The efficacy of computer-enabled discharge communication interventions: a systematic review

Soror Mona Motamedi,[1,2] Juan Posadas-Calleja,[3] Sharon Straus,[4,5] David W Bates,[6,7] Diane L Lorenzetti,[8,9] Barry Baylis,[2,10] Janet Gilmour,[2,10] Shandra Kimpton,[2] William A Ghali[1,2,10]

[1]Department of Community Health Sciences, University of Calgary, Calgary, Canada
[2]Medical Ward of the 21st Century, Foothills Medical Centre, Calgary, Canada
[3]Department of Critical Care Medicine, University of Calgary, Calgary, Canada
[4]LiKaShing Knowledge Institute at St Michael's, Toronto, Canada
[5]University of Toronto, Toronto, Canada
[6]Division of General Internal Medicine and Center of Excellence for Patient Safety Research and Practice, Brigham and Women's Hospital Boston, Massachusetts, USA
[7]The Department of Health Policy and Management, Harvard School of Public Health, Boston, Massachusetts, USA
[8]Centre for Health and Policy Studies, University of Calgary, Calgary, Canada
[9]Institute of Health Economics, University of Calgary, Calgary, Canada
[10]Department of Medicine University of Calgary, Calgary, Canada

Correspondence to
Soror Mona Motamedi, W21C Research and Innovation Centre, GD01 TRW Building, 3280 Hospital Drive, Calgary, Alberta, Canada NW T2N 4Z6; Mona.Motamedi@AlbertaHealthServices.ca

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ABSTRACT

Context: Traditional manual/dictated discharge summaries are inaccurate, inconsistent and untimely. Computer-enabled discharge communications may improve information transfer by providing a standardised document that immediately links acute and community healthcare providers.

Objective: To conduct a systematic review evaluating the efficacy of computer-enabled discharge communication compared with traditional communication for patients discharged from acute care hospitals.

Data sources: MEDLINE, EMBASE, Cochrane CENTRAL Register of Controlled Trials and MEDLINE In-Process. Keywords from three themes were combined: discharge communication, electronic/online/web-based and controlled interventional studies.

Study selection: Study types included: clinical trials, quasiexperimental studies with concurrent controls and controlled before–after studies. Interventions included: (1) automatic population of a discharge document by computer database(s); (2) transmission of discharge information via computer technology; or (3) computer technology providing a 'platform' for dynamic discharge communication. Controls included: no intervention or traditional manual/dictated discharge summaries. Primary outcomes included: mortality, readmission and adverse events/near misses. Secondary outcomes included: timeliness, accuracy, quality/completeness and physician/patient satisfaction.

Data extraction: Description of interventions and study outcomes were extracted by two independent reviewers.

Results: 12 unique studies were identified: eight randomised controlled trials and four quasi-experimental studies. Pooling/meta-analysis was not possible, given the heterogeneity of measures and outcomes reported. The primary outcomes of mortality and readmission were inconsistently reported. There was no significant difference in mortality, and one study reported reduced long-term readmission. Intervention groups experienced reductions in perceived medical errors/adverse events, and improvements in timeliness and physician/patient satisfaction.

Conclusions: Computer-enabled discharge communications appear beneficial with respect to a number of important secondary outcomes. Primary outcomes of mortality and readmission are less commonly reported in this literature and require further study.

INTRODUCTION

Computer-enabled discharge summaries have been introduced in recent years in response to the well-documented problems faced by traditional handwritten and dictated summaries.[1 2] Concerns about inadequate and incorrect content, lack of standardised structure and untimely information transfer are the most commonly cited.

Despite their growing popularity, there has been no comprehensive systematic review examining the efficacy of these new computerised systems. In 2007, Kripalani and colleagues[2] investigated the prevalence of discharge communication deficits and looked broadly at all types of interventions that target those deficits. Of the 18 interventions identified, 16 of these were implemented prior to 2000; very few involved significant contributions of databases to construct the discharge summary, and none used the internet to transmit information. Much of the literature cited in a second review from 2007 included uncontrolled studies and some that were not peer-reviewed.[3]

This systematic review was carried out, therefore, in response to a significant gap in the literature. The objective was to evaluate the efficacy of computer-enabled discharge communication interventions for patients discharged from acute care hospitals.

METHODS

Search strategy

A search of the literature was initially done on 15 March 2008, with the most recent updated on 1 November 2010 using MEDLINE, EMBASE, the Cochrane CENTRAL Register of Controlled Trials, and MEDLINE In-Process and Other Non-Index. The Cochrane Database of Systematic Reviews was searched to identify existing systematic reviews. We applied a detailed search strategy combining terms/keywords from the following three themes: (1) Discharge Communication; (2) Electronic/Online/Web-based communication; and (3) Controlled Interventional Studies.

For theme 3, the study design search filter described by Egger *et al*[4] was amended to include both randomised clinical trials and other prospective interventional studies with control groups (ie, quasiexperimental studies with concurrent controls or controlled before–after studies). The initial search strategy was developed for use in MEDLINE, but was adapted for use in other databases. We considered both adult and paediatric populations, as well as studies in all languages. Hand searching of reference lists was also performed. The full search strategy is available from the authors on request.

Study selection

Titles and abstracts of all studies retrieved from the search were reviewed independently by two investigators (SMM, JP). Studies that were obviously unrelated and studies containing non-primary data were excluded in this first step. A full text review was then independently conducted by the same two reviewers for studies that were retained to determine if they met the inclusion criteria outlined below. Agreement among reviewers was quantified using κ statistics.

Inclusion and exclusion criteria

Interventions that focused on computer-enabled discharge communication, specifically for patients discharged from acute care to community care, were included. Also considered were computer-enabled discharge communications available directly to the patient. In order to be judged a 'computer-enabled discharge communication,' the intervention had to contain one or more of the following features: (1) automatic population of the discharge document by computer database(s); (2) transmission of discharge information via computer technology (eg, text message, email, or World Wide Web/internet); or (3) computer technology providing a platform for dynamic bidirectional discharge communication to occur between parties. Studies had to include a comparison group that received either no intervention or a traditional handwritten/dictated discharge summary. Studies included were therefore clinical trials, quasiexperimental studies with concurrent controls or controlled before–after studies.

Primary outcomes of interest were (postdischarge) mortality, readmission/emergency department visits and adverse events (including adverse drug events). Secondary outcomes included timeliness (time to complete, time to receive or time to read), accuracy of discharge information, quality/completeness and physician/patient satisfaction (including patient understanding of medical condition). Study-specific definitions for the various outcomes were compared and contrasted to determine the appropriateness of combining results across studies.

Studies with no comparison group were excluded, as were those without primary data, those with no reported outcomes and those not meeting our definition of a computer-enabled discharge communication (eg, non-electronic transmission, manually created documents or simple word processing). Additional exclusions applied to tele-health interventions that did not specifically relay discharge communication and to web-portals that contained only non-patient specific information (eg, only clinical practice guidelines, education materials, drug prescriptions and cost information, or referral information).

Data extraction and quality assessment

The data were independently extracted by two authors (SMM, JP) and entered directly into data tables. Differences in data-extraction decisions were resolved through discussion and review of source documents. Study quality for identified randomised controlled trials (RCTs) was assessed using criteria described by Jadad *et al*.[5] Allocation concealment was also assessed, although this study quality criterion is not part of the Jadad score. For non-RCTs, the inferior study design was considered to be the main indicator of evidence quality.

Data synthesis

We compiled a detailed description of the selected studies with tabular presentation of the study design, intervention, outcomes of interest, results and study quality. A statistical met-analysis was planned a priori but was not performed, owing to the heterogeneity of measures across studies.

RESULTS

The search identified 4415 articles that were initially assessed by review of titles and abstracts. Forty-nine of these were included for full text review. One additional study was identified through hand-searching of references, and another four identified on an updated

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verification search. A total of 12 studies published between 1992 and 2009 were considered unique and appropriate for final inclusion (figure 1). Study publications by Afilalo *et al*[6], Lang *et al*,[7] Callen *et al*[8 9] and Graumlich *et al*[10 11] reported data collected from common studies (and are therefore grouped in the tables below).

Description of studies and interventions

Eight RCTs and four quasiexperimental studies were identified (among the latter: 1 prospective cohort study with concurrent controls, and 3 before–after studies). In total, seven interventions employed computer database (s) to automatically populate the discharge document.[8–14] Four studies explicitly stated that computer technology was used to transmit discharge information via text messaging, email or the world wide web.[6 7 13 15] Two studies were classified as a computer technology providing a platform for dynamic discharge communication (including a web-based call center).[16 17] One intervention combined all three features.[18] Descriptions of each intervention are provided in table 1.

Study quality

Each RCT was assigned a Jadad score[5] of 3 or 4 out of 5, which is indicative of moderate study quality. Each appropriately described the procedure of randomisation as well as withdrawals/dropouts. No study explicitly performed double blinding. Allocation was concealed in all studies, except for perhaps two studies, where this methodological element was unclear. Table 2 provides a summary of study quality.

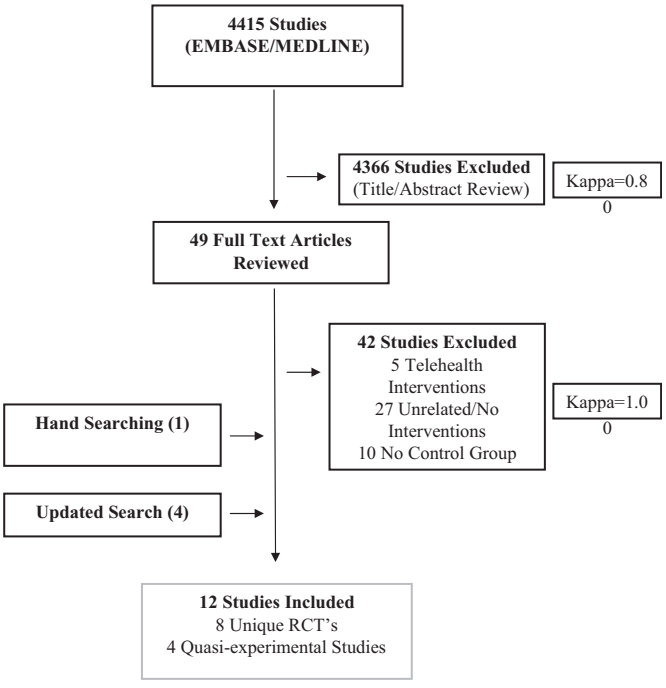

Figure 1 Selection process for study inclusion into systematic review.

Primary outcomes: mortality, readmission/ED visits, adverse events

Studies were quite variable with respect to outcomes reported (table 3). Only four studies reported on primary outcomes: three reported on both readmission and mortality,[10 13 16] one reported on readmission only,[6 7] and two reported on actual or primary care physician (PCP) perceived reductions in adverse events/near misses.[13 14] No significant differences in mortality were reported between groups at 30 days, 6 months or 12 months.[10 13 16] Readmission/emergency department visits were similar between groups at 14 days, 28 days and 6 months,[6 7] and were significantly lower in the intervention group at 12 months.[16] O'Leary *et al*[14] reported a significant reduction in PCP perceived preventable adverse events (40.7% vs 30.2%, p=0.02) and near misses (65.7% vs 52.9%, p=0.008) over 6 months following deployment of an electronic discharge summary. Graumlich *et al*[10] employed a more rigorous process of determining number of adverse events developed by Forster *et al*[21 22] and reported no differences between groups in adverse events over 1 month.

Secondary outcomes: timeliness, accuracy, quality/completeness, satisfaction

The majority of studies reported on at least one secondary outcome. Surveys/questionnaires were the most common means of data collection.[6 7 11 13–15 17–19]

Timeliness

Of eight studies, five showed that intervention discharge summaries were generated significantly more efficiently than traditional summaries and were transmitted to the PCP more quickly.[6 7 11–15 20 23] The majority of intervention summaries were available within 48 h, while the control summaries were received from 1 to 106 days postdischarge.[12 15 20] One study reported that intervention summaries were prepared significantly more quickly and easily, and reduced the burden on workload,[20] two reported no difference in time burden,[11 13] and one found that physicians perceived electronic summaries to require more effort to complete. It was not possible to pool timeliness data because each study measured time in different units (hours/days (including mean of 0 days)/or as a proportion of discharge summaries generated by a specified time).

Accuracy, quality/completeness

Accuracy and quality/completeness of discharge summaries were assessed using study-specific rating scales or by the number/percentage of omitted data

Table 1 Characteristics of studies included in review by study design

Study: authors, country (year)	Design	Setting/patients	Intervention group	Control group
Afilalo *et al*, Canada (2007)[6]; Lang *et al*, Canada (2006)[7]	RCT (4-period cluster crossover)	ED	► n=23 (PCPs) ► 1048 patient visits to ED ► Two 10-week periods ► PCPs received a secure, web-based communication system including ED notes, as consultant notes, laboratory results, ECG, imaging reports, discharge planning, medication changes ► Daily/immediate advisory emails alerting PCP of ED visit	► n=Same 23 (PCPs) ► 974 patient visits to ED ► Two 10-week periods ► PCPs received usual posted copies of the ED notes (1–2 weeks postdischarge)
García-Aymerich *et al*, Spain (2007)[17]	RCT	Chronic obstructive pulmonary disease patients: Respiratory and Environmental Health Research Unit	► n=44 Four key features: ► Comprehensive assessment of the patient at discharge ► Educational programme on self-management ► Individually tailored care plan shared across the system via interaction between nurse care manager and the primary care team ► Information and communication technologies platform including web-based call centre containing discharge information	► n=69 ► Patients received pharmacological prescriptions and in-hospital treatment ► Standard protocols of centres involved (no help from specialised nurse, no educational programme, no access to the call centre)
Casas *et al*, Spain, Belgium (2006)[16]	RCT	Chronic obstructive pulmonary disease patients: Respiratory and Environmental Health Research Unit	► n=65 Four key features: ► Comprehensive assessment of the patient at discharge ► Educational programme on self-management ► Individually tailored care plan shared across the system via interaction between nurse care manager and the primary care team ► Information and communication technologies platform including web-based call centre containing discharge information	► n=90 ► Patients received pharmacological prescriptions and in-hospital treatment ► Followed standard protocols of centres involved (no help from specialised nurse, no educational programme, no access to the call centre)

Continued

Table 1 Continued

Study: authors, country (year)	Design	Setting/patients	Intervention group	Control group
Gray *et al*, USA (2000)[18]	RCT	Infants in neonatal intensive care unit	► n=26 ► Families accessed Baby CareLink, a multi-faceted telemedicine program (videoconferencing and internet technology). ► Six areas of clinical content were available: a daily clinical report, message centre, infant photos, family room, clinical information, individualised preparation for discharge	► n=30 ► Usual care (no access to Baby CareLink)
van Walraven and Rokosh, Canada (1999)[19]	RCT	General internal medicine patients	► n=184 ► Database created DS, posted/faxed	► n=187 ► Dictated DS, posted/faxed
Maslove *et al*, Canada (2009)[13]	RCT (Cluster)	513-bed tertiary care hospital, General Internal Medicine Service	► n=56 surveys, 46 DS, 50 patient phone interviews ► EDS created by text fee-entry, pasting from hospital IT system, pick lists	► n=63 surveys 48 DS, 54 patient phone interviews ► Traditional dictated DS (mailed/faxed to outpatient physicians)
Graumlich *et al*, USA (2009)[10 11]	RCT (Cluster)	730-bed, tertiary care hospital, General Internal Medicine Service	► n=34 physician clusters, 316 patients ► Computerised physician order entry system/EDS including decision support. Output of four documents: personalised PCP letter, prescription list, patient instructions, discharge orders by fax/post.	► n=35 physician clusters, 315 patients ► Traditional handwritten DS
Kirby *et al*, UK (2006)[12]	Prospective Intervention (Concurrent Control)	Department of Diabetes and Endocrinology	► n=50 ► New EDS integrated with electronic discharge prescriptions	► n=52 ► Conventional discharge system (conventional discharge prescriptions and dictated discharge summaries, posted/faxed)
Branger *et al*, Netherlands (1992)[15]	Before–after	27 PCPs, two regional hospitals, unspecified services	► n=27 PCPs, 1388 (admission-discharge reports, 1396 laboratory results) ► Electronically transmitted messages (admission and discharge reports, laboratory reports, free text)	► n=NA ► Traditional paper-based communication, posted/faxed
Callen *et al*, Australia (2008)[8]; Callen *et al*, Australia (2010)[9]	Before–after	Medical and rehabilitation patients, 78-bed public hospital	► n=151 ► EDS integrated with electronic discharge prescriptions, posted to PCP	► n=94 ► Handwritten DS posted
O'Leary *et al*, USA (2009)[14]	Before–after	General medical patients admitted to a 753-bed hospital	► n=95 ► EDS generated by electronic medical record ► Automatic insertion of data, automatic fax to outpatient physicians	► n=101 ► Traditional dictated DS (mailed/faxed to outpatient physicians)

DS, discharge summary; ED, Emergency Department; EDS, electronic discharge summary; PCP, primary care physician/outpatient physician; RCT, randomised controlled trial.

Table 2 Study quality criteria that constitute the Jadad study quality score

Jadad quality criteria	Afilalo *et al*[6], Lang *et al*[7]	García-Aymerich *et al*[17]	Casas *et al*[16]	Gray *et al*[18]	van Walraven and Rokosh[19]	Maslove *et al*[13]	Graumlich *et al*[10 11]
Was the study described as randomized? (0, 1 point)	1	1	1	1	1	1	1
Was the method used to generate the sequence of randomisation described and appropriate? If yes and appropriate, add 1 point. If yes and not appropriate, deduct 1 point.	1	1	1	1	1	1	1
Was the study described as double blind? (0,1 point)	0	1	0	0	0	0	0
Was the method of double blinding described and appropriate? If yes and appropriate, add 1 point. If yes and not appropriate, deduct 1 point.	0	0	0	0	0	0	0
Was there a description of withdrawals and dropouts? (0, 1 point)	1	1	1	1	1	1	1
Total Jadad Score (out of 5)	3	4	3	3	3	3	3
Allocation concealment	Yes	Yes	Yes	Not explicit	Yes	Not explicit	Yes

elements. Only two studies examined accuracy in relation to transcription errors and reported that intervention summaries were more accurate or contained a similar number of errors.[8 9 15] Three of five studies assessing completeness demonstrated significant improvements in the intervention group, specifically with respect to legibility,[6 7] comprehensiveness[6 7] and brevity,[20] and more frequently included information on diagnosis,[20] medications,[20] planned follow-up,[14 20] tests pending[14] and information provided to the patient.[14] One study found no differences in discharge summary quality.[13] Callen *et al*[8 9] had mixed findings and noted that intervention summaries contained significantly more errors/omissions regarding discharge date, additional/other diagnoses, follow-up requirements and discharge medications. A small number of physicians were responsible for 76% of all errors/omissions reported in this study.

Satisfaction

Eight studies reported on either the satisfaction of the physician (PCP, residents) with the discharge intervention or of the patient/family.[6 7 10 11 13 17 18 20] Among all populations studied, satisfaction with intervention summaries was similar to or greater than that with traditional summaries. Each study employed unique definitions for satisfaction and, with three exceptions,[11 13 18] used non-standardised/custom questionnaires.

Primary care physicians reported that intervention summaries were very useful and more comprehensive,[6 7 15] providing them with better knowledge of their patients' hospital visits[6 7] and the ability to ultimately better manage their patients.[6 7] PCPs also generated significantly more follow-up actions upon receiving these summaries.[6 7] Outpatient physicians studied by Graumlich *et al*[11] also reported better perceptions of discharge quality for intervention patients who were discharged using computer software. Furthermore, residents expressed preference for the intervention over traditional dictated summaries.[13 20]

Patient/family preference varied by specific intervention. Patients with access to web-based resources in addition to personalised online discharge information[16] or with access to Baby CareLink (a tele-medicine initiative providing daily clinical reports)[18] had significantly improved knowledge of disease and self-management techniques and were more satisfied with overall quality of care and the care environment. Graumlich *et al*[11] reported that patients who were discharged using the intervention discharge software perceived greater discharge preparedness and similar satisfaction to the usual care group with respect to knowledge of discharge medications. In the study by Maslove *et al*,[13] computer-enabled discharge documents were provided directly to the patient, although attendance at follow-up

Table 3 Description of study outcomes and corresponding results

Study: authors, country (year)	Outcomes of interest	Results
Afilalo *et al*, Canada (2007)[6]; Lang *et al*, Canada (2006)[7]	Readmission, timeliness, PCP satisfaction, quality/completeness 1. Readmission to emergency department within 14 days; 28 days 2. Duplication of diagnostic tests and specialty consultations (2022 questionnaires to PCPs) PCP satisfaction: a web-based questionnaire was emailed to PCPs 21 days postdischarge (responses dichotomised from original 5-point Likert scale: strongly disagree (0), neutral (3), to strongly agree (5)). Responses 1–3=negative; responses 4, 5=affirmative. Applicable to outcomes 4–9. 4. Timeliness 5. Usefulness of information, completeness 6. Knowledge of patients ED visit 7. Patient management 8. Actions initiated by PCP 9. Higher rate of follow-up visits to PCPs office (ED advised, PCP-initiated or patient-initiated)	1. NS difference in 14-day readmission (OR 1.10, 95% CI 0.8 to 1.51); NS difference in 28-day readmission (OR 1.01, 95% CI 0.8 to 1.27) 2. NS difference in duplication of tests (24 vs 22, p=0.93). 4. IG PCPs received information more often (73% vs 49%, OR 3.14, 95% CI 2.6 to 3.79). Also received information more often in 48 h (66% vs 0.5%, p<0.001) 5. IG PCPs found information more useful (59% vs 29%, OR 5.1, 95% CI 3.49 to 7.46), and more comprehensive (72% vs 14%, p<0.001[+]) 6. IG PCPs had better knowledge of patient ED visit (62% vs 21%, OR 6.28, 95% CI 5.12 to 7.71). 7. IG PCPs felt they could better manage patients (45% vs 25% OR 2.46, 95% CI 2.02 to 2.99) 8. IG PCPs initiated more follow-up actions upon information receipt 9. NS increase in patient follow-up visits after ED care (17% vs 14%, OR 1.25, 95% CI 0.97 to 1.61)
García-Aymerich *et al*, Spain (2007)[17]	Patient satisfaction (self-management/understanding) 1. Patient satisfaction: self-management/knowledge (name of disease, identification of exacerbation, early treatment of chronic obstructive pulmonary disease exacerbation), Adherence to oral treatment (MAS Scale), adherence to inhaled treatment (IAS Scale), correct inhaler manoeuvre, long term oxygen therapy	1. IG patients significantly improved knowledge of diseaseincluding: name, exacerbation, adherence to inhaled treatment, inhaler manoeuvres. Other outcomes in this category NS.
Casas *et al*, Spain, Belgium (2006)[16]	Mortality, readmission, resource use 1. Mortality: mortality at 12 months (from hospital records, family interviews) 2. Readmission/ED visits: readmission to hospital during 12 month follow-up 3. Assessment of resource use by nurse at 1, 3, 6, 9, and 12 months	1. NS difference (12 deaths (19%) IG vs 14 (16%) usual care). Survival without readmission 32 (49%) vs 28 (31%), p=0.03 2. IG lower rate of rehospitalisation at 12 months (1.5±2.6 vs 2.1±3.1, p=0.033) 3. NS difference
Gray *et al*, USA (2000)[18]	Patient/family satisfaction (quality of care), LOS, discharge location 1. Patient/family satisfaction: quality of care assessed by Picker Institutes Neonatal Intensive Care Family Satisfaction Survey (1–4 months postdischarge)	1. IG patients/families reported significantly higher satisfaction with overall quality of care and environmental/visitation dimensions. IG did not report higher satisfaction with coordination of care. IG reported fewer problems with quality of care (mean problem score 3% and vs 13%)

Continued

Table 3 Continued

Study: authors, country (year)	Outcomes of interest	Results
Van Walraven *et al*, Canada (1999)[20]	Timeliness, quality/completeness, PCP and housestaff satisfaction 1. Timeliness: proportion of admissions for which a discharge summary was created by 4 weeks postdischarge 2. Timeliness: number of days from patient discharge to summary generation 3. Quality/completeness: organisation (of 14 items, proportion ofcontent items from chart review reported with a heading or cited in first sentence of paragraph) 4. Quality/completeness: overall quality (100 mm VAS; 0 indicating worst to 100 indicating best). Stratification by physician type. 5. Quality/completeness: completeness (21 items, by chart review) 6. Housestaff questionnaire. Time and burden to complete, rated 0 (worst) to 100 (best). Preference for each method (100 mm VAS, ratings >50 indicated preference for database/IG system)	1. IG significantly faster generation at 4 weeks postdischarge (79.6% vs or 57%, p<0.001). This difference persisted post-4 weeks 2. More IG summaries generated within 1 week postdischarge (94.7%, vs 80.2%, p<0.001) 3. NS difference. IG summaries significantly shorter with headings 4. NS difference. Stratification by specialty: PCPs rated IG summaries higher on timeliness (ratings 72.2 vs 62.6, p=0.04). Consultants gave lower ratings to IG summaries for quality (64.6 vs 76.2, p=0.02) and completeness. (68.2 vs79.5, p=0.01) 5. NS difference (mixed results) 15/21 items cited with significantly different frequency between groups. Ten items (discharge diagnosis, medications, follow-up) more common in IG. 5 /21 items (social history, admission diagnosis, hospital consultations, and functional status at discharge) more common in control summaries. 6. IG summaries significantly faster to complete (65.3 vs 46.3, p=0.007), less of a burden (65.2 vs 43, p=0.002) and preferred over the dictated summaries (p=0.004)
Kirby *et al*, UK (2006)[12]	Timeliness 1. Timeliness: time between patient discharge and posting of discharge summary on to PCP accessible computer system	1. IG summaries significantly less time to produce and post (mean 0 days vs 80 days, range 55−106, p≤0.0001)
Branger *et al*, Netherlands (1992)[15]	Timeliness and PCP satisfaction 1. (Before) timeliness: time to receive paper based posted reports (PCP estimate) 2. (After) timeliness: time between generation and delivery to PCP of electronically generated messages 3. (After) timeliness: time for PCP to read messages (measured only over 3 of 10 weeks) 4. (Before/after) other: percentage of laboratory results stored by PCP, Number of transcription errors 5. (After) PCP satisfaction: satisfaction with intervention 3 months postreceiving electronic messages regarding accuracy, burden to process, speed of reporting, integration into existing computer based patient record (5-Point Likert Scale: useless (0) to very useful (5))	1. Between 1 and 10 days by post 2. 91% of reports available at 1 h, remainder at 3 h postgeneration 3. PCPs read messages between 0 and 48 h after receipt 4. More IG summaries were stored than control/paper reports, more errors were found in transcribed paper reports (19 compared with 0) 5. 20/23 PCPs rated electronic communication of admission-discharge report as ≥4/5 with respect to the benefit of this type of communication. 15/23 reported electronic communication has provided more accurate knowledge of the care being delivered to patients. 10/23 PCPs reported less burden to process electronic communications.

Continued

Table 3 Continued

Study: authors, country (year)	Outcomes of interest	Results
Callen *et al*, Australia (2008)[8]; Callen *et al*, Australia (2010)[9]	Quality/completeness 1. Quality/completeness: presence of data items in appropriate locations (discharge date, additional/other diagnoses, summary of patient progress including treatment, investigations and results, follow-up requirements, discharge medications) 2. Quality/completeness: comparison of medication transcription error rate between electronic summaries and traditional handwritten summaries 3. Quality/completeness: comparison of medication documentation quality by level of physician medical training	1. IG summaries contained more omissions/errors regarding discharge date (OR 0.17, 95% CI 0.09 to 0.31, p<0.05), additional/other diagnoses (OR 0.33, 95% CI 0.15 to 0.89, p<0.05), follow-up requirements (OR 0.96, 95% CI 0.42 to 2.16, p<0.05), discharge medications (OR 0.5, 95% CI 0.20 to 1.26, p<0.05). IG summaries more commonly reported progress including treatment (OR 18.3, 95% CI 3.33 to 100, p<0.05), investigations and results (OR 3.18, 95% CI 0.84 to 12.0, p<0.05) 2. NS difference: medication omission the most common error type in both summaries 3. NS difference in error rates by physician medical training level (intern, resident and registrar)
Graumlich *et al*, USA (2009)[10 11]	Readmission, emergency department visits, adverse events, patient discharge preparedness and satisfaction, physician satisfaction, timeliness 1. Readmission/ED visits: proportion of patients readmitted at 6 months 2. Readmission/ED visits: proportion of patients visiting emergency departments at 6 months 3. Adverse events: proportion of patients experiencing an adverse event related to medical management within 1 month after discharge 4. Patient discharge preparedness (B-PREPARED questionnaire) 5. Patient satisfaction (Information About Medicines Scale questionnaire) 6. Outpatient physician satisfaction (Modified Physician-PREPARED questionnaire) 7. Timeliness (hospital physician effort to complete, 10-point Likert Scale: very dissatisfied (1) to very satisfied (10)).	1. NS difference in hospital readmission at 6 months 2. NS difference in emergency department visits at 6 months 3. NS difference in proportion of patients experience adverse events 4. Patient mean scores significantly higher for intervention patients (M=17.7, SD 4.1 vs 17.2, SD 4.0; coefficient=0.147; 95% CI 0.005 to 0.289, p=0.042) 5. Patient satisfaction scores with medication information similar between groups (M=12.3, SD 4.8 vs 12.1, SD4.6; coefficient=0.212; 95% CI 0.937 to 0.513, p=0.567) 6. Outpatient physicians reported higher satisfaction with discharge quality of intervention summaries (M=17.2, SD 3.8 vs 16.5, SD 3.9; coefficient=0.133; 95% CI 0.015 to 0.251, p=0.027) 7. Hospital physician reported significantly greater effort was required to complete intervention summaries (M=6.5, SD 1.9 vs 7.9, SD 2.1, p=0.011)

Continued

Table 3 Continued

Study: authors, country (year)	Outcomes of interest	Results
Maslove *et al*, Canada (2009)[13]	Mortality/ED visits/readmissions, timeliness, quality/completeness, PCP, housestaff and patient satisfaction 1. Composite outcome: emergency department visits, readmissions, death at 30 days 2. PCP satisfaction: overall satisfaction (100 point VAS), quality, completeness, organisation, timeliness 3. Housetaff satisfaction (100 point VAS): overall satisfaction, ease of use, preparation time 4. Patient satisfaction: patient understanding −Rates of attendance at outpatient follow-up tests and appointments −Patient satisfaction (Care Transitions Model-3 score (ranging from 0 to 100)	1. NS differences between groups 2. NS differences between groups on quality, completeness, organisation, timeliness 3. NS difference in overall satisfaction −Housestaff found the IG summaries easier to use (mean rating 86.5 vs 49.2; p=0.03); no difference in time burden (mean rating 36.8 vs 55.2; p=0.23) 4. NS difference in rates of attendance at outpatient follow-up tests and appointments. −No difference in Care Transitions Model-3 scores (patient satisfaction) between groups (80.3 vs 81.2, p=0.81)
O'Leary *et al*, USA (2009)[14]	1. Adverse events/near misses, timeliness, quality/completeness 2. Adverse events/near misses: PCP perceived 3. Timeliness: proportion of summaries completed within 3 days postdischarge 4. Timeliness: PCP rating (5-Point Likert Scale: very dissatisfied (1) to very satisfied (5)) 5. Quality/completeness: proportions of summary elements present (16 elements using custom 'Discharge Summary Completeness Score') 6. Quality/completeness: clarity/readability of summary (5-Point Likert Scale: unintelligible (1) to lucid (5))	1. IG PCPs perceived that 1 or more of their patients hospitalised in the preceding 6 months sustained a near miss (65.7% vs 52.9%, p=0.008) or a preventable adverse event (40.7% vs 30.2%, p=0.02) due to poor information transfer before implementing IG summaries 2. Greater proportion of IG summaries completed within 3 days (72.6% vs 59.4%, p=0.05) 3. Greater physician satisfaction with timeliness of IG summaries 3.34±1.09 vs control summaries 2.59±1.02 (p≤0.001) 4. 3/16 elements more common in IG summaries: discussion of follow-up issues (52.0% vs 75.8%; p=0.001), pending test results (13.9% vs 46.3%; p<0.001), and information provided to the patient and/or family (85.1% vs 95.8%; p=0.01) 5. Authors indicate that 'quality' (clarity/readability) improved significantly with IG summaries (3.64±0.99 vs 3.04±0.93, p≤0.001)

VAS, visual analogue scale.

Table 4 Semiquantitative visual assessment of study results

Authors	Mort-ality	Read-mission	Adverse events/ near misses	Time-liness	Accuracy	Quality/ completeness	Physician satisfaction	Patient satisfaction/ knowledge
Afilalo *et al*[6]; Lang *et al*[7]	NR	↔	NR	+	NR	+	+	NR/NR
García-Aymerich *et al*[17]	NR	NR	NR	NR	NR	NR	NR	↔/+
Casas *et al*[16]	↔	+	NR	NR	NR	NR	NR	NR/NR
Gray *et al*[18]	NR	NR	NR	NR	NR	NR	NR	+/NR
van Walraven *et al*[20]	NR	NR	NR	+	NR	↔	+	NR/NR
Kirby *et al*[12]	NR	NR	NR	+	NR	NR	NR	NR/NR
Branger *et al*[15]	NR	NR	NR	+	+	NR	+	NR/NR
Callen *et al*[8 9]	NR	NR	NR	NR	NR	−/+*	NR	NR/NR
O'Leary *et al*[14]	NR	NR	+	+	NR	+†	+	NR/NR
Maslove *et al*[13]	↔	↔	NR	↔	NR	+	↔/+	↔
Graumlich *et al*[10 11]	↔	↔	↔	↔	NR	+	+	↔/+†

*The Callen *et al* study focuses on completeness of information. Electronic summaries were poorer on some items, but better on other items.
†The O'Leary *et al* study revealed improved completeness in some, but not all of the domains that were assessed. Similarly, the studies from Graumlich *et al* reported favourable outcomes on some but not all domains assessed.
+, Significantly improvement(s) in the intervention group; −, significantly poorer in the intervention group; ↔, no significant difference between groups; NR, not reported.

visits/appointments and CTM-3 satisfaction scores were similar to those of patients whose discharge summaries were dictated (and these dictations were not necessarily provided to the patient).

Meta-analysis and summary visualisation of results

A priori, our study protocol anticipated possible meta-analytical pooling of outcomes. This was, however, not possible, given the heterogeneity of measures and outcomes reported across studies. Table 4 provides a semiquantitative summary of our review's findings. While no one study reports on all outcomes of interest, the body of literature as a whole points to some beneficial effects of computer-enabled discharge communication interventions, particularly for the secondary outcomes that we assessed.

DISCUSSION

To our knowledge, this is the first systematic review to assess the efficacy of computer-enabled discharge communication. With the exception of two studies, the 12 interventions identified generally did not overlap with those described by two reviews done in 2007.[2 3] Mortality and readmission to hospital/emergency departments within 6 months appear to be similar for patients regardless of type of discharge summary, although one study found a significant reduction for patients in the intervention group at 12 months. There is limited information about the impact on postdischarge adverse events, as only two studies reported this outcome; one study relied on physician recall of events after 6 months, and the second more rigorously identified events, albeit at only 1 month. More definitive benefits of computer-enabled summaries were identified with respect to improved quality and completeness, timeliness of delivery to care providers, as well as satisfaction among physicians and patients/families.

Our review has several caveats and limitations. Relatively few studies have been carried out in this area, all of moderate methodological quality, with heterogeneous patient populations, measures used and outcomes reported—ultimately limiting our ability to pool results in a meaningful way. Readers will recognise that electronic health records and discharge tools are complex interventions that require interplay between information technologies and human factors in a local context. For example, high rates of medication transcription errors found in traditional discharge summaries can be easily carried over to electronic summaries, and physicians may perceive that greater effort is required to complete these summaries if stand-alone systems are used (that is those not integrated with existing information technology infrastructure and therefore requiring human data entry).[9] Also, efficacy in one setting or context does

not guarantee a similar benefit in other hospitals or jurisdictions.

A final point to mention is that a number of computer-based interventions were excluded from our review because they were only descriptions of the technology or because only uncontrolled evaluations of the interventions had been reported.[23–31] While outside the scope of this review, it would also be pertinent to examine communication of medication information at the time of discharge between inpatient and outpatient pharmacies,[32–34] given that information transfer relating to medications is also a particularly vulnerable handoff.[33]

Should healthcare organisations now move to invest in the establishment of computer-based discharge communication tools based on the evidence that we have reviewed? Or should they dogmatically wait for more definitive research to be published on hard clinical outcomes of interest before investing in such systems? Such questions are challenging ones to answer, because they weigh the realisation that the status quo for discharge communication under usual care conditions is not tenable. Yet, from the standpoint of scientific enquiry, rigorous studies comparing various communication tools versus usual care are still needed to better characterise the efficacy of such tools. A reasonable balance to addressing the tension of scientific enquiry versus the need for immediate health system improvement is for us to state unequivocally that there is (in this review) certainly evidence to support the implementation of such systems now. However, we encourage organisations that move now to implement such systems to also incorporate formal evaluation protocols to expand collective knowledge on their efficacy, and perhaps also their cost-effectiveness. Such an approach would allow health systems to address the clear need for immediate system enhancements, while also potentially contributing new information to the evidence base on such computer-based communication interventions.

CONCLUSIONS

In conclusion, our findings globally support the notion that computer-enabled discharge communication tools are beneficial and worth implementing now. However, the evidence in support of their widespread implementation is still relatively limited in scope. Given the rapid uptake and continuing evolution of electronic patient information systems in acute and primary care settings, it is important to continue to scientifically study the extent to which such systems affect patient outcomes.

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