Strategies for utilisation management of hospital services: a systematic review of interventions

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Abstract

Background: To achieve efficiency and high quality in health systems, the appropriate use of hospital services is essential. We identified the initiatives intended to manage adult hospital services and reduce unnecessary hospital use among the general adult population.

Methods: We systematically reviewed studies published in English using five databases (PubMed, ProQuest, Scopus, Web of Science, and MEDLINE via Ovid). We only included studies that evaluated interventions aiming to reduce the use of hospital services or emergency department, frequency of hospital admissions, length of hospital stay, or the use of diagnostic tests in a general adult population. Studies reporting no relevant outcomes or focusing on a specific patient population or children were excluded.

Results: In total, 64 articles were included in the systematic review. Nine utilisation management methods were identified: care plan, case management, care coordination, utilisation review, clinical information system, physician profiling, consultation, education, and discharge planning. Primary case management was shown to effectively reduce emergency department use. Care coordination reduced 30-day post-discharge hospital readmission or emergency department visit rates. The pre-admission review program decreased elective admissions. The physician profiling, concurrent review, and discharge planning effectively reduced the length of hospital stay. Twenty-three studies that evaluated costs, reported cost savings in the hospitals.

Conclusions: Utilisation management interventions can decrease hospital use by improving the use of community-based health services and improving the quality of care by providing appropriate care at the right time and at the right level of care.

Keywords: Utilisation management, Utilisation review, Health policy and systems research, Hospital

Background

Hospitals provide a wide range of services necessary to meet the increasing demand for health care services and are an integral component of any health delivery system. However, inappropriate utilisation of high-cost but unnecessary or ineffective tests and medications in hospitals remains a significant challenge in many health systems [1]. Several studies documented improper hospital service use, which can be defined as “a hospital admission to provide care that could have been given in a less complex healthcare environment and at a lower cost” [2]. For example, it was previously shown that up to one-third of days of care [3–5]
and diagnostic tests [6, 7], and one-fifth of all hospital admissions [8] could be inappropriate or unnecessary, negatively impacting patients’ physical and mental well-being, and driving up overall health care costs. Hence, eliminating inappropriate utilisation and waste is essential given the existing shortage of financial and human resources.

Advances in medical technology and, consequently, aggressive marketing to health care providers, direct-to-consumer advertising, political pressure from advocacy organisations, defensive medical decision making, fragmentation and discontinuity of care within and between health and social sectors - all can become the cause of healthcare overutilisation [9, 10]. Cost containment strategies can limit healthcare-related expenditure by eliminating inappropriate use of health care services while ensuring the continuous improvement of the quality of care. For example, one could consider controlling demand or supply for care, altering provision structures or hospital performance, cost-sharing, managed care, reference pricing, and generic substitution [11]. Another strategy is fostering hospital mergers and networks that may speed up restructuring through economies of scale at relatively small hospital sizes. However, creating a dominant position in the local hospital market may have an anticompetitive effect [12].

With the rising demand for healthcare services, hospitals can apply innovative methods to increase their efficiency [4]. This can be achieved by strengthening operational efficiency and targeting more significant healthcare expenditure cases. A range of measures can be used for this purpose: reducing duplication of services, decreasing the use of expensive inputs, decreasing the length of stay for inpatient care, reducing the number of long-stay beds, and reducing medical errors [13–15]. Another approach would be implementing measures that could rebalance services provision across the health system, improve allocative efficiency, and centralise administrative functions. Such measures could include shifting the provision of care from the hospital into the community, improving care coordination, strengthening preventative care, increasing the use of day surgeries, providing appropriate levels of acute care at home (hospital at home), and facilitating the discharge of patients who have to stay in hospitals longer [16, 17]. One could also consider implementing initiatives that lower management expenses and enhance administrative efficiency, such as simplifying managerial procedures; introducing uniform standards, distribution strategies and the availability of real-time consumer and provider information; improving electronic mechanisms of lodging, processing, and reimbursement of payments and claims; and outsourcing member management systems and other back-office services [18, 19].

Most importantly, besides the cost-saving and improving operational, allocative, and administrative efficiency, reducing inappropriate utilisation could eliminate potential iatrogenic effects of unnecessary services while improving healthcare quality. However, previous studies primarily focused on evaluating the effectiveness of interventions in reducing a specific service, while studies that would provide a clear overview of the utilisation management strategies for adult hospital services are still lacking. Hence, our study aimed to identify the initiatives intended to manage adult hospital services and reduce unnecessary hospital use among the general adult population.

**Methods**

We conducted a systematic review of published studies investigating initiatives intended to manage adult hospital services and reduce unnecessary hospital use among the general adult population.

**Inclusion criteria**

Studies were included if they reported using intervention in a general population aimed to reduce relevant primary outcomes (i.e., hospital services and/or emergency department (ED) use, frequency of hospital admissions, LOS, and use of diagnostic tests) compared to care as usual or different intervention. There were no time restrictions, but the publication language was restricted to English only.

**Exclusion criteria**

We excluded studies that targeted adult patient populations only with a specific medical condition (e.g., diabetes, asthma, cardiac failure, or cancer) or children to increase homogeneity and comparability between studies.

**Search strategy**

Five bibliographic databases (PubMed, ProQuest, Scopus, Web of Science, Ovid/Medline) were searched until March 2020. To capture a broad range of primary outcomes, in addition to utilisation management and utilisation review, we included the following search terms: concurrent review, prospective review, retrospective review, pre-admission review, pre-admission review, pre-certification, pre-admission certification, pre-admission certification, pre-admission authorisation, pre-admission authorisation, pre-admission testing, pre-admission...
testing, prior authorisation, same-day admission, physician profiling, provider profiling, physician financial incentives, demand management, case management, discharge planning, second surgical opinions, second opinions, step therapy, therapeutic substitution, closed formulary, utilisation. We additionally searched the references of included studies for other potentially essential studies.

Study selection, data extraction, and synthesis
Results from the bibliographic databases were merged, and duplicates removed. Two reviewers (LD and RKh) independently screened the search results by title, abstract and performed a full-text review. Disagreements were resolved by discussion and consensus with a third reviewer (HJ). We extracted the following information from the studies included in the review: type of intervention, study design, details of the intervention, and effects on primary outcomes (hospital services and ED use, admissions, LOS, use of diagnostic tests) and secondary outcomes (readmissions and costs). This review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses [20].

Assessment of the methodological quality
We used an adapted version of the Quality Assessment Tool for Quantitative Studies (developed by the Effective Public Health Practice Project [21] to assess the methodological quality of the included studies (Appendix). The tool contains 19 items in eight key domains: (1) study design; (2) blinding; (3) representativeness in the sense of selection bias; (4) representativeness in the sense of withdrawals/drop-outs; (5) confounders; (6) data collection; (7) data analysis; and (8) reporting. Studies can have between six and eight component ratings, with each component score ranging from 1 (low risk of bias; high methodological quality) to 3 (high risk of bias; low methodological quality). An overall rating for each study was determined based on the component ratings. For example, if eight ratings have been given, a rating of ‘strong’ was attributed to those with no weak ratings and at least five strong ratings, ‘moderate’ to those with one weak rating or fewer than five strong ratings, and ‘weak’ attributed to those with two or more weak ratings. To minimise the risk of bias, assessments were completed independently by two reviewers (LD and EK). The ratings for each of the eight domains and the total rating were compared, and a consensus was reached on a final rating for each included article.

Data Analysis
Descriptive analyses were used to describe all studies that met the inclusion criteria, focusing on study design, participants, interventions and outcomes.

Results
The results of the screening process are shown in Fig. 1. After removing duplicates, 2261 papers were screened by title and abstract for possible inclusion in the review. The full text of 264 articles was obtained and assessed for eligibility. Of them, 56 selected papers were eligible for review. After screening references of included papers, we identified additional nine papers. Sixty four studies [22–85] met the eligibility criteria and were included in the final review.

Characteristics of the selected studies
Included studies were published between 1982 and 2020, conducted mostly in the USA (n = 34) [22–24, 29–32, 37, 39, 40, 42, 43, 45, 47, 49, 56, 57, 60, 63, 65, 67–71, 73–75, 77, 78, 81, 82, 84, 85], Canada (n = 4) [26, 35, 55, 61], Australia (n = 4) [38, 41, 59, 83], UK (n = 3) [36, 64, 72], Sweden (n = 3) [62, 66, 76], and one each in the Netherlands [52], Korea [44], China [53], Taiwan [27], Singapore [54], and Bahrain [34]. All studies focused on the general adult population; however, some focused on specific broader subgroups with psychiatric problems [29, 45, 54, 83], comorbid conditions [49, 77], psychosocial problems (e.g., problems with housing, medical care, substance abuse, mental health disorders, or financial entitlements) [70], uninsured [30, 31, 43, 68], patients with chronic medical conditions [27, 46, 49, 61, 67], or older patients [41, 43, 47, 49, 64, 66, 67, 76]. The duration of the study follow-up ranged from one month to seven years (Table 1).

Fourteen studies (21.9%) were randomized controlled trials [22, 23, 43, 47, 49, 52, 53, 55, 62, 66, 69, 70, 73, 74], three were multicenter research trials [36, 63, 76], two were quasi-experimental studies [31, 67], four were controlled before-and-after studies [30, 68, 72, 85], twenty-one studies (32.8%) were non-controlled before-and-after studies (NCBA) [24, 27–29, 32, 35, 37–39, 41, 42, 50, 54, 56–61, 75, 78], three were time-series studies [26, 34, 44], three were case-control studies [64, 65, 84], one was a prospective cohort study [77], one was longitudinal study, six were retrospective cohort studies [25, 33, 79–82], and four were cross-sectional studies [40, 45, 71, 83]. While, in two studies were not stated type of design [48, 51]. Forty studies (59.7%) can be categorized as assessing interventions targeted at the patient...
journey during hospital stay or medical center-based interventions [22–24, 26, 27, 29, 30, 34, 37, 39, 40, 42, 44, 45, 49, 54, 56, 57, 59–63, 65, 69, 70, 72, 74, 75, 78, 81–83, 85]; four evaluated interventions aimed at discharge [41, 47, 55, 76]; and 13 examined community-based interventions [31, 35, 38, 43, 46, 52, 53, 64, 66–68, 73, 77].

Methodological quality assessment
In the overall assessment, the methodological quality of only one reviewed study (1.5%) was rated as ‘strong’, while seven (11%) and 56 (87.5%) articles were rated as ‘moderate’ and ‘weak’, respectively (Appendix). In terms of study design, 21 studies (32.8%) were rated as ‘strong’. The remaining 13 studies (20.3%) scored ‘moderate’ and 30 studies (46.9%) scored ‘weak’. We were able to rate 39 studies for representativeness relating to withdrawals and drop-outs: 25 (64.1%) studies rated as ‘weak’, four (10.3%) as ‘moderate’, and ten (25.6) as ‘strong’. With respect to confounders, 11 (17.2%) studies were rated as ‘strong’, six (9.4%) as ‘moderate’, and 47 (73.4%) as ‘weak’. There were 23 studies (35.9%) rated as ‘weak’ for their data collection because the authors did not provide sufficient information on the validity or reliability of their collection methods. There were 37 papers (57.8%) rated as ‘moderate’ and four papers (6.3%) rated as ‘strong’. Based on the data analysis of each reviewed study, 36 (56.3%) of the reviewed studies were rated as ‘strong’, while 12 (18.8%) and 16 (25.0%) were rated as ‘moderate’ and ‘weak’, respectively. The reporting quality of the reviewed articles was also analysed. Out of the 64 articles included, 36 studies (56.3%) were rated as ‘strong’, 21 studies (32.8%) and seven studies (10.9%) were rated as ‘moderate’ and ‘weak’, respectively.
| Author (Year) Country | Design | Health care setting | Type of intervention | Control | Health Professionals involved in an intervention | Period, months | Number of Participants |
|-----------------------|--------|---------------------|----------------------|---------|-----------------------------------------------|--------------|------------------------|
| Sandberg et al. [66] (2015) Sweden | RCT | Community | Case management consisted of assessment, care coordination, providing general information, specific information and safety and monthly home visiting | Usual care | Nurse case managers, physiotherapists, physicians | 12 F/U | Control: 73 Exposed: 80 |
| Haldiman et al. [40] (2014) the United States | Cross-sectional | Hospital | Prospective review of requests for fresh-frozen plasma and platelets using guidelines and pathologists as consultants | Before review | Blood bank staff, pathologist, ordering physician | 48 F/U | NR |
| Goodnough et al. [37] (2014) the United States | NCBA | Hospital | Concurrent review using a real-time clinical decision support system (CDSS) consisted of interruptive best practice alerts (BPAs) at the time of physician order entry (POE) | CDSS | Physicians | 22 before and 30 F/U | NR |
| Joo [46] (2014) the United States | longitudinal | Community | Case management comprises assessment, care plans, care services in homes, clinic settings or telephone consults, evaluation | No Case Management | Nurse case managers | Up to 24 F/U | Control: - Exposed: 252 |
| Buckley et al. [24] (2013) the United States | NCBA | Medical institution | Drug-utilization management program using evidence-based guidelines and clinical pharmacists | Pre-Implementation of Drug-Utilization Review | Clinical pharmacists, physicians, nurses, hospital administrators | 6 before and 6 F/U | Control: 496 Exposed: 300 |
| Reinius et al. [62] (2013) Sweden | RCT | Hospital | Case management using a personalised programme, telephone contact | Usual care | Nurses | 12 F/U | Control: 57 Exposed: 211 |
| Crane et al. [30] (2012) the United States | CBA | Hospital | Case management comprises drop-in group visits, telehealth line and life skills training | Before Case Management | Family physician, nurse care manager, behavioural health professional | 12 before and 12 F/U | Control group: 36 Exposed: 340020 |
Table 1 (continued)

| Author (Year) Country | Design     | Health care setting       | Type of intervention                                                                 | Control                                         | Health Professionals involved in an intervention | Period, months | Number of Participants |
|-----------------------|------------|---------------------------|--------------------------------------------------------------------------------------|-------------------------------------------------|-------------------------------------------------|---------------|------------------------|
| Roland et al. [64]    | Case-control | From hospital to community | Case management focused on integrated care, delivery system redesign, improved     | No Case Management                               | Case managers, GPs, community nurses, social    | 6 before 6 F/U | Control group: 17,311 Exposed: 3646 |
|                       | (2012) the United Kingdom |                       | clinical information systems                                                        |                                                 | workers                                         |               |                        |
| Koehler et al. [49]   | RCT        | Hospital                  | Care coordination using supplemental care bundle consists of medication counselling, | Usual care                                      | Care coordinator, pharmacist                    | 2 F/U         | Control: 21 Exposed: 20 |
| (2009) the United States |            |                           | reconciliation by a clinical pharmacist, patient education, enhanced discharge       |                                                 |                                                 |               |                        |
|                       |            |                           | planning, and phone follow-up                                                       |                                                 |                                                 |               |                        |
| Schraeder et al. [67] | Quasi-experimental | Primary care            | Case management emphasises collaboration between physicians, nurses and patients,    | Usual care                                      | Nurse case managers, primary care physicians    | 36 F/U        | Control: 277 Exposed: 400 |
| (2008) the United States |               |                           | risk identification, comprehensive assessment, collaborative planning, health       |                                                 |                                                 |               |                        |
|                       |            |                           | monitoring, patient education and transitional care                                  |                                                 |                                                 |               |                        |
| Holsinger et al. [42] | NCBA       | Hospitals                 | Collaborative model of learning, a “trial-and-learn” approach to quality           | Before model                                    | Physicians, medical staff, representatives      | 19 before and | 54 hospitals            |
| (2008) the United States |            |                           | improvement, including Plan-Do-Study-Act cycles to test and implement changes      |                                                 | from quality improvement, utilisation review    | 14 F/U        |                        |
|                       |            |                           |                                                                                     |                                                 | or case management, billing, compliance,       |               |                        |
|                       |            |                           |                                                                                     |                                                 | and medical records departments                |               |                        |
| Author (Year) Country | Design | Health care setting | Type of intervention | Control | Health Professionals involved in an intervention | Period, months | Number of Participants |
|-----------------------|--------|---------------------|----------------------|---------|-----------------------------------------------|----------------|-----------------------|
| Sweeney et al. [77] (2007) the United States | Prospective cohort | HMO | Patient-centred management involves on-site assessment, education, home visits, frequent contact, and goal-oriented care plans | Usual case management | Care managers, team managers, nurses, physicians | 3 to 18 F/U | Control: 398 Exposed: 358 |
| Phillips et al. [59] (2006) Australia | NCBA | ED | Case management includes psychosocial evaluation, access to health care practitioners | Before Case Management | Nurses, allied health professionals, social workers, psychiatrists, primary care provider | 12 before and 12 F/U | Control: 60 Exposed: 60 |
| Sledge et al. [73] (2006) the United States | RCT | Primary care services | Case Management, including comprehensive medical and psychosocial assessment, care planning, follow-up, care coordination, self-management, counselling, telehealth line, home visiting | Usual care | Nurse case manager, social worker, psychiatrist, internist, primary care provider | 12 F/U | Control: 49 Exposed: 47 |
| Mahendran et al. [54] (2006) Singapore | NCBA | From hospital to community | Case Management includes care planning, care coordination, continuity of care, patient education, referral, counselling, telephone contacts, home visiting, assessment, evaluation, and supportive therapy | No Case Management | Psychiatric nurses were recruited as psychiatric case managers | 12F/U | Control: - Exposed: 227 |
| Zemencuk et al. [85] (2006) the United States | CBA | Hospital | Physician profiling | No profiling | Physicians | 12 before and 12 F/U | Control: 6 hospitals Exposed: 1 hospital |
| Latour et al. [52] (2006) the Netherlands | RCT | From hospital to community | Case management includes home visiting after discharge, assessment, set care plan consisting of psychosocial support, referral, and telephone follow up | Usual care | A nurse case manager, medical supervisor, general practitioner | 6F/U | Control: 69 Exposed: 78 |
Table 1 (continued)

| Author (Year) Country | Design | Health care setting | Type of intervention | Control | Health Professionals involved in an intervention | Period, months | Number of Participants |
|-----------------------|--------|---------------------|----------------------|---------|-----------------------------------------------|---------------|-----------------------|
| Hegney et al. [41] (2006) Australia | NCBA | Hospital | Discharge planning using a risk screening tool | Before intervention | Specialist community nurse | 9 before vs 9 F/U | Control: - Exposed: 2139 |
| Horwitz et al. [43] (2005) the United States | RCT | Hospital | Case Management including referral to PCP, telephone or mail contacts, home visiting | Usual care | Case managers | 6 F/U | Control 109 Exposed: 121 Control 51 Exposed: 59 |
| Leung et al. [53] (2004) China | RCT | Community | Case Management includes regular monitoring of subjects’ health status, telehealth line, home visiting, community-based supportive services | Usual service | A nurse case manager, case geriatricians | 12 F/U | Control: 47 Exposed: 45 |
| Cox et al. [29] (2003) the United States | NCBA | Medical Center | Case management emphasizes on the management of personal resources, medication compliance and therapeutic relationships | Before Case Management | Psychiatrists, nurses, psychologists, social worker | 12 to 84 F/U | Control: - Exposed: 185 |
| Hwang et al. [44] (2002) Korea | Time series | Hospital | POE system | Pre-Physician’s order entry | Physicians | 3 before and 6 F/U | Control: 73 Exposed: 38 |
| Fateha [34] (2002) Bahrain | Time series | Hospital | Concurrent Review | Before review | Medical staff | 96 F/U | - |
| Ferrazzi et al. [35] (2001) Canada | NCBA | Community | Advanced life support drug treatment is given by ambulance attendants | Before the program | Ambulance attendants | 18 before vs 18 F/U | Control: 215 Exposed: 191 |
| Okinet al [57], (2000) the United States | NCBA | Hospital | Case Management includes services coordination, individual and group supportive therapy, housing arrangement, financial entitlements, referral to PCP, substance abuse referral, community services, home visiting | Before Case Management | Psychiatric social worker, case manager | 12 before and 12 F/U | Control: - Exposed: 53 |
| Author (Year) Country | Design | Health care setting | Type of intervention | Control | Health Professionals involved in an intervention | Period, months | Number of Participants |
|-----------------------|--------|---------------------|----------------------|---------|-----------------------------------------------|---------------|-----------------------|
| Bates et al. [22] (1999) the United States | RCT | Hospital | Computerised physician order entry is given a reminder to the physician | No reminder | Physicians | 4 F/U | Control: 5886 Exposed: 5700 |
| Wickizer et al. [82] (1998) the United States | Retrospective analysis | Hospital | Utilisation management strategies including: Pre-admission review, concurrent review | Before Utilisation management | Nurse reviewers, physician advisers | 60 | 49,654 |
| Spillane et al. [74] (1997) United States | RCT | Hospital | Case management includes individualised care plans, psychosocial evaluation, care coordination | Usual care | ED physician, social worker, psychiatrist, ED nurse practitioner | 12 before and 12 F/U | Control: 25 Exposed: 27 |
| Bree et al. [23] (1996) the United States | RCT | Hospital | Pre-certification includes mandatory radiology consultation; each radiology examination requires approval by the attending radiologist before it is performed | No Pre-certification | Attending radiology consultant, radiology clerical personnel | 12 F/U | Control: 1178 Exposed: 1022 |
| Shea et al. [69] (1995) the United States | RCT | Hospital | Clinical information systems include: computer-generated informational messages directed to physicians | No message | Physicians | 23 F/U | Control: 6990 Exposed: 7109 |
| Cardiff et al. [26] (1995) Canada | Time-series | Hospitals | Utilisation management strategy includes identifying patients who did not need to be in acute care beds, as defined by the ISD-A explicit criteria and modifying the level of care for such patients | Before Utilisation management program | Nurse reviewers, physicians | 12 before and 12 F/U | Control: Hospital C: 281 Hospital D: 312 Exposed: Hospital A: 600 Hospital B: 597 |
Table 1 (continued)

| Author (Year) Country | Design                          | Health care setting    | Type of intervention                                                                 | Control                                                                 | Health Professionals involved in an intervention | Period, months | Number of Participants |
|-----------------------|--------------------------------|------------------------|---------------------------------------------------------------------------------------|------------------------------------------------------------------------|-------------------------------------------------|----------------|------------------------|
| Styrborn [76] (1995)  | Multicenter controlled trial   | From hospital to community | Discharge Planning comprised: patient assessment, development of discharge plan, implementation in the form of provision of services, including patient/family education and service referrals follow up/evaluation | Ordinary discharge routines                                           | Consultant geriatrician, nurse                    | 3 F/U Control: Hospital B: 166 Hospital C: 190 Exposed: Hospital A: 180 |
| Rosenberg et al. [65] (1995) the United States | Case-control                      | Hospital                | Utilisation review, second opinion, discharge planning, case management                     | Sham review                                                         | Nurses, physicians                                  | 8 F/U Control: 3743 Exposed: 3702 |
| Jambunathan et al. [45] (1995) the United States | Cross-sectional                     | Outpatient clinic        | Case management including biopsychosocial assessment, care planning, care delivery, care coordination | Before Case Management                                          | Nurses                                                  | 18 F/U Control: - Exposed: 21             |
| Williams et al. [83] (1994) Australia | Cross-sectional                     | Hospital                | Drug utilisation review                                                                  | No review                                                          | Drug use review panel                         | Patient admission to discharge Control: - Exposed: 75 |
| Wickizer [81] (1992) the United States | Retrospective analysis            | Hospital                | Utilisation Review consists of pre-admission authorisation and concurrent review            | No Review                                                           | Registered nurses, physician advisors, medical personnel | 36 F/U Control: - Exposed: 1844          |
| Woodside et al. [84] (1991) the United States | Case-control                        | Hospital                | Utilisation management strategies including concurrent review, consultation, discharge planning, care coordination | No Utilisation management                                          | Care coordinator, physician, nurses              | 3 F/U Control: 191 Exposed: 73          |
| Silver et al. [71] (1992) the United States | Cross-sectional                     | Hospital                | Prospective review using guidelines                                                      | No review                                                          | Transfusion service technical personnel, physicians | 12 F/U Control: - Exposed: 543          |
| Author (Year) Country        | Design                                         | Health care setting | Type of intervention                                                                                           | Control                                                                                       | Health Professionals involved in an intervention | Period, months | Number of Participants |
|-----------------------------|-----------------------------------------------|---------------------|----------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|-------------------------------------------------|---------------|------------------------|
| Fowkes et al. [36] (1986)   | Multicenter controlled trial                 | Hospitals           | Appointment of a utilisation review committee, informational feedback given to physicians, the introduction of a new chest X-ray request form, concurrent review | No review                                                                                 | Physicians, clerical staff                      | 12 F/U        | 44,632                 |
| Echols et al. [32] (1984)   | NCBA                                          | Hospital            | Drug utilisation Review using an antibiotic order form                                                        | Before the introduction of the order form                                                  | Physicians                                       | 25 F/U        | NR                     |
| Restuccia [63] (1982)       | Multicenter controlled trial                 | Hospitals           | Utilisation review consists of providing concurrent feedback to physicians                                   | No feedback                                                                                 | Nurses review coordinators, physicians           | 2 F/U         | Control: hospital D: 51 Exposed: hospital A: 145 hospital B: 68 hospital C: 60 |
| Murphy [56] (2014)          | NCBA                                          | Hospital            | Case management includes multidisciplinary ED care coordination, individualised ED care guidelines, and information system | Before ED-care-coordination program                                                       | Physicians, nurses, mental health and substance abuse professionals, ED nurse managers, a pharmacist, a social worker, a chaplain | 12 before and 12 F/U | Control: 65 Exposed: 65 |
| Chiang et al. [27] (2014)   | NCBA                                          | Hospital            | Case management using dynamic, internet-mediated, team-based support led by emergency physicians             | Before Case Management                                                                     | ED physicians, primary care physicians, psychiatrists, social workers, and pharmacologists | 6 before and 6 F/U | Control: - Exposed: 14 |
| Pillow et al. [60] (2013)   | NCBA                                          | Hospital            | Care plans include social work assessment, directives to call pain team for the development of pain contract, radiologic studies, out-patient referral for speciality clinics, urinary toxicology studies, managed care referral, and psychiatric assessment | Before CP                                                                                  | Social workers, case managers, physicians       | 6 before and 11 F/ Uphil | Control: - Exposed: 50 |
| Author (Year) Country | Design | Health care setting | Type of intervention | Control | Health Professionals involved in an intervention | Period, months | Number of Participants |
|----------------------|--------|---------------------|----------------------|---------|-----------------------------------------------|---------------|-----------------------|
| Dehaven et al. [31] (2012) the United States | Quasi-experimental | From hospital to community | A community-based partnership includes improving access to a primary care provider through in-person or telephone access to the community health worker, referral | Usual care | Primary care providers, hospital-based coordinators, community health worker | 12 F/U | Control: 309 Exposed: 265 |
| Tadros et al. [78] (2012) the United States | NCBA | EMS | Case management includes coordination of treatment and social services, in-person contact, EMS interface, referrals, phone calls, transports | Before Case Management | Primary care physicians, social workers, case managers and adult protective services personnel | 16 before and 15 F/U | Control: - Exposed: 51 |
| Shah et al. [68] (2011) the United States | CBA | Primary care services | Care management includes access to medical and social resources, scheduling primary care appointments, following up on referrals, arranging for support services, e.g., housing, care transitions while in hospital, care navigation and care coordination between specialists and primary care providers | Before Case Management | Case managers, Primary care providers | 12 before and 3 to 12F/U | Control: 160 Exposed: 98 |
| Stokes-Buzzelli S et al. [75] (2010) the United States | NCBA | Hospital | Health Information Technologies consist of identifying the most frequently presenting patients and creating individualised care plans for those patients and access to care plans through electronic medical records | No HIT | ED attending, ED medical social worker, ED mental health social worker, ED psychologist, ED resident, ED clinical nurse specialists | Same pre-and post-intervention time for each patient but varied between patients from 3 to 23 | Control: - Exposed: 36 |
| Author (Year) Country | Design | Health care setting | Type of intervention | Control | Health Professionals involved in an intervention | Period, months | Number of Participants |
|-----------------------|--------|---------------------|----------------------|---------|-----------------------------------------------|---------------|----------------------|
| Grimmer-Somers et al. [38] (2010) Australia | NCBA Community | Individualised care plan including health assessment, social support, problem-solving, empowerment, education, goal setting and mentoring | Before program | Social workers, nurses | 12 before and 12 F/U | Control: Exposed: 37 |
| Grover et al. [39] (2010) the United States | NCBA Hospital | Case management using patient care plans consisted of referral to PCP, limiting narcotic use, pain management, chemical dependency, behavioural health evaluation, social services | Before Case Management | Physicians, nurses, social service providers, pain management clinicians, specialists in behavioural health | 6 before and 6 F/U | Control: 96 Exposed: 96 |
| Skinner et al. [72] (2009) the United Kingdom | CBA Hospital | Case management includes evaluation, individualised care plan, referrals to other services, key contact, close observation | Before Case Management | ED consultant, ED specialist registrar, psychiatric nurse specialist, social workers, housing officers | 6 before vs 6 F/U | Control: 21 Exposed: 36 |
| Shumway et al. [70] (2008) the United States | RCT Hospital | Case management including individual assessment, crisis intervention, individual and group supportive therapy, arrangement of stable housing and financial entitlements, linkage to medical care providers, referral to substance abuse services, ongoing assertive community outreach | Usual care | Psychiatric social workers, nurse practitioners, primary care physicians, psychiatrist | 24 F/U | Control: 85 Exposed: 167 |
| Author (Year) Country | Design | Health care setting | Type of intervention | Control | Health Professionals involved in an intervention | Period, months | Number of Participants |
|----------------------|--------|---------------------|---------------------|---------|-----------------------------------------------|---------------|------------------------|
| Pope et al. [61] (2000) Canada | NCBA | Hospital | Case management includes individualised care plan, limiting narcotics and benzodiazepines prescriptions and laboratory tests requested in ED, referral to PCP, pain program, addiction counselling, communicating care plans with other EDs, supportive therapy, arrangement of food services | Before Case management | Social workers, ED medical director, director of continuous quality improvement, patient care manager, psychiatric nurse, clinical nurse specialist, family physicians, community care providers | 12 before and 12 F/U | Control: 24 Exposed: 24 |
| Moher et al. [55] (1992) Canada | RCT | Clinical teaching units | Discharge planning based on individual patient needs | Standard medical care | Nurse | 4F/U | Control: 131 Exposed: 136 |
| Kennedy et al. [47] (1987) the United States | RCT | Hospital | Discharge Planning is based on individual patient needs, emphasising communication with the patient and family | Care not described | Nurses | 1 F/U | Control: 41 Exposed: 39 |
| Kurant et al. [51] (2018) the United States | Not stated | Hospital | Laboratory-based utilisation management programs, including electronic health record (EHR) laboratory orders database | Usual service | Not applicable | 8 months | 160,000 EHR laboratory orders |
| Copeland et al. [28] (2017) the United States | NCBA | Hospital | Modelling of collective and individual oncologist per patient imaging counts | Before model | | 12 months | 4605 patients |
| Author (Year) Country | Design | Health care setting | Type of intervention | Control | Health Professionals involved in an intervention | Period, months | Number of Participants |
|-----------------------|--------|---------------------|----------------------|---------|-------------------------------------------------|---------------|-----------------------|
| Pena et al. [58] (2014) the United States | NCBA   | Hospital            | Blood management program includes Improving communications and transfusion guidelines, Benchmarking using the issue-to-transfusion ratio and audits and gatekeeping of selected blood products | Before the Blood management program | The staff of the laboratory of the Blood Transfusion Service | 36 months | All of the transfused components at MGH from 2010 to 2012 |
| Weilburg et al. [80] (2017) the United States | Retrospective cohort | Hospital | Analysis of high-cost imaging utilisation in a stable cohort of patients cared for by PCPs during a 7-year period | Statewide high-cost imaging use data from a major private payer on the basis of the same claim set | Primary care physicians & specialty care physicians | 84 months | 109,823 patients |
| Konger et al [50] (2016) the United States | NCBA | Hospital | Reductions in unnecessary clinical laboratory testing by using LES and POE Pre-LES test volume | Pathologists | 36 months | 14,359 Exclusion Requests |
| El-Othmani et al. [33] (2019) the United States | Retrospective analyse | Hospital | The Joint Utilization Management Program | Before the Joint Utilization Management Program | Physicians, post-acute care providers, and inpatient interdisciplinary teams | 12 before and 12 F/U | 683 JUMP patient |
| Kim & Lee [48] (2020) Korea | Not stated | Medical Aid Beneficiaries | Case Management | Before Case Management | The case manager, a registered nurse or social worker | 12 Months | 1741 case management clients |
| Wasfy et al. [79] (2019) the United States | Retrospective cohort | Hospital | Hospital Readmissions Reduction Program | Pre-law trends | Not applicable | 36 Months | 3,038,740 total index hospital stays |
| Calsolaro et al. [25] (2019) Italy | Retrospective analyse | Hospital | Potentially Preventable Readmission Grouping | Comparing stand-alone admissions, index admissions, and potentially preventable readmissions | Geriatricians | 30 days | 1263 stand-alone admissions, 171 index admissions |

Notes: RCT Randomised controlled trial, ED Emergency Department, CM Case Management, NCBA Non-controlled before-and-after studies, LES Laboratory expert system, HIT Health Information Technologies, EMS Emergency medical services, POE Physician's order entry, CDSS Before Clinical Decision Support System, HMO Health maintenance organisation
| Author (Year) Country | Type of intervention | Main Outcome Measure | Outcomes | Statistically significant (P < .05) |
|-----------------------|----------------------|----------------------|----------|-----------------------------------|
|                       |                      |                      | Control  | Intervention |                      |
|                       |                      |                      | Before   | After        | Difference |
|                       |                      |                      | Before   | After        | Difference |
| Sandberg et al. [66]  | Case management      | No. of admissions, mean | 0.62     | 0.48         | 0.48       | 0.49      | No |
| (2015) Sweden         |                      | LOS, mean            | 3.90     | 4.05         | 5.05       | 4.60      | No |
|                       |                      | No. of ED visits leading to hospitalization, mean | 0.36 | 0.42 | 0.39 | 0.34 | No |
|                       |                      | No. of ED visits not leading to hospitalization, mean | 0.22 | 0.37 | 0.15 | 0.08 | Yes |
|                       |                      | Proportion of ED visits not leading to hospitalisation | 16 (38.1%) | 23 (46.7%) | 12 (27.9%) | 4 (17.4%) | Yes |
|                       |                      | No. of outpatient visits, mean | 6.10 | 5.29 | 5.30 | 4.09 | Yes |
| Haldiman et al. [40]  | Prospective review   | No. of FFPs transfused per 1000 patients discharged per year | – | – | Y1: 66.7 | Y4: 46.9 | - 19.8 (-29.7%) | Yes |
| (2014) the United States |                      | No. of platelets transfused per 1000 patient discharged per year | – | – | Y1: 23.7 | Y2: 18.7 | -5 (-21.1%) | Yes |
| Goodnough et al. [37] | Concurrent review    | Annual cost savings  | $130,000,000 | – | – | – | NR |
| (2014) the United States |                      | % of blood transfusions in patients with HB levels exceeded 8g/dl | – | – | 57% | 30% | Yes |
|                       |                      | Total RBC transfusions | – | – | – | – | NR |
|                       |                      | Total plasma transfusions | – | – | – | – | NR |
|                       |                      | Total platelets transfusions | – | – | – | – | NR |
|                       |                      | All blood components | – | – | – | – | NR |
|                       |                      | Net savings           | $1,616,750 | – | – | – | NR |
**Table 2** (continued)

| Author (Year) Country | Type of intervention | Main Outcome Measure | Outcomes | Outcomes | Statistically significant ($P < .05$) |
|-----------------------|----------------------|----------------------|----------|----------|--------------------------------------|
|                       |                      |                      | Control  | Intervention |                                       |
|                       |                      |                      | Before   | After     | Difference                           |
|                       |                      |                      | Before   | After     | Difference                           |
|                       |                      |                      | Before   | After     | Difference                           |
| Joo [46] (2014) the United States | Case management | No. of Admissions | –       | –         | –                                   | Y1: 0.62 | Y2: 0.47 | Yes     |
|                       |                      | Total LOS            | –       | –         | –                                   | Y1: 3.05 | Y2: 2.28 | No      |
|                       |                      | NO. of ED visits     | –       | –         | –                                   | Y1: 0.38 | Y2: 0.36 | No      |
|                       |                      | Symptom control      | –       | –         | –                                   | B: 4.07  | Y1: 4.19 | Yes     |
|                       |                      | Quality of life      | –       | –         | –                                   | B: 3.89  | Y1: 4.01 | Yes     |
|                       |                      | Personal well-being  | –       | –         | –                                   | B: 4.09  | Y1: 4.13 | No      |
| Buckley et al. [24] (2013) the United States | Drug-utilisation management program | The proportion of patients prescribed epoetin | –       | –         | –                                   | 2.4%     | 1.6%     | Yes     |
|                       |                      | No. of patients inappropriately prescribed epoetin | –       | –         | –                                   | 184/496 (37.1%) | 37/300 (12.3%) | Yes     |
|                       |                      | Total no. of epoetin units administered | –       | –         | –                                   | 24,531,340 | 13,511,800 | −45%     |
|                       |                      | Total epoetin costs  | –       | –         | –                                   | $220,786 ($36,797/mo) | $121,606 ($20,268/mo) | −45%     |
|                       |                      | % of total costs was attributed to inappropriate epoetin prescribing | –       | –         | –                                   | 36.8%     | 13%       | Yes     |
|                       |                      | Annual cost savings  | –       | –         | –                                   | $198,352 ($16,529/mo) |                        | Yes     |
| Author and Year | Country | Type of intervention | Main Outcome Measure | Outcomes (Control Before, After, Difference) | Outcomes (Intervention Before, After, Difference) | Statistically significant (P < .05) |
|----------------|---------|----------------------|----------------------|---------------------------------------------|-------------------------------------------------|----------------------------------|
| Reinius et al. [62] (2013) Sweden | Sweden | Case management | No. of ED visits | – 6.4 – – | 4.9 – | RRs 0.77; 95% CI 0.69-0.87 |
| | | | No. of admissions, mean | – 2.1 – – | 1.7 – | No |
| | | | No. of hospital days per patient per year | – 16.9 – – | 7.0 – | –58% Yes |
| | | | No. of out-patient visits, mean | – 25.4 – – | 21.4 – | –15.7% |
| | | | Costs per patient per year | – €26,490 – – | €11,417 – | –57% Yes |
| Crane et al. [30] (2012) the United States | the United States | Case management | No. of ED visits, median | 6.96 5.04 | 6.96 2.76 | –4.2 Yes |
| | | | Total ED and inpatient charges per patient per mon, mean | – – – | $1167 – | $230 | –$937 Yes |
| Roland et al. [64] (2012) the United Kingdom | the United Kingdom | Case management | No. of emergency admissions | – – – | – | +9% Yes |
| | | | No. of elective admissions | – – – | – | –21% Yes |
| | | | No. of out-patient visits | – – – | – | –22% Yes |
| | | | Inpatient and out-patient costs | – – – | – | –$223 | –9% Yes |
| Koehler et al. [49] (2009) the United States | the United States | Care coordination | No. of 0-30 day post-discharge readmissions/ ED visits | – 8 (38%) – – | 2 (10%) – | Yes |
| | | | No. of 31-60 day post-discharge readmissions/ ED visits | – 1 (4.8%) – – | 4 (20%) – | No |
| | | | Total post-discharge readmissions/ED visits at 60 days | – 9 (42.9%) – – | 6 (30%) – | No |
| Author (Year) Country | Type of intervention | Main Outcome Measure | Control | Intervention | Statistically significant ($P < .05$) |
|-----------------------|----------------------|----------------------|---------|--------------|-------------------------------------|
| Schraeder et al. [67] (2008) the United States | Case management | Admissions, % | – | 53.8 | – | 51 | – | No |
| | | Hospital bed days, mean | – | 13.89 | – | 8.19 | – | Yes |
| | | ED visits, mean | – | 1.79 | – | 1.48 | – | No |
| | | Readmissions | – | 28.8% | – | 19.2% | – | No |
| | | Cost of care per patient per mon, mean | – | $708 | – | $1193 | $485 | Yes |
| | | Adjusted cost of care per patient per mon (cost savings) | – | – | – | – | $106 | No |
| Holsinger et al. [42] (2008) the United States | Collaborative model | 1-day hospital stays | – | – | – | – | – | NR |
| Sweeney et al. [77] (2007) the United States | Patient-centred management | No. of admission, mean | – | 1.9 | – | 1.2 | – | No |
| | | Hospital days, mean | – | 13.4 | – | 8.5 | – | Yes |
| | | No. of ED visits, mean | – | 1.5 | – | 1.0 | – | No |
| | | Rehabilitation days, mean | – | 5.8 | – | 3.7 | – | No |
| | | Hospice days, mean | – | 2.4 | – | 3.3 | – | No |
| | | Home care days, mean | – | 30.9 | – | 36.8 | – | No |
| | | The overall cost per patient for 18 mon, mean | – | $68,341 | – | $49,742 | $18,599 | (−27.2%) | NR |
| Author (Year) Country | Type of intervention | Main Outcome Measure | Outcomes | Statistically significant ($P < .05$) |
|-----------------------|----------------------|----------------------|----------|-------------------------------------|
|                       |                      |                      | Control  | Intervention | Before | After | Difference | Before | After | Difference |                          |
|                       |                      |                      | Before | After | Difference | Before | After | Difference |          |            |             |                          |
| Phillips et al. [59]  | Case management      | Admissions, sum of the percentage | – – – | 1104 | 931 | No |                          |
| (2006) Australia      |                      | No. of ED visits, mean | – – – | 10.2 | 13.0 | +2.8 (27.4%) | No | $P = 0.55$ |                          |
|                       |                      | ED LOS, minutes, mean | – – – | 297 | 300 | +3 | No |                          |
|                       |                      | No. of ED overnight observation, mean | – – – | 1.3 | 3.4 | +2.1 (166%) | Yes |                          |
|                       |                      | Housing stability score | – – – | 3.6 | 4.1 | 0.5 (14%) | Yes |                          |
|                       |                      | Primary care engagement score | – – – | 2.6 | 3.1 | 0.5 (19%) | Yes |                          |
|                       |                      | Community care engagement score | – – – | 2.1 | 3.2 | 1.1 (52%) | Yes |                          |
| Sledge et al. [73]    | Case management      | Drug and alcohol use | – – – | 68.3% | 58.9% | No |                          |
| (2006) the United States |                      | No. of admissions, mean | 2.0 | 1.7 | –0.3 | 1.9 | 1.3 | –0.6 | No |                          |
|                       |                      | No. of ED visits, mean | 3.3 | 2.7 | –0.6 | 2.0 | 1.5 | –0.5 | No |                          |
|                       |                      | No. of clinic visits, mean | 5.9 | 5.7 | –0.2 | 6.4 | 7.9 | +1.5 | Yes |                          |
|                       |                      | Total cost, mean | $17,721 | $15,447 | $-2,274 | $17,265 | $16,291 | $-974 | No |                          |
|                       |                      | SF-36 Mental Health Function Score | 21.7 | 22 | 0.3 | 21.3 | 21.4 | 0.1 | No |                          |
|                       |                      | Overall patient satisfaction | 7.24 | 6.7 | –0.54 | 7.47 | 7.6 | 0.13 | No |                          |
| Mahendran et al. [54] | Case management      | No. of readmissions | – – – | 65 | 26 | –39 | Yes |                          |
| (2006) Singapore      |                      | No. of patients who defaulted follow-up appointments | – – – | All outpatient: 24% | CM patient: 11.9% | Yes |                          |
|                       |                      | No. of days per admission, mean | – – – | 15.6 | 4 | –11.6 | Yes |                          |
| Author (Year) | Country                  | Type of intervention | Main Outcome Measure | Outcomes Statistically significant (P < .05) |
|--------------|--------------------------|----------------------|----------------------|---------------------------------------------|
| **Zemencuk et al. [85] (2006) the United States** | Physician profiling | LOS                  | – – – – – 0.32 day   | Yes                                         |
| **Latour et al. [52] (2006) the Netherlands** | Case management        | Readmission rate     | – 11 (1.59%) – 16 (20.6%) | No                                          |
| **Latour et al. [52] (2006) the Netherlands** | Case management        | Quality of life      | – – – – – No         | No                                          |
| **Latour et al. [52] (2006) the Netherlands** | Case management        | Psychological functioning | – – – – – No | No                                          |
| **Hegney et al. [41] (2006) Australia** | Discharge planning using risk screening tool | ED revisitation rate | – – 21% 5% –16% | Yes                                         |
| **Hegney et al. [41] (2006) Australia** | Discharge planning using risk screening tool | Readmission rate     | – – 9 (10.2%) 7 (4.7%) – 2 (5.5%) | No                                          |
| **Hegney et al. [41] (2006) Australia** | Discharge planning using risk screening tool | ALOS                  | – – 6.17 5.37 –0.8 | NR                                          |
| **Horwitz et al. [43] (2005) the United States** | Case management        | No. of admission     | – 7/109 (6.4%) – 3/121 (2.5%) | No                                          |
| **Horwitz et al. [43] (2005) the United States** | Case management        | No. of ED visits     | – 32/109 (29.4%) – 38/121 (31.4%) | No                                          |
| **Horwitz et al. [43] (2005) the United States** | Case management        | Primary care contact in 60 days | – 15/109 (13.8%) – 62/121 (51.2%) | Yes                                         |
| **Horwitz et al. [43] (2005) the United States** | Case management        | Cost of an ED visit, mean | $330 $319 $330 $243 | NR                                          |
| **Leung et al. [53] (2004) China** | Case management        | Total no. of admissions, mean | 1.4 2.7 3.0 2.3 | Yes                                         |
| **Leung et al. [53] (2004) China** | Case management        | Total no. of hospital bed days, mean | 6.8 10.7 12.9 9.6 | Yes                                         |
| **Leung et al. [53] (2004) China** | Case management        | Total no. of visits, mean | 0.4 0.8 0.5 0.3 | No                                          |
| **Leung et al. [53] (2004) China** | Case management        | Total no. of outpatient visits, mean | 6.7 6.9 9.0 8.3 | Yes                                         |
| **Cox et al. (2003) [29] the United States** | Case management        | No. of admissions, mean | – – 3.11 0.82 –2.29 | Yes                                         |
| **Cox et al. (2003) [29] the United States** | Case management        | Hospital days, mean   | – – 46.6 12.4 –34.2 | Yes                                         |
| **Cox et al. (2003) [29] the United States** | Case management        | Cost-saving per inpatient day | – – – $166 | Yes                                         |
| **Hwang et al. [44] (2002) Korea** | Physician's order entry system | LOS, mean            | – – 11.4 8.2 –3.2 | Yes                                         |
| **Hwang et al. [44] (2002) Korea** | Physician's order entry system | No. of daily orders  | – – 10.9 18.9 +8 | Yes                                         |
| **Hwang et al. [44] (2002) Korea** | Physician's order entry system | No. of stat lab tests | – – 3.3 18 –1.5 | Yes                                         |
| **Fateha [34] (2002) Bahrain** | Concurrent Review      | LOS, mean            | – – 8.3 66 –1.7 (−20.5%) | Yes                                         |
| Author (Year) Country | Type of intervention | Main Outcome Measure | Outcomes | Control | Intervention | Statistically significant (P < .05) |
|-----------------------|----------------------|----------------------|----------|---------|--------------|---------------------------------|
|                      |                      |                      |          | Before  | After        | Difference | Before  | After  | Difference |
| Ferrazzi et al. [35] (2001) Canada | Advanced life support drug treatment given by ambulance attendants | Proportion of admissions | – – – | 145 (67.4%) | 102 (54.3%) | Yes |
|                      |                      | ED LOS, min, mean    | – – –    | 2069    | 2209         | −14        | No       |
|                      |                      | Ambulance scene time, min | – – –    | 12.3    | 14.2         | Yes       |
| Okin et al. [57] (2000) the United States | Case management | No. of ED visits, median | – – –    | 15      | 9            | −6 (−40%) | Yes |
|                      |                      | No. of out-patient visits, median | – – –    | 2      | 4            | No        |
|                      |                      | No. of admissions, median | – – –    | 1      | 1            | No        |
|                      |                      | Medical inpatient days, median | – – –    | 5      | 2            | No        |
|                      |                      | ED costs, median      | – – –    | $4124   | $2195        | $1938     | Yes |
|                      |                      | Medical inpatient costs, median | – – –    | $8330   | $2786        | $5446     | Yes |
|                      |                      | Medical out-patient costs, median | – – –    | $476    | $612         | $94       | No |
|                      |                      | Homelessness          | – – –    | 35      | 15           | −20 (−57%) | Yes |
|                      |                      | Alcohol use           | – – –    | 37      | 29           | −8 (−22%) | Yes |
|                      |                      | Drug use              | – – –    | 27      | 20           | −7 (−26%) | Yes |
|                      |                      | Linkage to primary care | – – –    | –      | –            | +74%      | Yes |
| Bates et al. [22] (1999) the United States | Computerised physician order entry | Net cost savings | $132,726 | NR |
|                      |                      | No. of clinical laboratory orders that were cancelled in response to reminders | – | Not applicable | – | 300 of 437 (69%) | – | Yes |
|                      |                      | The proportion of the redundant tests that were performed | – | 257 (51%) | – | 117 (27%) | – | Yes |
|                      |                      | Annual lab cost savings | – | $35,000 | $NR |


| Author (Year) Country | Type of intervention | Main Outcome Measure | Outcomes | Statistically significant ($P < .05$) |
|-----------------------|----------------------|----------------------|----------|-------------------------------------|
| Wickizer et al. [82] (1998) the United States | Utilisation management strategies | No. of days approved | – – – – – – 50% | Yes |
| Spillane et al [74] (1997) the United States | Case management | No. of ED visits, median | 13 6 7 7 –7 | NO |
| Bree et al [23] (1996) the United States | Pre-certification | No. of examinations per admission, mean | 4.4 6.1 4.4 – | No |
| | | LOS, mean | – 88.7% – 88% | No |
| | | % of patients with one or more tests | – 336.0 – 356.1 | No |
| | | Relative value units (RVUs), mean | – 10.2 – 8.8 | No |
| | | Adjusted RVUs | – 0.012 – – | No |
| Shea et al. [69] (1995) the United States | Clinical information system | Adjusted LOS, mean | – 0.011 –2.3% | Yes |
| Cardiff et al. [26] (1995) Canada | Utilisation management | Inappropriate admissions | C: 26 (18%) D: 36 (23%) | Among hospitals in both time period: Yes |
| | | Adjusted inappropriate continued days of stay | C: 0.0656 D: 0.0617 | B: Yes A,C,D: No |
| | | 30-day readmission (rate per 1000 discharge) | C: 105 D: 92 | A,B,D: Yes CNo |
| Styrborn [76] (1995) Sweden | Discharge planning | Adjusted LOS | B: 105 C: 109 A: 9.6 A-(B+C): −1.1 | No |
| | | No. of bed-blocking patients | B: 35 C: 35 A: 31 | –4 NR |
| | | Waiting days/patient | B: 113 C: 180 A: 8.2 A-(B+C): −6.4 | Yes |
| | | Charge days per patient | B: 62 C: 13.4 A: 4.2 A-(B+C): −5.6 | Yes |
| Author       | Year | Country       | Type of intervention                     | Main Outcome Measure                                                                 | Outcomes | Statistical significance (P < .05) |
|--------------|------|---------------|------------------------------------------|-------------------------------------------------------------------------------------|----------|------------------------------------|
| Rosenberg et al. [65] | 1995 | the United States | Utilisation review, second opinion, discharge planning, case management | No. of out-patient procedure                                                         | Before: 913  After: 789  Difference: -124 | Yes |
| Jambunathan et al. [45] | 1995 | the United States | Case management                        | No. of case management visits/Adjusted LOS (r-value)                                  | Before: –  After: 641.8  Difference: 16.4 | No |
| Williams et al. [83] | 1994 | Australia     | Drug utilisation review                  | No. of patients using benzodiazepines                                                | Before: –  After: 30 (40%)  Difference: -15 (−20%) | Yes |
| Wickizer [81] | 1992 | the United States | Utilisation review                        | No. of admissions                                                                     | Before: –  After: –  Difference: -12% | Yes |
| Woodside et al. [84] | 1991 | the United States | Utilisation management strategies        | Adjusted LOS                                                                         | Before: 11.8  After: 9.1  Difference: -2.3 | NR |
| Silver et al. [71] | 1992 | the United States | Prospective review                      | No. of orders cancelled                                                               | Before: –  After: 114 (21%)  Difference: -114 | NR |
|               |      |               |                                          | Total costs                                                                             | Before: $22,695  After: $19,042  Difference: -3,653 | NR |
|               |      |               |                                          | Cost savings per employee per year                                                    | Before: $115  After: –  Difference: -1,15 | NR |
| Author (Year) Country | Type of intervention | Main Outcome Measure | Outcomes | Statistically significant (P < .05) |
|----------------------|----------------------|----------------------|----------|------------------------------------|
|                      |                      |                      | Control Before After Difference | Intervention Before After Difference |
| Fowkes et al. [36] (1986) the United Kingdom | Utilisation review | No. of X-ray tests per 100 operations | – – – 29.4 13.3 | –16.1 Yes |
| Echols et al. [32] (1984) the United States | Drug utilisation review | No. of antibiotic treatment courses | – – – – | –30% Yes |
|                      |                      | No. of patients receiving any antibiotic | – – 47% 30% | –17% Yes |
| Restuccia [63] (1982) the United States | Utilisation review | No. of inappropriate days, mean | D: 3.25 – – A: 2.59 B: 2.75 C: 3.25 | A-D: -0.66 B-D: -0.5 C-D: 0 Yes |
|                      |                      | Adjusted LOS, mean | D: 14.59 – – | A: 12.23 B: 13.81 C: 15.23 | A-D: -2.36 B-D: -0.78 C-D: 0.64 Yes |
| Murphy [56] (2014) the United States | Case management | No. of ED visits | – – – 7 2 | –5 Yes |
|                      |                      | No. of out-patient visits | – – – 7 2 | –5 Yes |
|                      |                      | Direct treatment costs | – – – $23,28 $1043 | -$1285 Yes |
|                      |                      | Direct treatment cost per visit | – – – $323 $235 | -$88 Yes |
|                      |                      | Net income | – – – -$608 -$177 | $431 Yes |
| Chiang et al. [27] (2014) Taiwan | Case management | No. of ED visits, mean | – – – 63 26 | –37 (-58%) Yes |
| Pillow et al. [60] (2013) the United States | Care plans | No. of ED visits per year per patient | – – – 22.6 21.2 | –1.4 Yes |
|                      |                      | No. of admissions per year per patient | – – – 7.3 6.8 | –0.5 No |
| Dehaven et al. [31] (2012) the United States | Community-based partnership | No. of ED visits, mean | – – 1.44 0.93 | Yes |
|                      |                      | No. of hospital days, mean | – – 1.07 0.37 | Yes |
|                      |                      | Direct hospital costs, mean | – – $1188 $445.6 | –62% Yes |
|                      |                      | Indirect costs, mean | – – $692.1 $313.3 | –55% Yes |
| Author (Year) Country | Type of intervention | Main Outcome Measure | Outcomes | Outcomes Statistically significant (P < .05) |
|-----------------------|----------------------|----------------------|----------|-----------------------------------------|
|                       |                      |                      | Control  | Intervention                           |
|                       |                      |                      | Before   | After        | Difference | Before | After        | Difference |
| Tadros et al. [78] (2012) the United States | Case management | No. of EMS visits, median | –        | –           | –         | 8      | 4           | –4         | Yes        |
|                       |                      | Total no. of EMS visits | –        | –           | –         | 736    | 459         | –37.6%     | Yes        |
|                       |                      | No. of ED visits, median | –        | –           | –         | 1      | 0           | –1         | No         |
|                       |                      | Total no. of ED visits | –        | –           | –         | 199    | 143         | –28.1%     | No         |
|                       |                      | No. of admissions, median | –        | –           | –         | 0      | 0           | 0          | No         |
|                       |                      | Total no. of admissions | –        | –           | –         | 33     | 30          | –9.1%      | No         |
|                       |                      | LOS, median | –        | –           | –         | 0      | 0           | 0          | No         |
|                       |                      | LOS, days | –        | –           | –         | 122    | 88          | –27.9%     | No         |
|                       |                      | EMS costs | –        | –           | –         | $689,743 | $468,394   | –32.1%     | Yes        |
|                       |                      | Outpatient costs | –        | –           | –         | $413,410 | $360,779   | –12.7%     | No         |
|                       |                      | Inpatient costs | –        | –           | –         | $687,306 | $646,881   | –5.9%      | No         |
|                       |                      | Total costs | –        | –           | –         | $1,790,459 | $1,476,053 | –531,406 (–17.6%) | NR        |
| Shah et al. [68] (2011) the United States | Care management | No. of ED visits per year, median | –        | –           | –         | 6.0     | 1.7         | –3.9       | Yes        |
|                       |                      | No. of admissions, median | –        | –           | –         | 0.0     | 0.0         | 0.0        | No         |
|                       |                      | Unadjusted ED cost per patient per year, mean | –        | –           | –         | $2545   | $1874       | –$671 (–26%) | Yes        |
|                       |                      | Unadjusted admission cost per patient per year, mean | –        | –           | –         | $ 20,298 | $7053       | –$13,245 (–65%) | Yes        |
Table 2 (continued)

| Author (Year) Country | Type of intervention | Main Outcome Measure | Outcomes | Control Before | After | Difference | Intervention Before | After | Difference | Statistically significant (P < .05) |
|-----------------------|----------------------|----------------------|----------|----------------|-------|------------|---------------------|-------|------------|----------------------------------|
| Stokes-Buzzelli S et al. [75] (2010) the United States | Health Information Technologies | No. of ED visits, mean | – | – | – | 67.4 | 50.5 | –16.9 (−%25) | Yes |
| | | ED LOS, min | – | – | – | 388 | 342 | –46 (−%12) | No |
| | | Lab studies ordered, mean | – | – | – | 1847 | 1328 | –519 (−%28) | Yes |
| | | ED charges | – | – | – | $64,721 | $49,208 | –15,513 (−24%) | Yes |
| | | Total Emergency Department Contact Time, hours | – | – | – | 443.7 | 270.6 | −173.1 or 7.21 days (−39%) | Yes |
| Grimmer-Somers et al. [38] (2010) Australia | Individualised care plan | No. of ED visits | – | – | – | 0.81 | 0.59 | NR |
| | | No. of admissions | – | – | – | 0.32 | 0.21 | NR |
| | | LOS | – | – | – | – | – | −1.3 | NR |
| Grover et al. [39] (2010) the United States | Case management | No. of ED visits, mean | – | – | – | 13.8 | 3.6 | −74% | Yes |
| | | No. of CT images | – | – | – | 153.6 | 61.2 | −60% | Yes |
| Skinner et al. [72] (2009) the United Kingdom | Case management | No. of ED visits, median | – | – | – | 12 | 6 | −6 | Yes |
| | | Total no. of ED visits | – | – | – | 720 | 499 | −221 (−31%) | Yes |
| Author (Year) Country | Type of intervention | Main Outcome Measure | Outcomes | Statistically significant ($P < .05$) |
|-----------------------|----------------------|----------------------|----------|--------------------------------------|
|                       | Control | Intervention | Difference | Before | After | Before | After | Difference |                           |
| Shumway et al. [70] (2008) the United States | Case management | No. of ED visits, mean | 5.2 | 2.0 | 3.6 | 0.9 | Yes |
|                       |         | No. of admissions, mean | 0.9 | 0.3 | 0.8 | 0.3 | No |
|                       |         | Medical inpatient days, mean | 3.4 | 1.7 | 3.4 | 1.3 | No |
|                       |         | No. of outpatient visits, mean | 2.5 | 2.6 | 2.7 | 2.2 | No |
|                       |         | ED costs, mean | 942 | 647 | 790 | 247 | Yes |
|                       |         | All hospital costs, mean | 8423 | 3849 | 8508 | 4761 | No |
|                       |         | Homeless, n (%) | 32 (80) | 11 (33) | 61 (76) | 22 (32) | Yes |
|                       |         | Problem alcohol use, n (%) | 21 (53) | 12 (30) | 38 (48) | 22 (28) | Yes |
|                       |         | No. of health insurance (%) | 31 (78) | 17 (53) | 59 (75) | 30 (44) | Yes |
|                       |         | No. of social security income (%) | 29 (74) | 18 (58) | 63 (79) | 26 (43) | Yes |
|                       |         | Basic financial needs, mean | 4.4 | 3.7 | 5.2 | 3.8 | Yes |
|                       |         | Psychiatric symptoms (total BSI score), mean | 10.0 | 9.8 | 11.6 | 10.4 | No |
| Pope et al. [61] (2000) Canada | Case management | No. of number of ED visits, median | – | – | 26.5 | 6.5 | –20 | Yes |
|                       |         | Total no. of ED visits | – | – | – | 616 | 175 | –441 (−72%) | Yes |
| Moher et al. [55] (1992) Canada | Discharge planning | LOS, mean | – | 9.4 | – | – | 743 | −1.97 | Yes |
|                       |         | Readmission rate at 2 weeks | – | 18 (14%) | – | – | 22 (16%) | No |
| Kennedy et al. [47] (1987) the United States | Discharge planning | LOS, mean | – | 9.7 | – | – | 78 | −1.9 | Yes |
|                       |         | Readmission rate at 8 weeks | – | 14 (34%) | – | – | 11 (28%) | −6% | NR |
Table 2 (continued)

| Author (Year) Country | Type of intervention | Main Outcome Measure | Outcomes | Control | Intervention | Statistically significant (P < .05) |
|-----------------------|----------------------|----------------------|----------|---------|-------------|--------------------------------------|
| Kurant et al. [51] (2018) the United States | Laboratory-based utilisation management programs | Total imaging per patient | – | – | – | – | – | RRs 1.93; 95% CI 1.67–2.23 |
| Copeland et al. [28] (2017) the United States | Modelling | Total RBC transfusions | – | – | 37,167 | 34,602 | Yes |
| | | Total plasma transfusions | – | – | 10,544 | 10,544 | NR |
| Pena et al. [58] (2014) the United States | Blood management program, benchmarking | Total platelets transfusions | – | – | 8202 | 7844 | NR |
| | | Total albumin transfusions | – | – | 23,949 | 24,557 | NR |
| | | Total IVIg transfusions | – | – | 52,085 | 44,973 | NR |
| Weilburg et al. [80] (2017) the United States | Analysis of high-cost imaging utilisation | No. of high-cost imaging per year | – | – | 0.43 examinations | 0.34 examinations | -21.3% | Yes |
| | | Overall laboratory utilisation | – | – | – | – | -9.4% | Yes |
| | | Inpatient stays | – | – | 0.453 | 0.422 | No |
| | | No. of departments visited | – | – | 0.558 | 0.823 | Yes |
| Konger et al. [50] (2016) the United States | Reductions in unnecessary clinical laboratory testing | Total test volume per year | – | – | – | – | -11.18% | Yes |
| El-Othmani et al. [33] (2019) the United States | Joint utilisation management program | LOS | 9.27 | 6.2 | 4.22 | 3.04 |
| | | The rate of 30 day readmission | 21.05 | 23.50 | 9.94 | 8.0 |
| | | Inpatient rehabilitation | 15.79 | 5.88 | 5.9 | 3.08 |
| Kim & Lee [48] (2020) Korea | Case Management | Inpatient days | 30.5 | 10.6 |
| | | Outpatient visits | 128.3 | 104.7 |
| | | Self-care ability | 15.41 | 18.64 |
| Author (Year) Country | Type of intervention | Main Outcome Measure | Outcomes | Statistically significant (P < .05) |
|-----------------------|----------------------|----------------------|----------|----------------------------------|
|                       |                      |                      | Control  | Intervention                     |                      |
|                       |                      |                      | Before   | After   | Difference | Before   | After   | Difference |
| Wasfy et al. [79] (2019) the United States | Hospital Readmissions Reduction Program | In-patient readmission | 0.023    | 0.002   | yes        |                      |
|                       |                      | Treat-and-discharge visit to emergency department | 0.014    | 0.029   | yes        |                      |
|                       |                      | Observation stay (not leading to inpatient readmission) | 0.019    | 0.024   | yes        |                      |
| Calsolaro et al. [25] (2019) | Hospital Readmissions Reduction Program | Potentially preventable readmissions (PPR) |                      |                      |                      | LOS (median and range) | 5 (4-6) | 6 (2-14) |                      |
Nine broad utilisation management methods
We identified nine broad utilisation management methods: care plan, case management, care coordination, utilisation review, clinical information system, physician profiling, consultation, education, and discharge planning. The findings related to these nine methods are described below in Table 2, using sub-categories of the following main types of interventions: non-organisational interventions aiming to reduce hospital utilisation, organisational interventions to reduce hospital utilisation, and interventions at the discharge stage of the patient journey.

Prehospital advanced life support drug treatment
These interventions focused on access to primary care, medical and social resources. For example, two studies [31, 68] evaluated interventions that aimed to improve access to primary care. Studies suggest that improving access to primary care centres is associated with fewer ED visits [31, 68], fewer inpatient hospital days than controls [31], but report no difference in inpatient admissions between groups [68]. One retrospective cohort study examined the effect of prehospital advanced life support drug treatment in reducing subsequent hospital utilisation by the medical patients receiving such drugs [35]. There was a significant decrease in admissions in the drug intervention group driven by chest pain patients and improved prehospital field conditions for all chief complaints. Care plan and case management were the main interventions related to prehospital advanced life support drug treatment.

Two comparative cohort studies examined the impact of patient care plans on service utilisation [38, 77]. Sweeney et al. [77] compared patient-centred management to usual case management for patients who had a life-limiting diagnosis with multiple comorbid conditions. Among the patient-centred management, inpatient admissions reduced by 38%, inpatient hospital days by 36%, and emergency department visits by 30%. Grimmer-Somers et al. [38] found that a holistic community-based program using a care plan for frequent ED attendees had significant improvements in client health and decreased crisis emergency department and inpatient admissions.

Case management
Primary care case management
Case management is “a collaborative process that assesses, plans, implements, coordinates, monitors, and evaluates the options and services required to meet an individual’s health needs using communication and available resources to promote quality and cost-effective outcomes” [50]. Eight studies focused on using case management interventions based outside the hospital. Five studies reported a decrease in hospital utilisation [45, 46, 64, 66]. Three studies found no significant difference between groups in neither ED visits nor hospital admissions [43, 67, 73].

Hospital-based case management
Of 23 studies evaluating case management interventions, 12 focused on case management as an ED-initiated or medical centre-based intervention for frequent hospital utilisers. Six comparative cohort studies observed a decrease in the mean or the median number of ED visits than the controls [30, 72] or before the case management [27, 39, 57, 61]. One study reported an increase of 2.79 median ED visits post-intervention [59]. This study included primarily patients with substance abuse or psychiatric problems underlying the ED visits, suggesting case management may be less effective in reducing ED utilisation in this population. One RCT reported no significant difference in the median number of ED visits following CM [74]. In contrast, two RCTs reported a decrease in the number of ED visits [62, 70] and hospital days [64] among those in the intervention group. Two studies have examined changes in hospital admissions or LOS, found a significant decrease in the number of admissions [29], hospital readmissions [54] and LOS.

Care coordination
Two studies examined the impact of care coordination programs on ED visit rate amongst frequent ED users [49, 56]. The randomised controlled pilot study by Koehler et al. [49] found that hospital-based care coordination using extra care bundle comprising three interventions (medication counselling, enhanced discharge planning, and phone follow-up) targeting high-risk older people compared to usual care was successful in reducing 30-day post-discharge hospital readmission or emergency department visit rates. The comparative cohort study by Murphy et al. [56] implemented a multidiscipline ED-care coordination program using a regional hospital information system capable of sharing patients’ individualised care plans between ED providers. The study reported a significant decrease in ED visits 12-months following the intervention.
Utilisation Review
The utilisation review program consists of several different review activities: pre-admission authorisation (prospective review), concurrent review (during the patient stay), retrospective review (relying on medical records), prospective review. One study investigating a pre-admission review program found a decrease in hospital admissions by approximately 12% [81]. Of eight studies that examined the effect of concurrent review on the LOS, five studies found a decrease in hospital LOS [26, 34, 63, 82, 84]. Another study that examined the effect of utilisation review on patterns of health care use found that the referrals for a second opinion have reduced the number of procedures performed in the review group. However, there was no significant difference between the groups during the study period in terms of rates of admission to medical-surgical, substance abuse, or psychiatric units, average LOS, the percentage of those who received pre-admission testing, or the rates of use of home care following utilisation review activities [65].

A retrospective analysis of utilisation management programs has concluded that pre-admission review rarely denies requests for admission, and nearly one-third of patients approved by pre-admission review for inpatient care requested approval for continued stay through concurrent review [82]. One multicenter trial examined the effect of utilisation management strategies on the use of a radiological test [36]. There was a consistent reduction from 29.4 to 13.3 X-rays per 100 operations after introducing the new request form and concurrent review. Two studies that evaluated the effectiveness of a prospective review program in reducing blood component utilisation reported that the implementation by the blood bank staff of a prospective review of orders for blood products resulted in a significant decrease of 38.8% and 31.4% in the use of fresh frozen plasma and platelets, respectively [40], as well as a total reduction inpatient medical costs realised as a result of cancelled orders [71]. Due to the importance of drug utilisation, this type of utilisation review has been categorised as a primary intervention.

Drug utilisation review
Three studies focused on drug utilisation review interventions. One study reported a significant decrease in the number of antibiotic treatment courses and the percentage of patients receiving any antibiotic following implementing an antibiotic order form for all inpatient antibiotic orders in the hospital [32]. The second study reported a significant decrease from 40% to 20% of patients using benzodiazepines after drug utilisation review activities in an inpatient setting [83]. Another retrospective cohort study examined the effect of implementing a drug utilisation management program and evidence-based guidelines on the appropriate use of drugs and found that implementing a drug-utilisation management program using clinical pharmacists was associated with a decrease in inappropriate epoetin prescribing and significant cost savings [24].

Clinical information system
A clinical information system is a computer-based system encompassing clinical or health-related information, distinguished from administrative information systems by the requirement for data entry or data retrieval by clinicians at the point of care. Some areas addressed by clinical information systems are clinical decision support, electronic medical records, physician's order entry, telemedicine, problem lists, summary reports, results review, nursing protocols and care plans, and alerts and reminders. Recently, interests have been focusing on medical errors with monitoring and managing variation in practice [86]. Electronic medical records and physician's order entry systems, and clinical decision support are the primary interventions related to clinical information systems.

Electronic Medical Record
One before-after analysis of an intervention targeting ED frequent users reported that the use of health information technologies to identify the most frequently visiting patients and easy access to individualised care plans through the EMR to all healthcare providers resulted in a significant reduction in the number of ED visits, labs ordered, total ED contact time, and ED charges [75].

Physician's order entry system
A physician's order entry system is a subsystem of a hospital information system. One prospective time series study reported that the number of stat lab tests and overall LOS at six months after physician's order entry implementation decreased significantly compared with the pre- physician's order entry system period [44]. Using a randomised controlled design, Shea et al. [69] demonstrated that a computer-generated informational message directed to physicians as an intervention resulted in reduced LOS in an inpatient setting. According to Bates et al. [22], 69% of
potentially redundant diagnostic tests were cancelled in response to reminders following the introduction of a clinical information system that included a physician’s order entry system.

Clinical decision support

A clinical decision support system is a computer-based application that analyses data and provides knowledge and person-specific information to aid physicians and other health providers in clinical decision making [87]. One study that evaluated real-time clinical decision support intervention observed improved blood utilisation. After implementing clinical decision support system, the percentage of patients transfused outside the guidelines decreased to 35% [37].

Physician profiling

Physician profiling is a cost-containment strategy whereby the patterns of health care provided by a practitioner or other provider (e.g., hospital) for the defined population are compared to other norms - profiles of other physicians or practice guidelines - based on practice [88]. A quasi-experimental study with control groups found that LOS at the profiled site decreased by an additional third of a day in the profiling year than at the non-profiled sites [85].

Consultation

The randomised controlled trials by Bree et al. [24] implemented mandatory radiology consultation whereby each radiology examination required prior approval. This intervention did not observe differences in inpatient imaging use following the mandatory radiology consultation.

Discharge planning

Discharge planning refers to developing a plan to treat the patient’s medical needs after leaving the inpatient department to contain costs and improve patient outcomes. Discharge planning should ensure that patients leave the hospital at an appropriate time in their care and that, with adequate notice, the provision of post-discharge services is organised [89]. We identified three studies that focused on interventions at the discharge stage of the patient journey [41, 47, 55]. All three studies that examined the effect of discharge planning on LOS in hospital and readmission rates compared with usual care found a decrease in hospital LOS for those allocated to discharge planning. There were lower readmission rates in the discharge planning group for older participants with a medical condition at three months of discharge [41, 47].

Early supported discharge

Discharge planning typically involves a greater degree of care provision and support following discharge than discharge planning interventions. Early supported discharge or early home-supported discharge may include discharge planning but aims specifically to accelerate discharge from the hospital with continued support in a community setting, typically at the same intensity that would have been provided had the patient remained in hospital. These interventions are usually provided by multidisciplinary teams, including doctors, nurses, and therapists. Still, the degree of coordination and whether they are driven by hospital outreach or community teams can vary [89].

Post-discharge case management

Two RCTs have examined the effectiveness of case management provided after patients are discharged from the hospital regarding the utilisation of hospital services by these patients. One study found a significant reduction in hospital admissions, bed-days and attendances at the out-patient department [53]. In contrast, the second study did not find significant differences between groups for readmission, care utilisation, quality of life, or psychological functioning [52].

Cost outcome

Of all included studies, 23 studies provided cost-related outcomes. Six studies reported savings after implementing utilisation review programs [24, 37, 40, 81, 84] or a computerised physician order entry system [22]. One study reported cost savings from reduced days of hospitalization [29]. Ten studies reported significantly reduced hospital charges [30, 31, 56, 62, 64, 67, 68, 77] or ED costs after the intervention [43, 75]. One randomised controlled trial of 96 patients observed a trend toward reduced total healthcare cost in the experimental group, but the difference was not statistically significant [73]. Two studies reported a mixed effect - one reported a significant decrease in ED and medical inpatient costs but no apparent change in the cost of medical out-patient, psychiatric inpatient, psychiatric emergency, or ambulance services [57]. The other found a significant decrease in ED costs. However, no difference was reported for inpatient services, psychiatric emergency services, outpatient services, physicians’ fees, or total hospital costs, with the cost of case management included [70]. Also,
Education
Developing education programs for patients, families and health care providers (i.e., nurses or physicians) is considered the primary intervention in many countries [49, 67, 77, 90]. The goal of the education programs is to provide health care providers with the principles of utilisation management.

Discussion
Our review identified nine utilisation management methods, including care plan, case management, care coordination, utilisation review, clinical information system, physician profiling, consultation, education, and discharge planning. Of all interventions reported in the reviewed studies, case management strategy was the most frequently examined. Disease management is considered an effective strategy for dealing with frequent hospital users with specific diseases (e.g., congestive heart failure or diabetes). Whereas disease management focuses on particular illnesses, case management is focused on optimising multidisciplinary treatment. We identified several models of case management, such as brokerage [54], assertive community treatment [46], clinical case management [57, 70], and different case management models (i.e., strengths-based case management, rehabilitation).

Our findings suggest that interventions aimed to increase primary care accessibility and case management effectively reduce ED visitation [31]. Though mostly uneven in methodological rigour, studies indicate that pre-admission review for hospitalisation is highly effective in reducing hospital admissions. The implementation of utilisation management interventions increased out-patient visits, possibly reflecting the link of frequent hospital users to other services. Overall, studies that focused on interventions during the patient stay in the hospital (e.g., concurrent review) and interventions at the discharge stage of the patient journey (e.g., discharge planning) effectively reduce the LOS. However, the limited evidence showed that mandatory radiology consultation interventions were ineffective in reducing inpatient imaging use. As a good outcome, introducing the clinical information systems (e.g., physician’s order entry system) reduced LOS. Such automated access to patient records improved the efficiency of information exchange among physicians across the continuum of care. Clinical decision support systems, which consisted of interruptive best practice alerts at the physician’s order entry system, also significantly improved blood utilisation. We found that interventions directed towards supply, such as physician profiling, were associated with decreased LOS without adversely affecting physician satisfaction. However, such reductions were also observed among control groups in ED visit numbers [30, 70, 73, 74], hospital admissions [66, 70, 73] and LOS [70]. Case or care management and utilisation review interventions were consistently reported to reduce hospital costs, and no studies reported increases in hospital costs following the intervention.

There were several limitations to this review. First, there is marked heterogeneity among reviewed studies. Second, in an attempt to focus on the literature concerning the general adult frequent user populations, studies were excluded that did not examine a general population (e.g., pediatric, individuals with asthma, cancer, diabetes, and cardiovascular disease) or focused on a specialised out-patient care setting.

Conclusion
To ensure the delivery of efficient and effective health care, to reduce the misuse of inpatient and outpatient services, the use of utilisation management strategies in hospitals is unavoidable. The use of relevant strategies and interventions allows for avoiding unintended consequences emanating from the financial incentives and disincentives on health care professionals’ decisions around care and service delivery.
### Appendix Table

| Authors (year)         | Study Design | Blinding | Selection Bias | Withdrawals/Drop-Outs | Confounders | Data Collection | Data Analysis | Reporting | Overall |
|-----------------------|--------------|----------|----------------|------------------------|-------------|-----------------|---------------|-----------|---------|
| 1. Sandberg et al. (2015) [66] | Strong       | Weak     | Strong         | Strong                 | Weak        | Strong          | Strong        | Strong    | Strong  |
| 2. Haldiman et al. (2014) [40] | Moderate     | No rating| Weak           | No rating              | Weak        | Weak            | Weak          | Weak      | Weak    |
| 3. Goodpough et al. (2014) [37] | Weak         | No rating| No rating      | No rating              | Weak        | Moderate        | Moderate      | Weak      | Weak    |
| 4. Joo (2014) [46]     | Moderate     | No rating| Weak           | Weak                   | Strong      | Strong          | Strong        | Strong    | Weak    |
| 5. Buckley et al. (2013) [24] | Weak         | No rating| No rating      | No rating              | Weak        | Moderate        | Weak          | Weak      | Weak    |
| 6. Reinius et al. (2013) [62] | Strong       | Moderate | Moderate       | Strong                 | Weak        | Strong          | Strong        | Weak      | Weak    |
| 7. Crane et al. (2012) [30] | Strong       | Weak     | Weak           | Weak                   | Weak        | Moderate        | Weak          | Weak      | Weak    |
| 8. Roland et al. (2012) [64] | Moderate     | No rating| Moderate       | Weak                   | Weak        | Moderate        | Moderate      | Weak      | Weak    |
| 9. Koehler et al. (2009) [49] | Strong       | Weak     | No rating      | Strong                 | Weak        | Moderate        | Strong        | Strong    | Weak    |
| 10. Schraeder et al. (2008) [67] | Weak        | No rating| Weak           | Strong                 | Weak        | Strong          | Strong        | Strong    | Weak    |
| 11. Holsinger et al. (2008) [42] | Weak        | No rating| Weak           | Weak                   | Weak        | Weak            | Weak          | Weak      | Weak    |
| 12. Sweeney et al. (2007) [77] | Strong       | No rating| Weak           | Strong                 | Weak        | Moderate        | Weak          | Weak      | Weak    |
| 13. Phillips et al. (2006) [59] | Weak        | No rating| Weak           | Weak                   | Weak        | Moderate        | Strong        | Weak      | Weak    |
| 14. Sledge et al. (2006) [73] | Strong       | Moderate | Moderate       | Weak                   | Weak        | Strong          | Strong        | Weak      | Weak    |
| 15. Mahendran et al. (2006) [54] | Weak        | No rating| Weak           | Weak                   | Weak        | Weak            | Moderate      | Weak      | Weak    |
| 16. Zemencuk et al. (2006) [85] | Strong       | Weak     | Weak           | Weak                   | Strong      | Weak            | Strong        | Weak      | Weak    |
| 17. Latour et al. (2006) [52] | Strong       | Weak     | Moderate       | Strong                 | Weak        | Weak            | Strong        | Weak      | Weak    |
| 18. Hegney et al. (2006) [41] | Weak         | No rating| Weak           | Weak                   | Weak        | Moderate        | Strong        | Moderate  | Weak    |
| 19. Horwitz et al. (2005) [43] | Strong       | Weak     | Weak           | Weak                   | Weak        | Strong          | Moderate      | Weak      | Weak    |
| 20. Leung et al. (2004) [53] | Strong       | Weak     | Weak           | Weak                   | Weak        | Moderate        | Strong        | Weak      | Weak    |
| 21. Cox et al. (2003) [29] | Weak         | No rating| Weak           | Weak                   | Weak        | Weak            | Moderate      | Weak      | Weak    |
| 22. Hwang et al. (2002) [44] | Moderate     | No rating| Strong         | Weak                   | Weak        | Moderate        | Strong        | Weak      | Weak    |
| 23. Fateha (2002) [34] | Moderate     | No rating| No rating      | Weak                   | Weak        | Moderate        | Moderate      | Moderate  | Weak    |
| 24. Ferrazzi et al. (2001) [35] | Weak         | No rating| No rating      | No rating              | Weak        | Moderate        | Strong        | Weak      | Weak    |
| 25. Okin et al. (2000) [57] | Weak         | No rating| No rating      | No rating              | Weak        | Moderate        | Strong        | Weak      | Weak    |
| 26. Bates et al. (1999) [22] | Strong       | Weak     | Weak           | Weak                   | Weak        | Strong          | Strong        | Weak      | Weak    |
| 27. Wickizer et al. (1998) [82] | Weak         | No rating| Weak           | Moderate               | Weak        | Moderate        | Strong        | Weak      | Weak    |
| Authors (year) | Study Design | Blinding | Selection Bias | Withdrawals/Drop-Outs | Confounders | Data Collection | Data Analysis | Reporting | Overall |
|---------------|--------------|----------|----------------|------------------------|-------------|----------------|--------------|----------|---------|
| 28. Spillane et al. (1997) | Moderate | Weak | Strong | No | Weak | Weak | Moderate | Moderate | Weak |
| 29. Bree et al. (1996) | Strong | Weak | Moderate | Strong | Moderate | Moderate | Strong | Strong | Weak |
| 30. Shea et al. (1995) | Strong | Weak | Moderate | Strong | Weak | Strong | Strong | Strong | Weak |
| 31. Cardiff et al. (1995) | Moderate | No rating | Weak | Weak | Weak | Moderate | Strong | Moderate | Weak |
| 32. Styrborn (1995) | Strong | Weak | Strong | Strong | Weak | Moderate | Strong | Moderate | Weak |
| 33. Rosenberg et al. (1995) | Moderate | No rating | Moderate | No | Moderate | Moderate | Weak | Strong | Moderate |
| 34. Jambunathan et al. (1995) | Moderate | No rating | No | No rating | Weak | Weak | Moderate | Strong | Weak |
| 35. Williams et al. (1994) | Moderate | No rating | Weak | No rating | Weak | Weak | Moderate | Moderate | Weak |
| 36. Wickizer (1992) | Weak | No rating | Weak | Weak | Weak | Strong | Moderate | Strong | Moderate |
| 37. Woodside et al. (1991) | Moderate | No rating | Weak | Moderate | No | Weak | Weak | Moderate | Weak |
| 38. Silver et al. (1992) | Moderate | No rating | No | No rating | Weak | Weak | Weak | Weak | Weak |
| 39. Fowkes et al. (1986) | Strong | Weak | Weak | Weak | Weak | Weak | Weak | Weak | Weak |
| 40. Echols et al. (1984) | Weak | No rating | Weak | No rating | Weak | Weak | Moderate | Moderate | Weak |
| 41. Restuccia (1982) | Strong | Weak | Weak | No rating | Weak | Strong | Moderate | Strong | Weak |
| 42. Murphy (2014) | Weak | No rating | Weak | No rating | Weak | Moderate | Moderate | Strong | Weak |
| 43. Chang et al. (2014) | Weak | No rating | Weak | No rating | Weak | Moderate | Strong | Strong | Weak |
| 44. Pillow et al. (2013) | Weak | No rating | No rating | No rating | Weak | Moderate | Weak | Moderate | Weak |
| 45. Dehaven et al. (2012) | Moderate | No rating | Weak | No rating | Weak | Moderate | Strong | Strong | Weak |
| 46. Tadros et al. (2012) | Weak | No rating | No rating | No rating | Weak | Moderate | Strong | Strong | Weak |
| 47. Shah et al. (2011) | Strong | Weak | No rating | No rating | Strong | Moderate | Strong | Strong | Moderate |
| 48. Stokes-Buzzelli et al. (2010) | Weak | No rating | No rating | No rating | Weak | Moderate | Moderate | Strong | Weak |
| 49. Grimmer-Somers et al. (2010) | Weak | No rating | No rating | No rating | Moderate | Moderate | Moderate | Moderate | Weak |
| 50. Grover et al. (2010) | Weak | No rating | No rating | No rating | Moderate | Moderate | Moderate | Moderate | Weak |
| 51. Skinner et al. (2009) | Weak | No rating | No rating | No rating | Weak | Moderate | Moderate | Moderate | Weak |
| 52. Shumway et al. (2008) | Strong | Weak | Weak | Weak | Strong | Strong | Strong | Strong | Weak |
| 53. Pope et al. (2000) | Weak | No rating | Weak | Weak | Weak | Weak | Weak | Moderate | Weak |
| 54. Moher et al. (1992) | Strong | Weak | Strong | Weak | Weak | Strong | Strong | Strong | Weak |
| 55. Kennedy et al. (1987) | Strong | Strong | Strong | Weak | Weak | Weak | Weak | Weak | Weak |
| Authors (year)      | Study Design | Blinding | Selection Bias | Withdrawals/ Drop-Outs | Confounders | Data Collection | Data Analysis | Reporting | Overall |
|---------------------|--------------|----------|----------------|------------------------|-------------|-----------------|---------------|-----------|---------|
| 56. Kurant et al. (2018) [51] | Weak         | No rating | No rating      | No rating              | Weak        | Moderate         | Weak          | Moderate  | Weak    |
| 57. Copeland et al. (2017) [28] | Weak         | No rating | rating         | No rating              | Strong      | Moderate         | Strong        | Moderate  | Moderate |
| 58. Pena et al. (2014) [58] | Weak         | No rating | No rating      | No rating              | Weak        | Moderate         | Weak          | Weak      | Weak    |
| 59. Weiburg et al. (2017) [80] | Weak         | No rating | No rating      | No rating              | Strong      | Moderate         | Strong        | Strong    | Moderate |
| 60. Konger et al. (2016) [50] | Weak         | No rating | No rating      | No rating              | Weak        | Moderate         | Weak          | Moderate  | Weak    |
| 61. El-Othmani et al. (2019) [33] | Moderate     | No rating | No rating      | No rating              | Weak        | Moderate         | Weak          | Moderate  | Weak    |
| 62. Kim & Lee, (2020) [48] | Weak         | No rating | Moderate       | No rating              | Strong      | Moderate         | Strong        | Strong    | Moderate |
| 63. Wasyly et al. (2019) [79] | Weak         | No rating | No rating      | No rating              | Strong      | Moderate         | Strong        | Strong    | Moderate |
| 64. Caloslaro et al. (2019) [23] | Weak         | No rating | No rating      | No rating              | Moderate    | Moderate         | Strong        | Strong    | Moderate |

Abbreviations
ED: Emergency Department; ED; LOS: Length of Hospital Stay; NCBA: Non-Controlled Before-and-After.

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Authors’ contributions
LD designed the study, provided the supervision and participated in drafting and finalising the manuscript. Rkh, HJ, MR, Ek extracted the data, performed the analysis and participated in drafting the manuscript. VSG critically revised the manuscript for important intellectual content. All authors read and approved the final manuscript.

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