospitals (Hospital 1 = 534 beds, Hospital 2 = 361 beds) and 25 Ambulance Victoria (AV) branches, the emergency medical service for Victoria. AV covers the state of Victoria with a population of over six million people, covering over 227,000 km^2. AV has over 260 branches and 3813 on-road clinical staff.[26] In 2017–2018, the hospital EDs received 111,322 ED presentations per annum, 58,048 (52%) triaged as Category 1–3 (i.e., requiring attention within 30 min).[27]

As Category 1 conditions, suspected stroke and cardiac events are time-critical, emergency health conditions, requiring multiple organisations and clinicians to mobilise swiftly to assess, diagnose and rapidly treat patients to enable the best possible outcomes. These conditions require inter-disciplinary care across different healthcare providers and were selected as the candidate conditions to trial Pulsara.

A clinical effectiveness evaluation within this study setting of Pulsara[28] showed off-ambulance stretcher faster times for patients with suspected stroke (8 min) and ST-elevation myocardial infarction (STEMI) (4 min), stroke cases received ED review (17 min faster) and computerised topography (CT) scans (44 min faster) significantly faster with STEMI cases' percutaneous intervention door-to-balloon times 17 min faster albeit nonsignificant.

2.3 | Intervention

The digital health technology communication app was implemented to augment (not replace during the evaluation period) usual care emergency care communication for patients with suspected stroke or heart attack. The Pulsara™ smartphone/tablet app (Pulsara; www.pulsara.com) is designed for secure (i.e., HIPAA compliant) sharing of patient details, symptoms, arrival time, plus tracking of delivery of care times (e.g., arrival at ED, CT brain scan or Catheterisation Laboratory [Cath lab] ready, treatment time) and contraindications for treatment (Figure 1). Minimum data fields allow rapid input and sharing between healthcare providers, with updates provided simultaneously to all users. Upon conclusion, a case summary is provided, and data extractions (e.g., for monitoring) can be made. Pulsara™ can be activated by ambulance paramedics to prenotify a patient's arrival to the hospital ED or the hospital can initiate a case for walk-ins or inpatients who experience a new stroke or cardiac event, as relevant. The ED can then simultaneously alert and initiate plans to synchronise care across multiple hospital departments as relevant (e.g., Cath Lab, Radiology, Stroke team, Cardiac team), before the ambulance arriving at the ED with a patient. At the time of implementation, only the stroke and STEMI modules for the Pulsara™ app were available (additional modules tailored for sepsis, trauma and sudden cardiac arrest are now available).

2.3.1 | Implementation of Pulsara™

The implementation strategy we used included three distinct phases (see Figure 2) involving multiple evidence-based behaviour change[29,30] and implementation techniques: pre-intervention (e.g., site-based team recruitment[31] including project coordinator and clinical champions, intra- and inter-site education sessions[32,33]), intervention (e.g., team-based training[34] by experienced personnel, mock cases[35] and run-in period, interim clinical results circulated[36]) and post-intervention (e.g., sustainability via embedding into established infrastructure,[37] final clinical results circulated). A total of approximately 110 hospital staff and 30 AV staff were trained during 28 scheduled group sessions in the initial implementation week in both regions. Beyond the formal training week, clinicians were encouraged to demonstrate the app to colleagues, local site-based project co-ordinators provided formal (e.g., training at department meetings, registrar induction) and informal (e.g., in situ, ad hoc) training as required, throughout the intervention period, supported by local, internal champions and externally based project team members. Before commencing the formal evaluation period, a trial implementation period was undertaken, whereby four cases each for stroke and STEMI were completed to assess the clinical protocol in each hospital. This period was on average 10 days (IQR = 7, 19 days; range: 6–22) and no changes to the clinical or implementation protocol were made.

While usual case communication varies, AV typically use radio, phone and fax to communicate with EDs about incoming patients, while hospital personnel would use phone, pager and fax to communicate within and between hospital departments. During the intervention period, usual clinical communication systems were used for patient details. This approach ensured that patient care was not compromised while a new system was trialled and evaluated. As such, clinicians used their usual communication method first, and then initiated Pulsara™ based communication.

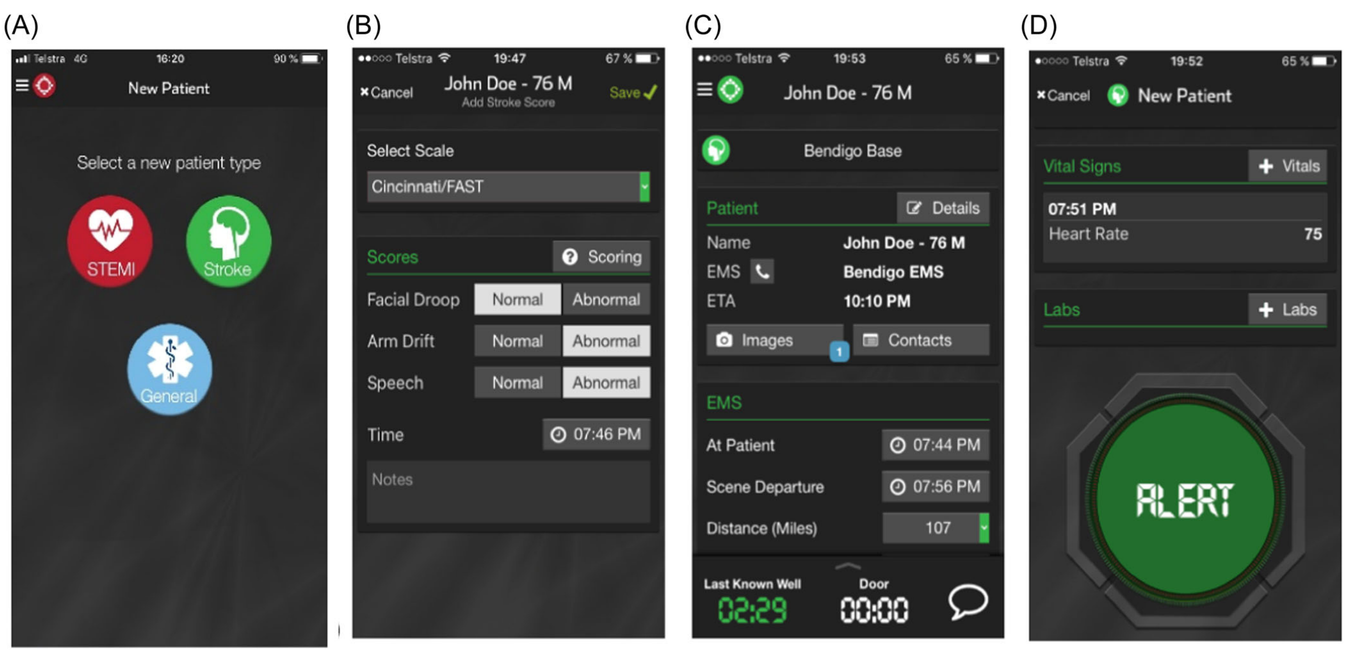

FIGURE 1 Screen shots Pulsara™ STOP Stroke/STEMI (version 4.6 originally implemented June 2016, version 40 in use September 2023): (A) select patient condition, (B) enter patient symptoms, (C) adding images (e.g., drivers licence) or messages, and (D) alert Emergency Department.

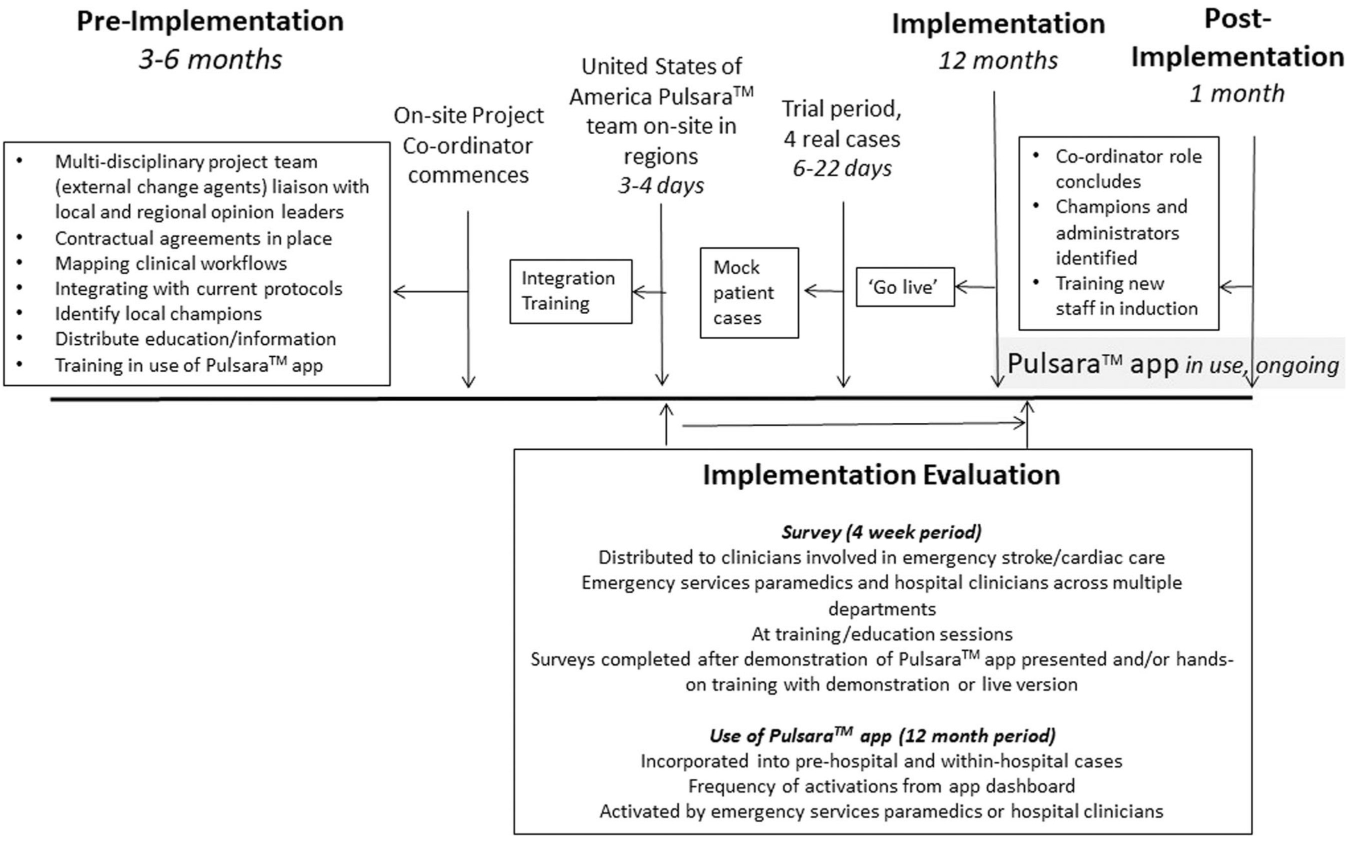

FIGURE 2 Preimplementation, implementation, post-implementation and evaluation components and timelines for Pulsara™.

2.3.2 | Participants and procedure

All clinicians from AV or the hospitals involved in care of patients with suspected acute stroke or cardiac symptoms were eligible to participate. After the education/training sessions, information sheets detailing the research and surveys were administered by author K.L.B. when in the field or by local hospital site co-ordinators. Survey completion was voluntary, with completion indicating implied consent. Surveys were completed anonymously, and were available as pen-and-paper or online, but all were completed in hard copy.

2.3.3 | Measures

Use of the Pulsara™ App was captured by the app administration dashboard. The survey included demographic items (*n* = 8 items, e.g., organisation, role, years of service), and items from established measures were adapted to include reference to 'the Pulsara™ App'. All dimensions for each measure and internal consistency are reported in Table 2.

Each organisation's readiness for change was measured using the Perceived Organisational Readiness (POR) dimension of the Organizational Readiness for Implementing Change (ORIC[38]) measure (*n* = 4 items, *n* = 1 factor, e.g., 'I believe the Pulsara™ App can be successfully implemented in my team/department').

Individual clinicians' acceptance and intentions to use Pulsara™ were examined using the Unified Theory of Acceptance and Use of Technology (UTAUT;[39] *n* = 23 items, *n* = 7 factors, e.g., performance expectancy—'I will find the Pulsara™ App useful in my daily work life', intention to use Pulsara™ —'I plan to use the Pulsara™ App').

Individuals' motivations to use Pulsara™ were examined with the Intrinsic Motivation scale from Self Determination Theory (IM-SDT[40]; *n* = 14 items, *n* = 4 factors, e.g., perceived competence—'I think I am pretty good at using the Pulsara™ app', perceived choice—'I feel like I have to use the Pulsara™ app').

A seven-point Likert response scale was used: 1 *completely disagree* to 7 *completely agree*. Survey items included participants' use of mobile phones in daily life, willingness to use a smart phone app for work purposes, with response options yes/no or frequency range options. Four items regarding phone and app use, and three open text items were included: 'describe three benefits or advantages…' and 'describe three barriers or concerns…' of using the App in your role/team/department, and 'any other thoughts or ideas about the implementation or use of Pulsara™'.

2.3.4 | Analysis plan

Quantitative

Descriptive statistics (e.g., mean, SD, frequencies) and group (i.e., in-hospital and emergency services personnel) comparisons (e.g., chi squares for categorical data) were conducted. Correlations for univariable relationships were conducted before multivariable regression analyses with ORIC, UTAUT, IM-SDT and organisation (independent variables) predicting intentions to use Pulsara™ (dependent variable). Statistical significance was determined by p value < 0.05. Analyses were conducted using IBM SPSS Statistics v25. We have used the Standards for Reporting Implementation Studies (STaRI[41]) for reporting results.

Qualitative

A deductive approach was undertaken with a directed content analysis[42] conducted on the open-text responses for the barriers and facilitators of using the app. This approach provided a systematic method for classifying text and identifying thematic categories, and the number of incidences of codes can be reported. The coding framework was based on UTAUT dimensions, allowing deeper exploration of the quantitative results. Two individuals (K. L. B., PhD Psychology; C. M., Honours Psychology) separately undertook the coding of all items for the benefits and barriers to using the App within the UTAUT coding framework. Inter-rater reliability using absolute agreement considers 75% acceptable when more than 5–7 rating levels with 90% considered high.[43] Each item was coded into a subcategory; subcategories were then grouped within an overarching category within the coding framework. Content that was inconsistent with the UTAUT framework was able to be separately noted. Categories and subcategories within each dimension were reviewed and discussed between K. L. B. and C. M. A final coding framework comprising agreed categories and subcategories was harmonised, renamed and the coding refined. Inter-rater reliability was calculated based on agreement of item coding at the most specific/lowest level (subcategory). All coding was undertaken within an Excel spreadsheet. Illustrative quotes are provided verbatim, with spelling and grammar corrected, and role of participant and years in role indicated. Qualitative results are presented according to COREQ (Consolidated Criteria for Reporting Qualitative Research) guidelines.[44]

Approval for this research was obtained from Human Research Ethics Committees from participating (Bendigo Health HREC approval: LRN/16/BHCG/5, 22 March 2016; Ballarat Health Services HREC approval LRN/17/BHSSJOG/13, 28 April 2017) and the Ambulance Victoria Research and Governance Committee (R16-005, 3 May 2016).

3 | RESULTS

During the intervention period, Pulsara™ was initiated 294 times by AV paramedics, 69 by hospital personnel on behalf of AV and 197 times by hospital personnel. There were 389 cases of suspected stroke and 171 of STEMI.

3.1 | Understanding participants and setting

There were 172 completed surveys: n = 90 hospital personnel, n = 82 AV personnel (Table 1). The majority of participants had attended an information session, with approximately half having viewed the Pulsara™ information video, and approximately 23% had downloaded the app onto their personal phone at the time of survey completion (Supporting Information: Table A).

Almost all participants used a smartphone or tablet in their daily life with approximately three-quarters using apps daily or multiple times per day. Differences in the standard practice of clinical information flow included AV paramedics were more likely than hospital personnel to provide clinical information, mostly by phone, face-to-face and other, while hospital personnel were more likely than paramedics to receive information including by phone, fax and face-to-face (Supporting Information: Table A). Clinicians from AV and the participating hospitals similarly reported that it was very important that clinicians know that a patient with suspected acute stroke or STEMI symptoms would be arriving to an ED (AV M = 6.48, SD = 0.89; hospital M = 6.46, SD = 0.67; $t(169)$ = 0.13, p = 0.90).

3.2 | Predicting intentions to use Pulsara™

Participants scored over the mid-point of the scale for all dimensions, except Perceived Choice and Pressure/Tension (Table 2). Hospital participants scored significantly higher than paramedic participants on Performance Expectancy, Hedonic Motivation, Habit, Interest/Enjoyment, but significantly lower on Perceived Competence.

POR, UTAUT and IM-SDI constructs were typically correlated moderately or strongly, positively and significantly with intentions to use Pulsara™, with the exception of Perceived Competence and Pressure/Tension (Supporting Information: Table B). Regression analyses [$F(11, 136) = 21.28$, $p < 0.001$, Adj $R^2 = 0.60$] revealed that five factors explained 60% of the variance in intentions to use Pulsara™ (Table 3). Habit was the factor most strongly associated with intentions to use the app, followed by Effort Expectancy. Perceived Organisational Readiness, Performance Expectancy and Organisation (AV) were also significant, positive predictors of the intention to use Pulsara™.

3.3 | Participant-identified benefits and barriers

High inter-rater agreement was achieved for the qualitative analysis: 95% agreement on benefits coding (303/319) and 92% agreement on barriers coding (226/246). On average, there were 1.8 benefits (Supporting Information: Table C) and 1.4 barriers (Supporting Information: Table D) reported per participant (319 benefits and 246 barriers identified by 170 participants). Identified benefits were related to Performance Expectancy, Effort Expectancy and Facilitating Conditions, while the barriers

TABLE 1 Subsample descriptives.

Variable *n* (%) unless specified	In-hospital personnel (*N* = 90)	Ambulance Victoria personnel (*N* = 82)	X^2	*df*	*p value*
Median age (IQR), years	37 (29–44)	44 (32–50)	2.57	162	0.011
Sex, *n* (% female)	50 (56.7)	30 (36.6)	7.35	1	0.007
Profession			147.06	7	<0.001
Physician	13 (14.4)	N/A			
Registrar (doctor undergoing speciality training)	8 (8.9)	N/A			
Intern (Resident, junior medical doctor)	1 (1.1)	N/A			
Nurse	32 (35.6)	N/A			
Manager	3 (3.3)	N/A			
Radiographer	22 (24.4)	N/A			
Paramedics	N/A	68 (82.9)			
Other	5 (5.6)	4 (4.9)			
Education (highest attained)			14.99	5	0.010
Diploma	22 (24.4)	35 (42.7)			
Bachelors degree	63 (70)	51 (62.2)			
Masters degree	9 (10)	1 (1.2)			
Doctorate degree	6 (6.7)	0 (0)			
Other	8 (8.9)	8 (9.8)			
Patients treated			31.62	2	<0.001
Stroke symptoms	10 (11.1)	1 (1.2)			
Cardiac symptoms	22 (24.4)	0 (0)			
Both	33 (36.7)	50 (61)			
Employment status			27.44	3	<0.001
Full-time ongoing	49 (54.4)	73 (89)			
Full-time fixed term	10 (11.1)	2 (2.4)			
Part-time ongoing	22 (24.4)	5 (6.1)			
Part-time fixed term	7 (7.8)	0 (0)			

Note: Responses may not add to 100% due to missing data
Abbreviations: *df*, degrees of freedom; X^2, chi square.

covered Performance Expectancy, Effort Expectancy, Facilitating Conditions Social Influence and Habit.

Benefits were identified by the full spectrum of clinicians within the UTAUT dimensions of Performance Expectancy, Effort Expectancy and Facilitating Conditions and not Social Influence, Hedonic Motivation or Habit. The majority of benefits (266/319; 84%) were associated with Performance Expectancy with the greatest nominations for faster care for patients and procedural efficiencies in workflow.

> Being able to include patient details = speed up of hospital clerical input = speed up treatment. (Participant 116, Paramedic; 12 years in role)

> Increased, timely care for patients. (Participant 12, ED Nurse, 11 years in role)

> More informed hospital/medical team prior to our arrival – efficient. (Participant 89, Paramedic, 5 years in role)

> Timely information with updates directly from AV. (Participant 40, Catheterisation Laboratory Nurse, 2 years in role)

Other commonly reported benefits were having access to information with that information documented, standardised or

TABLE 2 Measure dimension descriptive statistics, including organisation (Ambulance Victoria, hospital) comparisons.

Measure and dimension	Cronbach's α	Total sample (N = 172) M (SD)	Ambulance Victoria (N = 82) M (SD)	In-Hospital (N = 90) M (SD)	t	df	p
Organisational readiness for implementing change							
Perceived Organisational Readiness	0.81	5.62 (0.80)	5.68 (0.82)	5.55 (0.76)	1.09	169	0.277
Unified theory of acceptance and use of technology							
Performance Expectancy	**0.89**	**5.15 (0.92)**	**4.93 (0.92)**	**5.29 (0.87)**	**−2.56**	**158**	**0.011**
Effort Expectancy	0.96	5.50 (0.87)	5.46 (0.85)	5.51 (0.86)	−0.36	158	0.719
Social Influence	0.92	4.69 (0.96)	4.58 (0.97)	4.78 (0.92)	−1.27	155	0.206
Facilitating Conditions	0.86	5.41 (0.86)	5.37 (0.82)	5.39 (0.84)	−0.16	158	0.873
Hedonic Motivation	**0.95**	**4.43 (1.13)**	**4.07 (1.04)**	**4.71 (1.14)**	**−3.67**	**155**	**0.000**
Habit	**0.72**	**5.09 (0.93)**	**4.94 (0.87)**	**5.24 (0.92)**	**−2.13**	**159**	**0.035**
Behavioural Intention (to use App)	0.93	5.71 (0.87)	5.82 (0.83)	5.66 (0.82)	1.24	159	0.216
Intrinsic Motivation Inventory							
Interest/Enjoyment	**0.87**	**4.75 (0.99)**	**4.55 (0.99)**	**4.91 (0.96)**	**−2.36**	**157**	**0.020**
Perceived Competence	**0.88**	**4.16 (0.30)**	**4.23 (0.29)**	**4.10 (0.32)**	**2.62**	**155**	**0.010**
Perceived Choice	0.63	4.20 (0.98)	4.27 (0.99)	4.14 (0.99)	0.83.	153	0.410
Pressure/Tension	0.84	3.74 (0.62)	3.63 (0.59)	3.81 (0.64)	−1.81	155	0.072

Note: Perceived Choice initial alpha was 0.42, but third item dropped for improved alpha of 0.63. Bold indicates significant differences between Ambulance Victoria and hospital clinicians.

TABLE 3 Regression to predict Behavioural Intention to use the Pulsara^{TM} app.

Dimension	B	B SE	β	t	p value	95% confidence intervals (lower, upper bound)
Perceived Organisational Readiness	**0.21**	**0.08**	**0.20**	**2.69**	**0.008**	**0.45, 3.98**
Performance Expectancy	**0.18**	**0.08**	**0.20**	**2.35**	**0.020**	**0.03, 0.34**
Effort Expectancy	**0.21**	**0.08**	**0.22**	**0.256**	**0.011**	**0.05, 0.38**
Social Influence	−0.09	0.06	−0.10	−1.49	0.138	−0.20, 0.03
Facilitating Conditions	0.08	0.09	0.08	0.87	0.384	−0.10, 0.26
Hedonic Motivation	0.09	0.06	0.12	1.56	0.120	−0.02, 0.19
Habit	**0.26**	**0.07**	**0.28**	**3.66**	**0.000**	**0.12, 0.40**
Perceived Competence	−0.20	0.16	−0.08	−1.27	0.205	−0.52, 0.11
Perceived Choice	−0.05	0.05	−0.06	−0.92	0.358	−0.16, 0.06
Pressure/Tension	−0.06	0.10	−0.04	−0.65	0.517	−0.25, 0.13
Organisation (AV = 0, hospital = 1)	**−0.33**	**0.10**	**−0.20**	**−3.31**	**0.001**	**−0.53, −0.13**

Note: Bold indicates significant result.

accurate, and communication intra or inter team/disciplines and early notification.

> Good to know whether CTA [computed tomography angiogram brain scan] is required straight away. (Participant 29, Radiographer, 5 years in role)

> Hopefully more standardized information available to everyone needing to know. (Participant 150, ED Nurse Unit Manager, 5 years in role)

> Timely information with 3-way combination. (Participant 50, Medical Physician, 13 years in role)

Benefits associated with Effort Expectancy focused on the ease of use and speed of using Pulsara™.

> Very easy to use: alarm keeps ringing until acknowledged (prior, faxes could be missed). (Participant 39, ED Physician, 11 years in role)

> Quick notification for receiving hospital. (Participant 131, Paramedic, 4 years in role)

Facilitating Conditions received few mentions, but included that the technology was on the same or familiar equipment and convenient.

> All staff using uniform equipment. (Participant 30, Radiographer, 12 years in role)

Barriers were identified within UTAUT dimensions of Performance Expectancy, Effort Expectancy, Facilitating Conditions Social Influence, Habit, but not Hedonic Motivation. The main concerns identified were network accessibility or black spots (Facilitating Conditions) and errors such as being locked out with incorrect passwords or PINs (Effort Expectancy).

> Mobile/data/internet connection - black spots - enough mobile data! (Participant 63, Cardiac Technician, 6 years in role)

> App locked out. (Participant 131, Paramedic, 4 years in role)

Concerns specific to the technology included usability such as blurred photos from a moving vehicle or GPS [Global Positioning System] accuracy (Performance Expectancy) and having access to a device or the app (Facilitating Conditions) were also raised.

> Photos of ECGs [rather] than transmitting [actual ECG, means image may be] fuzzy or poor lighting may affect this. (Participant 89, Paramedic, 6 years in role)

> Limitations of current technology used by ED - A/O [Admitting Officer] phone inferior to own personal mobile phones [which are] not carried on shift. (Participant 38, ED Physician, 4 years in role)

Human factors were involved in concerns, including remembering to charge phone, remembering to use, how to log on and how to use (Habit), staff being sufficiently technologically literate and being able to learn the technology (Effort Expectancy), requiring training and education (Facilitating Conditions).

> Some staff members [are] not familiar with mobile technology. (Participant 119, Paramedic, 15 years in role)

> Familiarity with app. (Participant 169, Cardiac Registrar, <1 year in role)

> Ensuring all relevant parties are educated about use of the app. (Participant 14, Medical Registrar, <1 year in role)

4 | DISCUSSION

To our knowledge, this is the first study to examine the implementation of a novel, unified communication system that was able to be successfully deployed across multiple healthcare organisations for patients with emergency conditions. Stroke and heart attack are leading causes of death and disability, and time to treatment impacts patient outcomes. We successfully implemented the Pulsara™ app in two regional hospitals and across 25 separate branches of AV servicing those hospitals, where clinicians used Pulsara™ to communicate and securely and efficiently share information about their patients with suspected stroke or STEMI. Our clinical evaluation provided evidence of faster times for key parts of patient assessment and delivery of treatment.[28] The results from this implementation study provide support for the feasibility of implementing a single technology solution for communication across multiple organisations and departments. Using an established predictive model for technology acceptance and use (i.e., the UTAUT[39]), rather than an implementation framework (which are unable to support predictive analyses when used alone), we were able to identify the main factors associated with clinicians' intentions to use the system. Importantly, the multimethod approach provided specific system-level and individual-level details to augment the factors predicting intentions to use the app. These details can provide support and tailoring for developing implementation plans of similar systems or the upscale of this app to other healthcare settings (summary in Table 4).

Organisational readiness[38] was important for intentions to use Pulsara™, and overall, personnel from both organisations reported strong readiness to implement Pulsara™. This result suggests that there was a very good fit between the proposed technology to be

TABLE 4 Technical, organisation and individual strategies to consider pre-implementation and implementation.

Stage	Level	Strategy
Preimplementation	Technical	Select technology that meets and addresses identified issue/s in local context, is easy to use, and integrates with current systems (e.g., Apple and Android devices, hospital wi-fi settings, medical health records, etc.). Distinguish between must-have and nice-to-have features, as it may not be possible to have a single solution address all identified issues in one step with available resources.
		Solution incorporates simple (e.g., phone call) and complex (e.g., patient status changing) functions, accessible in real time and supports multiorganisational, multidisciplinary scenarios.
		Addresses shared and unique needs across pre-hospital (e.g., paramedic, Emergency Medical Services dispatch) and within hospital (e.g., Emergency Department [ED], Catheterisation Laboratory, Radiology) for all roles involved (e.g., intake, nursing, consultant; on-site and on-call), including for patient-facing care through to medical records.
		Technology provider is well-established, accessible, provides 24/7 support and rapidly adapts to changes in clinical care. Request references, discuss and compare details with those who are using identified options for solution.
		Ensure contracts include unlimited users, organisational-level licences and have unlimited support.
	Organisation	Identify where and how the communication app could improve the rapid delivery of care for time-critical, acute conditions.
		Identify benefits of the communication app, drawing on published or local results, addressing prenotification to hospital clinicians beyond ED; these may include important patient information provided, retained and accessible also updateable in real time; improved clinical care timelines; post-case monitoring to identify delays.
		Consider implementing for use with multiple conditions to normalise use, increase frequency of use and streamline communication to one system (once medicolegal surety reached).
		Map patient journey from community to admission or discharge from ED, illustrating the different communication methods in use. Involve all stakeholders not only patient-facing clinicians, but also by including personnel from Intake, Information Technology and Medical Health Records.
	Individual	Socialise idea of a solution to identified issues (i.e., the new system) early to identify setting-specific perceived barriers and facilitators. A new system is a considerable disruption, requiring a multipronged approach.
		Consider identifying digital navigator role (similar to boundary spanner); someone who liaises between the technical and clinical teams, facilitates training and support in initial implementation phase. Recruit known respected clinician from within setting and have in place early.
Implementation	Technical	Provide required hardware (e.g., smartphone or tablets), ensure familiar and accessible, where relevant.
		Indicate that data input is quick, easy and minimal for hospital prenotification and patient care, but are subsequently accessible for download and analysis (e.g., to review a specific case or to summarise patient care timelines overall).
	Organisation	Systemic support from organisation to use phones and apps (e.g., bring-your-own-device policies are in place) and are acceptable and accessible for use during patient-facing care.
	Team/Individual	Address barriers to use through access to a 'dummy' version of the digital solution, provide detailed hands-on demonstrations, share or circulate user feedback from known personnel/local champions or available data (e.g., published case studies, literature); hands-on training addressing identified barriers, demonstrate ease-of-use and build confidence for accessing and using app before acute setting. Consider formal and informal training delivery models.
		Conduct multidisciplinary care scenarios with all relevant team members in face-to-face setting for shared understanding of discipline-specific processes, building collaborative team connections, shared understanding of information provision and patient-centred outcomes.

implemented and the organisation's requirements.[45] Pulsara™ met each of the recommendations identified previously for hospital communication technology.[46] Further, hospital clinicians and paramedics identified more benefits overall than barriers when considering using Pulsara™. These results are likely due to the known concerns of current informal systems[13,47] that would be addressed by the proposed system, and that both hospitals were familiar with other technology-based communication used for health care (e.g., acute telemedicine services). During implementation, benefits were emphasised[46] and issues raised were addressed initially with education, demonstrations of app functionality, hands-on training with a demonstration version, and with data being fed back to provide evidence of improved patient treatment times when the system was used—first with published United States of America data,[19–21] and then local data[48] once available.

Habit was identified as the strongest predictor of clinician intentions to use the app and importantly, identified as one of the potential barriers. Concerns included remembering to use the app (usual communication systems were retained during this implementation) and how to use the app with few relevant cases. Such concerns are also reported when implementing other technology-based solutions, such as telemedicine services.[37] Expanding use of the app for prenotification of all conditions (not just stroke and STEMI as evaluated here) would increase frequency of use and simplify all prenotification to a single system across multiple healthcare organisations. As this was a feasibility study, usual communication methods were retained for medicolegal surety, requiring clinicians to duplicate communication content. Established communication methods can limit uptake of new methods for interdisciplinary team care with patients.[49] Incorporating the app as standard practice would also support frequency of use and reduce duplication of effort once adopted for routine clinical care replacing outdated and repetitive methods of communication. Indeed, the Pulsara app has since been successfully implemented into a third regional area and is used for cases beyond stroke and STEMI, such as trauma cases. Integrating communication data captured more broadly into other healthcare organisations systems (e.g., images and vitals from ECG monitors, automatically importing patient details from app into patient hospital records) would increase benefits and further embed into usual practice.[50] As with other programs requiring behaviour change, time and repetition is required to build automaticity, with prior use of technology established as a predictor of future use.[39,51]

Paramedics reported higher perceived competence than hospital personnel, and perceived competence was strongly associated with intending to use Pulsara™. The former result may be due to the individual hands-on approach to the training[46,52] of the majority of paramedics at the time of this evaluation. Only a small proportion of the paramedic workforce were able to attend the formal training sessions in the initial week. Paramedics were also using smartphones to access their Clinical Practice Guidelines app.[53] The majority of both hospital and AV personnel were using smartphones and apps in work circumstances, consistent with other reports from clinical settings.[54] Given the already large proportion of clinical teams using technology platforms that support apps, our findings remain current for the Australian context and elsewhere clinicians use their mobile phones or tablets for work. What was novel was the use of an app accessed by both pre- and within-hospital clinicians, with information simultaneously shared between different healthcare organisations, hospital departments and professional groups. Considerable advances have been made with wearable devices for digital monitoring,[55] electronic consultations[56] and telemedicine models,[57,58] yet calls continue for research understanding influential factors in successful implementation and sustained use in clinical settings.[55,56] While technical skills are required for implementation (e.g., digital navigators),[59,60] communication remains critical[59] with collaborative skills and interprofessional communication between interdisciplinary clinical team members important for digital health solutions.[61–63] These are particularly important factors for technical solutions that cross discipline and organisational boundaries. Despite their ubiquitous presence, appropriate use of mobile phones in clinical settings needs to be considered,[64] including in curriculum and interprofessional education, and organisation policies[65] to support clinician and patients' perspectives.

Benefits were readily identified and predominantly related to the impact from using the app, including improved communication,[66] workflow[7,47] and patient care. Participants' concerns were mostly related to the ease of using the app and included system factors such as blackspots,[17] and human factors such as potential issues with being locked out or password/PIN codes. Ensuring ease of use and access are commonly cited as key factors for uptake.[17,66] Strong hospital networks should be available[17,67] as even infrequent dropouts are likely to have a major negative impact.[7,68] Having devices that are consistent with role requirements including dedicated department devices and log-in/passwords or individual smartphones[46] may have exacerbated this concern. Apps with organisational-level licences with unlimited users should be utilised to ensure all relevant team members have access, and not just selected individuals.[17] Solutions should support complex, urgent cases, including phone call functionality as required.[7,13]

Emphasising the benefits (performance expectancy) and addressing concerns (effort expectancy) should be specifically targeted in hands-on, practical education and training sessions to facilitate clinicians' intentions to use app-based communication systems. None of the individual motivation factors (i.e., perceived competence, perceived choice or pressure/tension)[40] were associated with intentions to use the app. Nor were important others (i.e., social influence[69]) or experience of enjoyment (hedonic motivation; not surprising as utilitarian benefits from healthcare communication are inconsistent with motivations more typically associated with technology-based games).[39] Although facilitating conditions was not an important factor in predicting intentions, system factors such as technology infrastructure and the app itself did feature heavily in clinicians' concerns.

Although a digital solution to streamline communication and improve patient care timelines was identified, identifying a new technology in and of itself is insufficient for success. Technical solutions have to be incorporated into complex, well-established individual and organisational systems. As such, there are multiple domains to consider when selecting and implementing digital solutions, including their ongoing maintenance and licensing costs (see Table 4). While more than half of the variance in intentions to use Pulsara™ was explained (60%), it is somewhat lower than reported for technology acceptance generally.[70] More of physicians' (68%, $n = 1150$ in four studies) and nurses' (77%, $n = 151$ in one study) intentions to accept technology (predominantly telemedicine services) has been explained.[70] The lower proportion explained in our communication app-based study is likely due to telemedicine services being more established and more familiar to clinicians than the novel app-based system we evaluated here. However, these results indicate that we can explain clinicians' intentions to use this technology more readily than physicians' intentions to comply with guidelines (50%) and clinical practice (54%).[70]

4.1 | Limitations and future research

Despite the novel insights identified, some caution is required. The main limitation is the prediction of intentions to use the app, rather than actual use. As our implementation included generic log-ins (e.g., a phone per ambulance branch or a tablet at hospital ED desk) where multiple personnel would use the single device/log-in, we were unable to link individual pre-implementation intention responses with post-implementation, objective behavioural use. This generic approach addressed potential barriers that were identified (ensuring easy access), but limited the study design to ascertaining intentions to use, not actual use. However, intentions are the strongest predictor of subsequent use[70] and use of the app continues to expand in these regional settings. As this implementation was conducted within two large rural hospital settings, generalisability to metropolitan areas may differ.[22] However, concerns such as few cases, regional area black-spots and drop outs may be less likely in metropolitan areas.

Specific resources are required to implement and embed the app to sustain use, such as project co-ordinators, and the ongoing annual licencing fees. While these expenses can be shared across healthcare organisations and hospital departments, a cost effectiveness evaluation needs to be conducted.[17] One app provider has indicated that apps are likely to be more cost-effective than paging systems,[71] but this claim requires further examination. Implementation and sustainability costs for communication systems remain relevant considerations on whether to invest in such programs and need to be weighed against the time saved for clinicians, more effective use of healthcare resources, and more patients receiving timely, definitive treatment.

Collecting the data for the clinical evaluation of Pulsara™ required access to five different in-hospital systems to be able to track the time-points for the patient journey through the hospital. However, a single system solution, that can facilitate such audit and feedback processes, such as Pulsara™, in real time[72] could reduce the resources needed for data acquisition. The ability to link person-level data from communication systems with electronic health records[17] further legitimises their advantages for widespread use. Digital solutions that do not integrate into electronic health records are likely to have limited uptake.[49] Those considering implementing a similar communication system should carefully select a solution that provides the functionality required clinically, but also take a wider perspective to consider interoperability with other healthcare organisation systems. Other factors include how established the company developing the app is, if the solution is their core business and long-term support and adaptation of the app being available. There was 24/7 support available from Pulsara™, personnel were extremely receptive to our feedback and queries, and important enhancements were readily available in updated versions of the app, including when changes to clinical practice occurred. Technical support and collaboration between those implementing (e.g., technical team) and those using (e.g., clinicians) is required,[73] consideration of having a digital navigator role to link technical and clinical members,[60] and ensuring sufficient time for learning curves and organisation policies to be put in place.[65]

5 | CONCLUSIONS

Modern emergency care of life-threatening conditions requires efficient communication systems that are user-friendly and purpose built and maintained. We have illustrated that a single communication system can be implemented with good acceptance across multiple healthcare organisations providing prehospital and intra-hospital care. Supporting personnel to develop a habit to use the solution is essential. The success required support for change management and applying evidence-based behaviour change strategies. When implementing multiorganisational, technology-based communication solutions, critical factors for success include ensuring organisations are ready for the change, emphasising the benefits of performance, such as improved patient care and procedural efficiencies, and low effort required to use while addressing the relevant barriers, such as having a local champion for troubleshooting, clarifying infrastructure functionality. Evaluating the sustainability of ongoing use now that formal project support has ended, scalability to new regions and conditions, and determining the potential cost-effectiveness of this solution awaits further research.

AUTHOR CONTRIBUTIONS

Kathleen L. Bagot: Conceptualisation; methodology; formal analysis; investigation; writing—original draft; project administration; funding acquisition. **Chris Bladin**, **Stephen Bernard**, **Karen Smith**: Funding acquisition, writing—review & editing. **Grant Hocking**, **Tessa Coupland, Debra Hutton**: Investigation; writing—review & editing. **Michelle Vu**, **Diane Badcock**, **Marc Budge**, **Voltaire Nadurata**, **Wayne Pearce**, **Howard Hall**, **Ben Kelly**, **Angie Spencer**, **Pauline Chapman**, **Ernesto Oqueli**, **Ramesh Sahathevan**, **Thomas Kraemer**, **Casey Hair**, **Dion Stub**: Writing—review & editing. **Connor McGuinness**: Formal analysis, writing—review & editing. **Dominique Cadilhac**: Conceptualisation; methodology; resources; writing—review & editing; supervision; funding acquisition.

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CONFLICT OF INTEREST STATEMENT

None of the authors have a financial interest in the Pulsara™ app or Pulsara Communicare Technology Inc. Kathleen L. Bagot and Dominique A. Cadilhac received a travel grant paid to their institution from Pulsara Communicare Technology Inc. This grant was a contribution to defray the costs of attending an international conference to present the final results. The peer-reviewed abstract submission was accepted prior to receiving the travel grant. The company had no input to the content of the abstracts or the presentations. The remaining authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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REFERENCES

1. Leape LL, Berwick DM. Five years after to err is human: what have we learned? *JAMA*. 2005;293(19):2384-2390.
2. Sutcliffe KM, Lewton E, Rosenthal MM. Communication failures: an insidious contributor to medical mishaps. *Acad Med*. 2004;79(2): 186-194.
3. Dinh DT, Wang Y, Brennan AL, et al. Delays in primary percutaneous coronary treatment for patients with ST-elevation myocardial infarction. *Med J Aust*. 2018;209(3):130-131.
4. Emberson J, Lees KR, Lyden P, et al. Effect of treatment delay, age, and stroke severity on the effects of intravenous thrombolysis with alteplase for acute ischaemic stroke: a meta-analysis of individual patient data from randomised trials. *Lancet*. 2014;384(9958):1929-1935.
5. Chen H-L, Liu K. Effect of door-to-balloon time on in-hospital mortality in patients with myocardial infarction: a meta-analysis. *Int J Cardiol*. 2015;187:130-133.
6. Carter AJE, Davis KA, Evans LV, Cone DC. Information loss in emergency medical services handover of trauma patients. *Prehosp Emerg Care*. 2009;13(3):280-285.
7. Wu RC, Lo V, Morra D, et al. The intended and unintended consequences of communication systems on general internal medicine inpatient care delivery: a prospective observational case study of five teaching hospitals. *J Am Med Inform Assoc*. 2013;20(4): 766-777.
8. Solet DJ, Norvell JM, Rutan GH, Frankel RM. Lost in translation: challenges and opportunities in physician-to-physician communication during patient handoffs. *Acad Med*. 2005;80(12):1094-1099.
9. Dawson S, King L, Grantham H. Review article: Improving the hospital clinical handover between paramedics and emergency department staff in the deteriorating patient. *Emerg Med Australas*. 2013;25(5):393-405.
10. Maddry JK, Simon EM, Reeves LK, et al. Impact of a standardized patient hand-off tool on communication between emergency medical services personnel and emergency department staff. *Prehosp Emerg Care*. 2021;25(4):530-538.
11. Fitzpatrick D, Maxwell D, Craigie A. The feasibility, acceptability and preliminary testing of a novel, low-tech intervention to improve pre-hospital data recording for pre-alert and handover to the emergency department. *BMC Emerg Med*. 2018;18(1):16.
12. McKnight R, Franko O. HIPAA compliance with mobile devices among ACGME programs. *J Med Syst*. 2016;40(5):129-136.
13. Nikolic A, Wickramasinghe N, Claydon-Platt D, Balakrishnan V, Smart P. The use of communication apps by medical staff in the Australian health care system: survey study on prevalence and use. *JMIR Med Inform*. 2018;6(1):e9.
14. Giordano V, Koch H, Godoy-Santos A, Dias Belangero W, Esteves Santos Pires R, Labronici P. WhatsApp Messenger as an adjunctive tool for telemedicine: an overview. *Interact J Med Res*. 2017;6(2):e11.
15. Thomas K. Wanted: a WhatsApp alternative for clinicians. *BMJ*. 2018;360:k622.
16. Chari A, Gane SB. Instant messaging applications in healthcare: are we harnessing their potential? *BMJ Innov*. 2018;4(1):5-8.
17. Pourmand A, Roberson J, Gallugi A, Sabha Y, O'Connell F. Secure smartphone application-based text messaging in emergency department, a system implementation and review of literature. *Am J Emerg Med*. 2018;36(9):1680-1685.
18. Troyer L, Brady W. Barriers to effective EMS to emergency department information transfer at patient handover: a systematic review. *Am J Emerg Med*. 2020;38(7):1494-1503.
19. Dickson R, Nedelcut A. STOP STROKE©—a novel medical application to improve coordination of stroke care: a brief report on door to thrombolysis times after initiating the application. *Stroke*. 2015; 46(suppl 1):Abstract WP207.
20. Dickson R, Nedelcut A, Nedelcut MM. Stop stroke: a brief report on door-to-needle times and performance after implementing an acute care coordination medical application and implications to emergency medical services. *Prehosp Disaster Med*. 2017;32(3):343-347.
21. Dickson R, Nedelcut A, Seupaul R, Hamzeh M. STOP STEMI©—a novel medical application to improve the coordination of STEMI care: a brief report on door-to-balloon times after initiating the application. *Crit Pathw Cardiol*. 2014;13(3):85-88.
22. Holmgren A, Pfeifer E, Manojlovich M, Adler-Milstein J. A novel survey to examine the relationship between health IT adoption and nurse-physician communication. *Appl Clin Inform*. 2016;07(4):1182-1201.
23. Ward R, Stevens C, Brentnall P, Briddon J. The attitudes of health care staff to information technology: a comprehensive review of the research literature. *Health Info Libr J*. 2008;25(2):81-97.
24. Dünnebeil S, Sunyaev A, Blohm I, Leimeister JM, Krcmar H. Determinants of physicians' technology acceptance for e-health in ambulatory care. *Int J Med Inform*. 2012;81(11):746-760.

25. Graham AK, Lattie EG, Powell BJ, et al. Implementation strategies for digital mental health interventions in health care settings. *Am Psychol*. 2020;75(8):1080-1092.
26. Ambulance Performance and Policy Consultative Committee. *Victoria's Ambulance Action Plan: Improving Services, Saving Lives*. Final report. Victorian Government DoHaHS; 2015.
27. Australian Institute of Health and Welfare. *My Hospitals*. 2019. Accessed February 14, 2019. https://www.myhospitals.gov.au/
28. Bladin CF, Bagot KL, Vu M, et al. Real-world, feasibility study to investigate the use of a multidisciplinary app (Pulsara) to improve prehospital communication and timelines for acute stroke/STEMI care. *BMJ Open*. 2022;12(7):e052332.
29. Abraham C. Charting variability to ensure conceptual and design precision: a comment on Ogden (2016). *Health Psychol Rev*. 2016;10(3):260-264.
30. Michie S, Richardson M, Johnston M, et al. The Behavior Change Technique Taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. *Ann Behav Med*. 2013;46(1):81-95.
31. Flodgren G, Parmelli E, Doumit G, et al. Local opinion leaders: effects on professional practice and health care outcomes. *Cochrane Database Syst Rev*. 2011;8:1-69.
32. Forsetlund L, Bjørndal A, Rashidian A, et al. Continuing education meetings and workshops: effects on professional practice and health care outcomes. *Cochrane Database Syst Rev*. 2009;2009(2):CD003030.
33. Grol R, Grimshaw J. From best evidence to best practice: effective implementation of change in patients' care. *Lancet*. 2003;362(9391):1225-1230.
34. Davis DA, Thomson MA, Oxman AD, Haynes RB. Changing physician performance: a systematic review of the effect of continuing medical education strategies. *JAMA*. 1995;274(9):700-705.
35. Demaerschalk BM, Berg J, Chong BW, et al. American telemedicine association: telestroke guidelines. *Telemed e-Health*. 2017;23(5):376-389.
36. Jamtvedt G, Young JM, Kristoffersen DT, O'Brien MA, Oxman AD. Does telling people what they have been doing change what they do? A systematic review of the effects of audit and feedback. *Qual Saf Health Care*. 2006;15(6):433-436.
37. Bagot KL, Moloczij N, Barclay-Moss K, Vu M, Bladin CF, Cadilhac DA. Sustainable implementation of innovative, technology-based health care practices: a qualitative case study from stroke telemedicine. *J Telemed Telecare*. 2020;26:79-91. doi:10.1177/1357633X18792380
38. Shea CM, Jacobs SR, Esserman DA, Bruce K, Weiner BJ. Organizational readiness for implementing change: a psychometric assessment of a new measure. *Implement Sci*. 2014;9:7.
39. Venkatesh V, Morris MG, Davis GB, Davis FD. User acceptance of information technology: toward a unified view. *MIS Q*. 2003;27(3):425-478.
40. Ryan RM, Deci EL. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *Am Psychol*. 2000;55(1):68-78.
41. Pinnock H, Barwick M, Carpenter CR, et al. Standards for reporting implementation studies (StaRI) statement. *BMJ*. 2017;356:i6795.
42. Hsieh H-F, Shannon SE. Three approaches to qualitative content analysis. *Qual Health Res*. 2005;15(9):1277-1288.
43. Shweta B, Ram B, Chaturvedi HK. Evaluation of inter-rater agreement and inter-rater reliability for observational data: an overview of concepts and methods. *J Indian Acad Appl Psychol*. 2015;41(3):20-27.
44. Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *Int J Qual Health Care*. 2007;19(6):349-357.
45. Snyder RA, Fields WL. Measuring hospital readiness for information technology (IT) innovation: a multisite study of the organizational information technology innovation readiness scale. *J Nurs Meas*. 2006;14(1):45-55.
46. Johnston MJ, King D, Arora S, et al. Requirements of a new communication technology for handover and the escalation of patient care: a multi-stakeholder analysis. *J Eval Clin Pract*. 2014;20(4):486-497.
47. Przybylo JA, Wang A, Loftus P, Evans KH, Chu I, Shieh L. Smarter hospital communication: secure smartphone text messaging improves provider satisfaction and perception of efficacy, workflow. *J Hosp Med*. 2014;9(9):573-578.
48. Bagot K, Cadilhac D, Smith K, et al. Streamlining interdisciplinary communication to improve suspected acute stroke assessment, diagnosis and treatment times: preliminary results for a smartphone communication app. *Eur Stroke J*. 2018;3(1s):162.
49. Husain A, Cohen E, Dubrowski R, et al. A clinical communication tool (loop) for team-based care in pediatric and adult care settings: hybrid mixed methods implementation study. *J Med Internet Res*. 2021;23(3):e25505.
50. Hillestad R, Bigelow J, Bower A, et al. Can electronic medical record systems transform health care? Potential health benefits, savings, and costs. *Health Aff*. 2005;24(5):1103-1117.
51. Kim SS, Malhotra NK. A longitudinal model of continued IS use: an integrative view of four mechanisms underlying postadoption phenomena. *Manage Sci*. 2005;51(5):741-755.
52. Lyon AR, Stirman SW, Kerns SEU, Bruns EJ. Developing the mental health workforce: review and application of training approaches from multiple disciplines. *Admin Policy Ment Health Ment Health Serv Res*. 2011;38(4):238-253.
53. Itunes App Store. *Ambulance Victoria Clinical Practice Guidelines*. 2018. Accessed January 31. https://itunes.apple.com/au/app/av-cpg/id1353278803?mt=8
54. Franko OI, Tirrell TF. Smartphone app use among medical providers in ACGME training programs. *J Med Syst*. 2012;36(5):3135-3139.
55. Smuck M, Odonkor CA, Wilt JK, Schmidt N, Swiernik MA. The emerging clinical role of wearables: factors for successful implementation in healthcare. *npj Digit Med*. 2021;4(1):45.
56. Baines R, Tredinnick-Rowe J, Jones R, Chatterjee A. Barriers and enablers in implementing electronic consultations in primary care: scoping review. *J Med Internet Res*. 2020;22(11):e19375.
57. Almathami HKY, Win KT, Vlahu-Gjorgievska E. Barriers and facilitators that influence telemedicine-based, real-time, online consultation at patients' homes: systematic literature review. *J Med Internet Res*. 2020;22(2):e16407.
58. Yee V, Bajaj SS, Stanford FC. Paradox of telemedicine: building or neglecting trust and equity. *Lancet Digit Health*. 2022;4(7):e480-e481.
59. Wisniewski H, Gorrindo T, Rauseo-Ricupero N, Hilty D, Torous J. The role of digital navigators in promoting clinical care and technology integration into practice. *Digit Biomark*. 2020;4(1):119-135.
60. Wisniewski H, Torous J. Digital navigators to implement smartphone and digital tools in care. *Acta Psychiatr Scand*. 2020;141(4):350-355.
61. Khurana MP, Raaschou-Pedersen DE, Kurtzhals J, Bardram JE, Ostrowski SR, Bundgaard JS. Digital health competencies in medical school education: a scoping review and Delphi method study. *BMC Med Educ*. 2022;22(1):129.
62. Wong BLH, Khurana MP, Smith RD, et al. Harnessing the digital potential of the next generation of health professionals. *Hum Resour Health*. 2021;19(1):50.
63. Aungst TD, Belliveau P. Leveraging mobile smart devices to improve interprofessional communications in inpatient practice setting: a literature review. *J Interprof Care*. 2015;29(6):570-578.

64. DeWane M, Waldman R, Waldman S. Cell phone etiquette in the clinical arena: a professionalism imperative for healthcare. *Curr Probl Pediatr Adolesc Health Care*. 2019;49(4):79-83.
65. Shah N, Martin G, Archer S, Arora S, King D, Darzi A. Exploring mobile working in healthcare: clinical perspectives on transitioning to a mobile first culture of work. *Int J Med Inform*. 2019;125:96-101.
66. Fang DZ, Patil T, Belitskaya-Levy I, Yeung M, Posley K, Allaudeen N. Use of a hands free, instantaneous, closed-loop communication device improves perception of communication and workflow integration in an academic teaching hospital: a pilot study. *J Med Syst*. 2017;42(1):4.
67. Patel B, Johnston M, Cookson N, King D, Arora S, Darzi A. Interprofessional communication of clinicians using a mobile phone app: a randomized crossover trial using simulated patients. *J Med Internet Res*. 2016;18(4):e79.
68. Moloczij N, Mosley I, Moss KM, Bagot KL, Bladin CF, Cadilhac DA. Is telemedicine helping or hindering the delivery of stroke thrombolysis in rural areas? A qualitative analysis: telemedicine and thrombolysis. *Intern Med J*. 2015;45(9):957-964.
69. Holden RJ, Karsh B-T. The technology acceptance model: its past and its future in health care. *J Biomed Inform*. 2010;43(1):159-172.
70. Godin G, Bélanger-Gravel A, Eccles M, Grimshaw J. Healthcare professionals' intentions and behaviours: a systematic review of studies based on social cognitive theories. *Implement Sci*. 2008;3(1):36.
71. HIMSS Analytics. *The Hidden Cost of Pagers in Healthcare: How Outmoded Technology is Draining Healthcare it Budgets*. 2016.
72. Ivers N, Jamtvedt G, Flottorp S, et al. Audit and feedback: effects on professional practice and healthcare outcomes. *Cochrane Database Syst Rev*. 2012;6:Cd000259.
73. Hughes Driscoll CA, Gurmu S, Azeem A, El Metwally D. Implementation of smart phones to facilitate in-hospital telephone communication: challenges, successes and lessons from a neonatal intensive care unit. *Healthcare*. 2019;7(3):100331.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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