Published in final edited form as:
Acad Emerg Med. 2013 October ; 20(10): 969–985. doi:10.1111/acem.12219.

Non–Emergency Department (ED) Interventions to Reduce ED Utilization: A Systematic Review

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Abstract

Objectives—Recent health policy changes have focused efforts on reducing emergency department (ED) visits as a way to reduce costs and improve quality of care. This was a systematic review of interventions based outside the ED aimed at reducing ED use.

Methods—This study was designed as a systematic review. We reviewed the literature on interventions in five categories: patient education, creation of additional non-ED capacity, managed care, prehospital diversion, and patient financial incentives. Studies written in English, with interventions administered outside of the ED, and a comparison group where ED use was an outcome, were included. Two independent reviewers screened search results using MEDLINE, Cochrane, OAIster, or Scopus. The following data were abstracted from included studies: type of intervention, study design, population, details of intervention, effect on ED use, effect on non-ED health care use, and other health and financial outcomes. Quality of individual articles was assessed using Grading of Recommendations Assessment, Development, and Evaluation (GRADE) guidelines.

Results—Of 39 included studies, 34 were observational and five were randomized controlled trials. Two of five studies on patient education found reductions in ED use ranging from 21% to 80%. Out of 10 studies of additional non-ED capacity, four showed decreases of 9% to 54%, and one a 21% increase. Both studies on prehospital diversion found reductions of 3% to 7%. Of 12 studies on managed care, 10 had decreases ranging from 1% to 46%. Nine out of 10 studies on

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Presented at the American College of Emergency Physicians Scientific Assembly, Denver, CO, October 2012.

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patient financial incentives found decreases of 3% to 50%, and one a 34% increase. Nineteen studies reported effect on non-ED use with mixed results. Seventeen studies included data on health outcomes, but 13 of these only included data on hospitalizations rather than morbidity and mortality. Seven studies included data on cost outcomes. According to the GRADE guidelines, all studies had at least some risk of bias, with four moderate quality, one low quality, and 34 very low quality studies.

Conclusions—Many studies have explored interventions based outside the ED to reduce ED use in various populations, with mixed evidence. Approximately two-thirds identified here showed reductions in ED use. The interventions with the greatest number of studies showing reductions in ED use include patient financial incentives and managed care, while the greatest magnitude of reductions were found in patient education. These findings have implications for insurers and policymakers seeking to reduce ED use.

Growing health care costs in the United States have made patients, providers, and payers examine the value of services delivered.[1] Concepts such as accountable care organizations and medical homes are gaining momentum with the goal of limiting avoidable, redundant, ineffective, or harmful treatments in favor of expanding effective care, access to care, and care coordination.

Many programs aimed at improving efficiency focus on the use of hospital-based emergency departments (ED) for care. EDs care for critically ill patients and acute unscheduled conditions and serve as a safety net for those with limited access to health care due to insurance status, the timely availability of clinic-based physicians, and the need for care outside of traditional business hours.[2] The focus on the ED as a place to improve efficiency stems from observations that ED care for low-acuity conditions results in higher charges than for similar diagnoses seen in other settings.[3] In addition, an ED visit may be a marker of a potentially avoidable injury or illness that could have been prevented with better primary care, patient education, or enhanced public health measures.

Studies have examined the effect of interventions to reduce ED use that are performed outside the ED, such as patient education, improved clinic access, care coordination, patient-centered care, and others. While ED-based interventions also exist, they are fundamentally different because of their location and their focus (e.g., follow-up vs. prevention). Our group recently conducted a systematic review of ED-based care coordination interventions.[4] Therefore, this review focuses specifically on interventions based outside of the ED looking at systems-level changes, rather than ED-specific changes. Prior reviews of aggregated non-ED interventions have either focused only on one type of intervention or excluded some subsets of visits such as pediatric patients or categories of intervention such as prehospital diversion.[5–7] To our knowledge, there has been no broad-based inclusive review of the comparative effectiveness of the myriad interventions tested to reduce ED use. The goal of this investigation was to review the evidence on the effectiveness of interventions based outside of the ED aimed at reducing ED use and, ultimately, to explore themes about which interventions may be most effective, along with any undesired consequences.

Methods

Study Design

We systematically reviewed the literature on the effectiveness of non-ED interventions aimed at reducing ED use. Non-ED interventions were defined as those implemented outside of an ED or hospital (e.g., insurance-based, outpatient clinic-based). No human subjects or medical records were reviewed as a part of this study so institutional review board approval was not required.

The databases MEDLINE, Cochrane, OAIster, and Scopus were examined from 1966 to the present. Keywords used included emergency department, emergency medical services, utilization, demand, patient education, primary care, capacity, extended hours, advanced access, telephone triage, general practitioner, care coordination, copayment, and payment reform (MEDLINE search terms in Appendix A). Searches were limited to English language publications. Because of the variety in the interventions and outcome measurements in the results, we performed a qualitative rather than quantitative systematic review.

Data Collection and Processing

Two independent reviewers (MA, SRM) screened search results and excluded those with titles that did not fit inclusion criteria (next section). The two reviewers then screened the abstracts of the remaining citations, again excluding those that did not fit inclusion criteria. The remaining articles underwent full-text review to exclude any remaining studies that did not fit inclusion criteria. Intrarater reliability was measured with a 10% sample of citations, resulting in a kappa of 0.92. Each article with conflicting opinion from reviewers was discussed with a third reviewer (JMP) for a final resolution.

The following data were abstracted from all eligible studies: type of intervention, study design, population, details of intervention, effect on ED use, effect on non-ED health care use, and other health and financial outcomes. Reviewers used a standard format to abstract data; this format mirrors the categories in the tables presented here. We attempted to standardize results across studies. In studies with data available for absolute number of ED visits before and after the intervention was implemented (as opposed to, for example, number of visits per person, etc.), we calculated a percentage reduction of ED visits. When visit numbers were reported, the difference between number of visits before and after the intervention was divided by the number of ED visits prior to intervention to standardize the comparison of study results.

We followed guidelines created in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement to create a four-phase flow diagram (Data Supplement S1, available as supporting information in the online version of this paper) showing the number of records included and excluded at each phase.[8]

Inclusion and Exclusion Criteria

Studies were included if they had interventions administered outside of the ED, had a comparison group where ED use was an outcome, and were in English. While studies in

other languages were excluded, studies were included regardless of country and health care system if published in English. Five categories of interventions were included: 1) patient education on medical conditions and appropriate medical care use for low-acuity conditions, 2) creation of additional capacity in non-ED settings (e.g., expanded hours or same-day access), 3) managed care (e.g., primary care physician capitation or gatekeeping), 4) prehospital diversion, and 5) patient financial incentives (e.g., copayments or deductibles). Two other interventions, telephone triage and case management, were initially searched for but because recent systematic reviews have compiled the results of those topics; these were excluded.[5,6]

Studies with ED-based interventions were excluded, as were studies without measurable objective outcomes. Studies with outcomes assessed through patient or provider subjective surveys were also excluded.

Quality Assessment

Quality assessment was done using the portion of the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) criteria aimed at assessing the risk of bias in individual articles.[9] Because of the heterogeneity in study designs, other components of the GRADE criteria, including the formal overall evaluation of the body of literature, were not used. Additionally, studies with risk-adjusted results and where significance was measured are reported.

Results

Literature Search

The search yielded 793 titles. After removing duplicates and exclusions based on title or abstract, 62 studies remained and underwent full-text review (Data Supplement S1). An additional 19 references were identified and also underwent full-text review, which resulted in a total number of included studies of 39 that ranged from publication dates of 1986 to 2011. The number of included studies per category is as follows: patient education on medical conditions and health care use, five studies;[10–14] creation of additional non-ED capacity, 10 studies;[15–24] prehospital diversion of low-acuity patients, two studies;[25,26] managed care, 12 studies;[27–38] and patient financial incentives, 10 studies.[39–47]

Description of Included Studies

Patient Education on Medical Conditions Health Care Use—Two out of five studies found significant reductions in the use of the ED after interventions, with reductions ranging from 21% to 80% (Table 1).[10–14] All studies were based in the United States. Interventions included use of booklets or in-person educational sessions. Both pediatric and adult patients are included. Three studies reported data on non-ED use with one finding 0.03 fewer clinic visits per person.[10–12] Three articles reported health outcomes and no significant adverse events were noted.[11–13] No studies reported risk-adjusted data.

Capacity Increase in Non-ED Settings—Of 10 studies, three examined interventions that expanded capacity through new community clinics, while the remainder involved

existing physician practices expanding appointments and/or hours of care. Four studies found significant decreases in the use of the ED after increases in non-ED capacity, with reductions ranging from 9% to 54%, while five were nonsignificant and one found an increase of 21% (Table 2).[15–24] Four studies were based in the United States and the remaining six in Canada or Europe. Regarding effect on non-ED use, five studies reported data with four showing increases in non-ED use ranging from 1% to 102%.[16,17,20–23] Of these, one article reported that while there was an increase in primary care use, there was a concurrent decrease in urgent care use.[20] Two articles reported health outcomes.[20,21] Three studies reported cost data showing 10% to 20% savings with the intervention.[15,18,20] Two studies risk-adjusted data.[20,21]

Prehospital Diversion of Low-acuity Patients—Both studies examining the effects of emergency medical services (EMS) diversion of low-acuity patients away from the ED found significant decreases in the use of the ED after interventions, with reductions ranging from 3% to 7% (Table 3).[25,26] One study was conducted in the United States, and the other, in the United Kingdom. One intervention involved EMS offering either home or clinic care to low-acuity patients.[25] The other involved transportation of such patients to clinic care without home care as an option.[26] Regarding effect on non-ED use, both studies found increases in use of other care settings. No studies directly addressed other health or cost outcomes. No data were risk adjusted.

Managed Care—Of the 12 studies examining the effects of managed care on ED use, six had interventions with capitated payment of primary care physician, five had a requirement of primary care physician approval or gatekeeping, and one was a hybrid of these two (Table 4).[27–38] Ten studies were based in the United States, one in Canada, and one in Ireland. The majority of U.S. studies were in Medicaid populations and included pediatric patients. Overall, nine studies (six with capitation and four with gatekeeping as interventions) found significant decreases in the use of the ED after managed care interventions, with reductions ranging from 1% to 46%, while two did not find any significant difference.[27–31,33–38] The final study found mixed results with no change in ED use when comparing physicians pre- and postcapitation, but with an increase in ED use among physicians compensated through capitation versus fee-for-service.[32]

Regarding the effect on non-ED use, six studies did report data, with only four reporting significance and mixed results.[28,30,32,35,37,38] Six articles included health outcome data, five in the form of effect on hospitalizations and one on morbidity indices; results were mixed and did not always assess for significance.[27,30,32,34,37,38] Two studies reported cost data with both showing decreases with capitation.[28,30] No studies reported risk-adjusted data.

Patient Financial Incentives—Of the 10 studies using costs to influence patients to use certain sites for care, or to use care efficiently, nine studies found significant decreases in the use of the ED after implementation of the intervention, with reductions ranging from 3% to 50% (Table 5).[39–47] The remaining study found a significant relative increase of 34% in ED visits.[48] All studies took place in the United States. The intervention in seven studies was the requirement for patient copayment or coinsurance, and in three it was the

implementation of a high deductible. Half of studies were in Medicaid populatons, with the majority of those single-state interventions, while the others involved commercial insurers.

Regarding effect on non-ED use, two studies did report data with one showing no change in urgent care, pediatric office, adult office, and ambulatory care visits, but one showed an increase in hospital outpatient department use.[42,43] Six studies reported health outcomes in the form of ED visits resulting in hospitalization, which decreased or were unchanged.[39–42,44,47] Of these six, two also reported effects on morbidity, one showing no change and one showing a decrease.[39,42] Three studies reported cost data with mixed results.[43–45] Five studies risk-adjusted data.[39,42,45,46,48]

Quality Assessment

Quality assessment for risk of bias in individual articles can be found in Table 6 and Data Supplement S2 (available as supporting information in the online version of this paper). All 34 observational studies were of very low quality according to GRADE guidelines, in which observational studies are at best low quality and any serious risk of bias lowers the quality to very low. Four of the randomized trials were of moderate quality and one of low quality.

Discussion

In 2003, Asplin et al.[2] identified input, throughput, and output factors associated with crowding in the ED. In this paper, we explore primarily the effect of how systems outside the ED can influence demand for ED care and focused entirely on “input.” This expands on previous work where we conducted a systematic review of care coordination within the ED.[4] With respect to non-ED interventions, we found there have been many studies exploring non-ED interventions to reduce ED use in various populations across more than two decades with mixed evidence. Over two-thirds (27 of 39, 69%) of the identified studies in the five categories of intervention included showed reductions in ED use, with reductions ranging from 1% to 80%. Nearly all of the studies were observational, many coinciding with systemic changes within the region, and only five out of the 39 were randomized trials. Only seven of 39 studies (17.9%) reported risk-adjusted data.

The areas with the largest number of studies showing reductions in ED use include patient financial incentives and managed care interventions, with nine of 10 (90%) and 10 of 12 (83%) of those studies showing reductions, respectively. By contrast, less than half (four of 10) of the studies on increasing capacity found reductions in ED use, and one even found an increase, suggesting that adding capacity could potentially have the opposite effect. This may be due to issues with supply-induced demand. Findings on capacity should be interpreted carefully, however, as the majority of articles on this topic are international, and several take place in single-payer health care systems. The area showing the largest magnitude of reduction is patient education, with a maximum of an 80% reduction in one study.

We hope to build on the growing body of literature that addresses the overall aim to reduce ED use. Prior reviews exist on two topics not included here, telephone triage and case management. For telephone triage, a Cochrane review of nine studies included seven studies

that examined the effect on ED use.[5] Of these, six showed no difference, and one showed an increase in ED use. A review of interventions targeted at frequent ED use included 11 studies, of which the intervention in seven was case management.[6] The results were mixed, with the majority of observational trials showing reductions in ED use, but one showing an increase, and only one out of three randomized trials showing a reduction.

More recently, Flores-Mateo et al.[7] examined interventions that increased the supply of non-ED services and those that reduced demand. Similar to our findings, the authors concluded that increasing the supply of primary care physicians and cost sharing with patients were effective in reducing ED use, but increased out-of-hours primary care was not. However, there were differences in our methods, especially inclusion criteria. We included different types of studies, specifically pediatric studies, physician capitation, advanced access scheduling, and prehospital diversion and excluded ED-based studies, telephone triage, those with survey data, and those without controls. As a result, the authors of the prior review found that educational interventions did not appear to reduce ED use, while we found the opposite.

We also reviewed the articles for the effect on utilization of other health care settings. About half of the articles reported this data, although the results were presented in different ways (primary care visits, urgent care visits, specialist visits, etc.) and varied significant by category. Two of five (40%) of the education studies that examined non-ED use found decreases in use, while the others found no significant effect, suggesting that perhaps education may reduce use in general, rather than the possibility of induced demand by adding capacity. Both of the studies on prehospital diversion and five of 10 (50%) of those on capacity increases found increases in non-ED use, which may represent a type of substitution effect in which patients do not reduce their overall consumption of health care, but instead shift it to other settings. Again, many of these studies took place in single-payer systems where patients may have more access to primary care settings, whereas in the United States, access could limit this shift. Only two of 10 (20%) studies on patient financial incentives examined non-ED use, and these showed reductions. Often, though, copayments were implemented both inside and outside the ED, so it is difficult to tease apart direct and indirect effects on ED use. Interventions involving managed care showed mixed results with some increasing and some decreasing non-ED use.

Seventeen of the 29 studies (43.5%) reported adverse events, and the outcomes used varied widely, although no significant adverse events were attributed to interventions. The health outcome that was generally measured was hospitalization, and this is really a secondary outcome, with morbidity and mortality being the primary health outcome of interest. Similarly, only eight of the 39 articles (20.5%) reported any cost data, which was both limited and mixed. Some of the interventions may have ethical questions. For one, those with financial implications for patients may result in patients avoiding needed care and could result in worse health outcomes, and in the long run, possibly increased costs to the health care system. Another example is systems designed with physician or nurse gatekeepers who take away the patient's autonomy by dictating whether insurance will cover an ED visit. Our findings, taken along with prior reviews, are promising that non-ED

interventions designed to reduce ED visits may be successful; however, it is clear that more study is needed to understand the most effective ways to reduce ED use.

When organizations decide that reducing ED visits is a priority, the choice must be made which interventions should be implemented. We think that the choice should be made based on organization priorities and considering the profile of pros and cons for each intervention. For example, education is simple, can be inexpensive, and has an added benefit of improving health literacy; however, it is difficult to standardize. On the other hand, managed care and patient financial incentives are powerful tools but may have unintended consequences, like deferring needed care or limiting patient choice. In addition, adding capacity may have the opposite effect as desired. However, we can conclude that reducing ED use will require broad, organizational changes. Change could include a careful multilayered approach integrating several interventions along with a feedback mechanism to monitor outcomes and adverse events.

Future research should attempt to delineate the balance of intended and unintended effects of these interventions. Across all categories, more exploration of the effect on health outcomes and costs would be beneficial. Regarding education, researchers should consider further study of specific educational materials, from booklet to in-person teaching, or even technology-based solutions. EMS diversion has such limited data that any deeper examination of this area would add to our knowledge, especially focusing on the safety and accuracy of EMS assessments. Most of the managed care studies are observations of large-scale systemic changes over several years. More randomized controlled trials are needed across all categories to reduce confounding and improve the generalizability of results.

Limitations

Many of the studies reported were observational with the potential for confounders, and few studies reported risk-adjusted data. In addition, some of the payment reform interventions were part of a bundle of changes, and it was impossible to unwind which specific intervention (or just the combination) was responsible for the changes in utilization. Many studies were similarly restricted to a single site, which reduces the generalizability to other settings.

Our primary audience was EDs in English-speaking parts of the world; therefore, we included only studies published in English. As a result, this study may miss important findings in from non-English studies. Also, eight of the 39 studies were based in Canada or Europe, while the rest were in the United States, and differences in health care systems, in particular the presence of single payer versus multipayer systems, may affect outcomes.

There was also variability in the interventions administered as well as the outcomes reported. For example, some studies reported total ED visits whereas others reported ED visits per user. This made comparison between the studies difficult and limits the ability to draw robust conclusions from the findings of the review.

Conclusions

We found that about two-thirds of the studied interventions showed reductions in ED use. Future studies should attempt to reduce confounding through robust design (i.e., randomization) and should measure unintended consequences of increased demand for other types of health care services, health outcomes, and financial effects.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Dr. Chang is generally supported by Award Number 1K12HL108974-01 from the National Heart, Lung, and Blood Institute. Dr. Pines is an associate editor for this journal, but had no involvement with the review or publication decision for this manuscript.

Appendix A:

MEDLINE Search Terms

(((“emergency medical services” [all fields] OR “emergency medicine” [all fields] OR “emergency department” [all fields]) AND ((“utilization” [subheading] OR “utilization” [all fields]) OR demand [all fields] OR visits [all fields])) AND (“intervention” [all fields] OR “solutions” [MeSH Terms] OR “solutions” [all fields])) AND (“advanced access” [all fields] OR “primary care” [all fields] OR capacity [all fields] OR “extended hours” [all fields] OR “telephone triage” [all fields] OR “care management” [all fields] OR “patient education” [all fields] OR “general practitioner” [all fields] OR “care coordination” [all fields] OR copayment [all fields] OR diversion [all fields] OR acuity [all fields]) AND English [lang] AND English [lang].

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Table 1

Patient Education on Health Care Use

Author/Year	Design	Population	Intervention	Effect on ED Use	Effect on Non-ED Use	Other Outcomes
			Intervention: Booklet			
Glavan et al. (1998)[10]	Pre–post interventional study United States 6 months	Air Force base Intervention group: 1,555 subjects Control group: 972 subjects	Subjects in intervention group were given a self-care book with an information session on how to use the book	Intervention group: reduction in ED use rate per person from 0.353 to 0.279 (p = 0.02) Control group: increase in ED use rate per person from 0.386 to 0.421	Intervention group: reduction in clinic use rate per person from 1.072 to 1.038 Control group: increase in clinic visits rate per person from 1.040 to 1.168	Not reported
Rector et al. (1999)[14]	Randomized, parallel group study United States January–July 1998	Two urban Medicaid health plans (Plan A and B) Intervention group: house holds sent educational brochure Control group: households not sent educational brochure	Households were randomized to receive a booklet, First Look, about care of common nonurgent conditions	Nonsignificant reductions in ED use of 1.1% (Plan A, 95% CI = −3.1% to 0.8%) and −1.2% (Plan B, 95% CI = −4.1% to 1.4%)	No difference in either plan in physician office visits	
			Intervention: Training Sessions			
McWilliams et al. (2008)[11]	Retrospective cohort-control study, difference-in-difference model United States 12 months	Primary care practices at academic health center Intervention group: 191 patients in practice Control groups: • 168 patients at same practice from previous year • 2 cohorts from same year at primary care sites without intervention, 133 and 126 patients	Nurses provided standardized education along with prescription for pain relieving ear drops Parents reminded of 24-hour medical advice telephone access	Reduction in ED use for ear pain by 80.3% (p = 0.009) at intervention site. Concurrent control site had 25% nonsignificant increase in ED use	Nonsignificant reductions in urgent care center use by 40.3% (p = 0.33), and primary care center use by 27.8% (p = 0.14) at intervention site. In control site, 28% reduction in urgent care use, and a 4% reduction in primary care use	3-year medical record review of all children in the intervention group revealed no episodes of mastoiditis
Rettig et al. (1986)[12]	Randomized controlled trial United States One year	Multiple home health nursing agencies Intervention group: 180 diabetic patients Control group: 193 diabetic patients	Diabetic patients in the intervention group underwent home teaching sessions on diabetic health problems	Nonsignificant reduction in ED visits in intervention vs. control group (0.06 vs. 0.08) (nonsignificant)	Nonsignificant increase in primary care visits within 6 months by intervention vs. control group (3.11 vs. 2.78)	Nonsignificant changes in hospitalization rates/1,000 members/year in intervention group vs. control group: • Non–diabetes related (544.4 vs. 440.4) • Nonpreventable diabetes related (66.7 vs. 82.9) • Preventable diabetes related (94.4 vs. 41.5)

Author/Year	Design	Population	Intervention	Effect on ED Use	Effect on Non-ED Use	Other Outcomes
Schonlau et al. (2005)[13]	Pre–post interventional study United States	Primary health care centers recruited through Break through Series Collaborative Intervention group: three sites with 109 patients Control group: two sites with 76 patients	Asthmatic patients at intervention sites underwent educational sessions	Nonsignificant differences in acute care visits between groups (1.72 vs. 0.92 average visits; p = 0.08)	Not reported	No significant difference in quality of life, number of bed days, and acute care service use

Table 2

Capacity Increase in Non-ED Settings

Author (Year)	Design; Country; Duration of Study	Population	Intervention	Effect on ED Use	Effect on Non-ED Use	Other Outcomes
			Intervention: Additional Clinic(s)			
Chalder et al. (2003)[22]	Matched time-series analysis England One year before and after	NHS developed walk-in centers with drop-in service Intervention group: 10 towns with walk-in center Control group: 10 similar size towns in same region without walk-in centers	Walk-in centers provided nurse-led, drop-in service with broad hours of operation	Decrease of 173.3 visits/month vs. decrease of three visits/month in control group ($p = 0.11$)	Before and after increase of 3.9 visits to primary care facility vs. 23.7 visits in control group ($p = 0.25$)	None
Hsu et al. (2003)[24]	Before-and-after observational study with control group England 6 months before and after	NHS developed walk-in centers with drop-in service Intervention group: one town with walk-in center Control group: one nearby town in the same region without walk-in center	Walk-in centers provided nurse-led, drop-in service with broad hours of operation	ED visits increased by 10% (adjusted RR = 1.10; 95% CI = 1.00 to 1.21)	0.10 fewer emergency consultations per day (95% CI = −3.75 to 3.55)	None
O'Kelly et al. (2010)[16]	Retrospective study Ireland 1999–2007	Single, large ED and out-of-hours general practice emergency service clinic associated with same hospital Intervention group: Dubdoc patients Control group: low-triage-level ED patients	"Dubdoc" is an out-of-hours general practice emergency services clinic	Significant decrease low-triage-level ED visits during Dubdoc hours (54% decrease in low-acuity ED visits vs. 52% decrease outside Dubdoc hours; $p < 0.033$)	Increase of 102% in "Dubdoc" visits (3,810 in 1999 to 7,696 in 2007)	Not reported
Rust et al. (2009)[19]	Cohort study United States 2003–2005	Rural counties in state of Georgia Intervention group: counties with CHCs ($n = 24$) Control group: counties without federally funded CHCs ($n = 93$)	CHCs provide care to the uninsured without medical homes	Non-CHC counties had higher rates of ED visits (RR = 1.21; 95% CI = 1.02 to 1.41)	None reported	None reported
			Intervention: Change in scheduling/hours			
Hudec et al. (2010)[15]	Case-comparison study before-and-after advance access implementation Canada 3 months	Four family physician practices Intervention group: patients of general practice with advanced access booking Control group: patients of three general practices with traditional booking	Practice instituted a model in which most appointments are same-day access	28% reduction in low-acuity ED visits in group	None	7% revenue increase for practice Improved self-reported patient satisfaction ($p < 0.05$)

Author (Year)	Design; Country; Duration of Study	Population	Intervention	Effect on ED Use	Effect on Non-ED Use	Other Outcomes
Philips et al. (2010)[23]	Before-and-after observational study with control group Belgium 2006–2007	Formation of GPCs Intervention group: city (Turnhout) that implemented GPC Control group: two other large cities that did not have GPC (Ghent and Antwerp)	GPC reorganized providers for that region and centralized out-of-hours primary health center, open on weekends and holidays	815 visits to ED before and 791 visits post (no significant change)	Primary care visits increased in the intervention region (714 to 1197 visits) (OR = 1.37; 95% CI = 1.20 to 1.57), while stayed relatively constant in control region (734 to 850 visits)	
Solberg et al. (2004)[20]	Retrospective pre–post study United States 1999–2001 Risk adjusted	Large, multispecialty medical group Patients with three select chronic conditions (heart disease, diabetes, depression) Intervention group: 17,376 patients in 2001 after implementation of open access Control group: 16,099 patients in 1999 before implementation of open access	Full advanced access appointments introduced, which included standardization of schedule slots and extra visit time for clinicians	No significant difference in risk-adjusted proportion of patients visiting ED (during this time period, ED visits also increased by 7.8% for the medical group) (all $p > 0.05$)	Increase in primary care visits (all $p < 0.01$) Significant decrease in risk-adjusted proportion of patients visiting urgent care (all $p < 0.001$)	Total cost per patients increased 10%–20% depending on condition Significant reduction of proportion of patients with hospitalizations (1%) and length of stay >3 days (4%) for heart disease patients only (nonsignificant changes for other conditions)
Solberg et al. (2006)[21]	Retrospective pre–post study United States 1999–2001 Risk adjusted	Large, multispecialty medical group owned by health plan Intervention group: 6,609 patients with depression in 2001 after implementation of open access Control group: 7,284 patients with depression in 1999 before implementation of open access	Advanced access appointments instituted (third next-day available appointment reduced from 19.4 to 4.5 days)	No significant change in ED visits	1% increase in primary care visits ($p < 0.01$) 2% increase in hospitalizations ($p < 0.05$)	17.6% reduction in proportion of patients with no follow-up after starting new medication ($p = 0.001$) Majority of visits with one physician (continuity of care) increased by 6.7% ($p < 0.001$)
van Uden et al. (2004)[17]	Retrospective pre–post cohort study Limburg, the Netherlands	Regional general practitioner cooperatives Intervention group: 12,319 patient contacts after implementation of GPCs Control group: 11,781 patient contacts before implementation of GPCs	Large cooperatives of general practitioners to offer out of hours primary care, also act as gatekeeper for ED visits	9% decrease in ED visits after hours 13.7% absolute reduction number of self-referrals to ED	10% increase in primary care visits after hours 4.6% increase in overall patient contacts after hours 3.6% shift in use from ED to primary care ($p < 0.001$)	None
Wang et al. (2005)[18]	Pre–post intervention study with comparison group United States 12 months	Large, private, primary care pediatric practice with Medicaid patients Intervention group: 17,382 children in the enhanced access program Control group: 26,066 Medicaid-eligible children who received services from other local community primary care providers	Increased care coordination, case management, expanded after-hours clinics and walk in hours at clinic	20% reduction in ED utilization for the intervention group ($p = 0.007$)		Cost per member per month was $8.53 was found in the control group and $7.17 in intervention group, thus a comparative savings of 16%

CHCs = community health centers; GPCs = group practitioner cooperatives; RR = rate ratio.

Table 3

Prehospital Diversion of Low-acuity Patients

Author (Year)	Design	Population	Intervention	Effect on ED Use	Effect on Non-ED Use
Schaefer et al. (2002)[25]	Cohort study with matched historical controls United States August 2000–January 2001	Two EMS Intervention group: 1,016 patients Control (historical) group: 2,617 patients	Low-acuity patients in the intervention group were offered an alternate care sources (clinic or home care) rather than ED use by the EMS staff	There was 7% fewer ED use by the intervention group compared to the control group (44.6% vs. 51.8%) (p = 0.001)	Clinic use: there was 3.5% more clinic use by the intervention group compared to the control group (8% vs. 4.5%) (p = 0.001) No transport (home care): there was 3.7% more home care (no transport) by the intervention group compared to the control group (47.4% vs. 4.5) (p = 0.043)
Snooks et al. (2004)[26]	Cluster randomized controlled trial United Kingdom 6 months	Two EMS. Intervention group: 409 patients Control group: 425 patients	Low-acuity patients in the intervention group were transported to a MIU by the EMS staff	There was 2.8% fewer ED use by the intervention group compared to the control group (74.1% vs. 76.9%)	MIU use: there was 1.3% more MIU use by the intervention group compared to the control group (10% vs. 8.7%)

MIU = minor injuries unit.

Table 4

Managed Care (Capitation or Gatekeeping)

Author (Year)	Design	Population	Intervention	Effect on ED Use	Effect on Non-ED Use	Other Outcomes
			Intervention: Gatekeeping			
Badgett (1986)[27]	Before-and-after study United States 3 years 1983–1985	Single, pediatric ED Intervention group: patients assigned to PCP under AFDC recipients, estimated ~40,000 Control group: same group of patients, 1 year prior to start of program	Citicare program (PCP approval required for ED services), provided physician coverage 24 hours a day, 7 days a week	Total ED visits: Pre: 35,704 During: 25,543 Post: 31,248 Total ED use decreased 23% during the study period compared to period after end of program, for patients enrolled in AFDC program, ED use decreased 46%	Not reported	Total hospital admissions from ED (no significant change): Pre: 3,545 During: 3,555 Post: 3,922
Franco et al. (1997)[31]	Prospective cohort study with historical controls	Single, university-based pediatric clinic. Medicaid patients. Intervention group: 4,766 patients (July 1–August 30, 1991) Control group: 2,798 patients (July 1–Augist 30, 1981)	Program requiring PCP approval for ED use	ED visits declined 2.4% ($p = 0.00005$) Inappropriate ED visits declined 33% ($p < 0.00001$)	Not reported	Not reported
Hurley et al. (1989)[33]	Retrospective cohort study	Four Medicaid demonstration programs Intervention group: AFDC in program requiring gatekeeper approval Control group: recipients of traditional Medicaid programs	Assigned PCP with approval required for ED services	Proportion of patients with one ED visit showed reductions from 27.5% to 36.7% in children, and between 30.6% to 44% for adults	None	None
Murphy et al. (1997)[35]	Before-and-after study Ireland 1993–1995	Large, single ED Intervention group: Patients were GMS ineligible did not qualify for free care in Ireland Control group: all patients who visited ED	Patients who were GMS ineligible were charged a certain amount for each visit to the ED instead of their GP. If the patient had a letter of referral from a GP, they were exempted from the charge.	The total number of GMS ineligible visited the ED during the year before the implantation of the copayment was 19,562/43,202 (45.3%) and in the year after was 19,947/45,302 (44%), which shows a reduction by 1.3% (95% CI = −0.6 to −1.9)	Among the GMS-ineligible patients referred by a GP to the ED, the total number of this group in the year before was 2,619/19,562 (13.4%) and the year after 3,156/19,947 (15.8%), an increase of 2.4% (95% CI = 1.73 to 3.1)	Not reported
Schillinger et al. (2000)[38]	Randomized control trial United States 1997–1998	Single, university-affiliated primary care practice Intervention group: 1,121 patients	Intervention group required PCP approval for access to	Nonsignificant increase in risk-adjusted, nonurgent ED visits in intervention	PCP visits: nonsignificant increase in intervention group	Inpatient care: significant reduction in hospitalizations in intervention group

Author (Year)	Design	Population	Intervention	Effect on ED Use	Effect on Non-ED Use	Other Outcomes
		Control group: 1,172 patients Control group: 1,172 patients	specialty and ED services	group (0.06 visits/patient/ year, p = 0.42)	(0.27 visits/patient/ year, p = 0.14) Specialty visits: significant reduction in visits in intervention group (0.57 visits/patient/ year, p = 0.04)	(0.14 hospitalizations/ patient/year, p = 0.02)
			Intervention: Capitation/Physician Payment			
Catalano et al. (2000)[28]	Interrupted time-series quasi-experiment	Pediatric Medicaid patients, single state Intervention group: recipients in areas with capitation Control group: recipients in areas without capitation	Community mental health centers under capitated agreement with Medicaid. Centers billed by hospital EDs for psychiatric emergency services.	No significant increase in the level of ED usage	Decrease in inpatient psychiatric admission Increase in outpatient visits in for for-profit capitated areas	Estimated decrease by $17–$21 million over 1 year in total (inpatient and outpatient) costs
Catalano et al. (2005)[29]	Interrupted time-series quasi-experiment	Single-state, Medicaid patients year prior and after intervention Intervention group: recipients in areas with capitation Control group: recipients in areas without capitation	Community mental health centers under capitated agreement with Medicaid. Centers billed by hospital EDs for psychiatric emergency services	28% decline in psychiatric ED visits compared to expected	Not reported	Not reported
Dickey et al. (1996)[30]	Before-and-after quasi-experiment	Single-state, Medicaid patients Intervention group: 10,685 patients (1993) 7,541 patients (1994) Control group: 6,614 patients (1991) 7,295 patients (1992)	Single provider of psychiatric services (inpatients and outpatient) contracted with state under capitated agreement	19% decrease in ED visits in years after intervention compared to years prior	Nonquantified increase in outpatient visits Inpatient admission decreased by 4% Median length-of-stay decreased by 3.3 days	Increase in 30-day readmissions by 1.9% Reduction in expenditures per beneficiary $420
Glazier et al. (2009)[32]	Retrospective cohort study Canada 2005–2006	Single province in country with universal health care system Intervention group: 487,131 patients in primary care practices of physicians who chose capitated system Control group: 2,517,527 patients in primary care practices of physicians who chose fee-for-service system	Physicians reimbursed by age- and sex-adjusted capitation payments and required patient enrollment (still eligible for fee-for-service payments for hospital services)	No change in ED visits in capitation group vs. same physicians precapitation Increase likelihood of OR = 1.20, 95% CI = 1.15 to 1.25) for capitation group vs. fee-for-service group (4% more patients in capitation group made visits to ED Higher ratio of low-acuity visits among capitation (1.6) vs. control (0.9) groups	Less after-hours care in capitation practices (OR = 0.68, 95% CI = 0.61 to 0.75)	Lower morbidity and comorbidity indices in capitation practices
Josephson et al. (1997)[34]	Retrospective cohort study	Members of five insurers in one city	Capitation in HMO. In IPA, capitated payments to the	ED use rates (p <0.05): 70 per 1000 members in capitated panel,	None	Admission for five ambulatory sensitive conditions

Author (Year)	Design	Population	Intervention	Effect on ED Use	Effect on Non-ED Use	Other Outcomes
		Intervention groups: 22,316 patients in fully capitated HMO Intervention groups: 22,316 patients in fee-for-service IPA Intervention groups: 22,316 patients in fully capitated HMO 38,030 patients in any of three IPA Control group: 14,110 patients in a traditional indemnity insurance plan (estimated)	assistant fully capitated HMO fee-for-service IPA compensation of physician	363 per 1000 members in HMO panel, 466 per 1000 members in indemnity panel (85% lower ED use rates in capitated vs. indemnity panel)		0.8 per 1000 members in capitated panel, 2.7 per 1000 members in IPA panel, 2.9 per 1000 members in indemnity panel
Piehl et al. (2000)[36]	Before-and-after study United States 1995–1997	Pediatric visits at two community EDs over 2 year, determined rates of ED visits after implementation of managed care plan Intervention group: Medicaid-managed care with 20,663 ED visits Control group: non-Medicaid group: 34,079 ED visits	Managed care program (recipients have assigned PCP and 24-hour access, at least telephone); PCP received monthly fee for each enrollee in addition to fee for each service	Medicaid group: 24% reduction in overall ED visits ($p < 0.001$) (33.5 [SD ± 5.3] reduced to 25.6 [SD ± 2.3] monthly ED visit per 1,000 enrollees); 37% reduction in nonurgent ED visits ($p < 0.001$) Non–Medicaid-insured group: 8% increase in overall ED visits ($p < 0.001$) 8% increase in nonurgent ED visits (p not given)	Not reported	Not reported
Price et al. (1999)[37]	Retrospective cohort study United States One year	Three asthmatic pediatric patients groups based on their type of insurance Fee-for-service group: 47 patients Capitated (HMO) group: 24 patients Medicaid group: 22 patients	The effect of the type of insurance on the medical care use in 1 year	ED use: Fee for service, 2/47 (4%); Capitated, 6/24 (25%); Medicaid, 7.5/22 (34%); $p = 0.038$	Physician visits Fee for service, 12/47 (25%); Capitated, 12/24 (50%); Medicaid, 9.5/22 (43%); $p = 0.56$ Specialist visits Fee for service, 6/47 (12.7%); Capitated, 7.5/24 (31%); Medicaid, 3/22 (13.6%); $p = 0.118$	Hospital visits Fee for service, 2/47 (4%); Capitated, 2/24 (8.3%); Medicaid, 3/22 (13.6%); $p = 0.14$

AFDC = Aid to Families with Dependent Children; GMS = General Medical Services; GP = general practitioner; HMO = health maintenance organization; IPA = independent practice associations; PCP = primary care clinic.

Table 5

Patient Financial Incentives

Author (Year)	Design	Population	Cost Intervention	Effect on ED Use	Effect on Non-ED Use	Other Outcomes
			Intervention: Copayment/Coinsurance			
Hsu et al. (2006)[39]	Quasi-experimental, longitudinal, concurrent controls United States 1999–2001 Risk adjusted	Prepaid integrated delivery system, 19 medical center Intervention group: commercially insured, 2,257,445 patients (copayment levels: $0, $1–$5, $10–$15, $20–$35, and $50–$10 per ED visit) Control group: Medicare, with employer supplementation, 261,091 patients (copayment levels: $0, $1–$15, and $20–$50 per ED visit)	• Comparison of various copayment levels over 36-month time period • Copayment level chosen by employer, not patient	• In commercially insured group, risk-adjusted RR of ED visit compared to no copayment group was 0.96 for $1–5 copayment group (CI = 0.96–0.97), 0.93 for $10–15 (CI = 0.92–0.94) 0.88 for $20–35 (CI = 0.87–0.89) 0.77 for $50–100 (CI = 0.76–0.77) • In Medicare group, RR of ED visit compared to no copayment group was 0.97 for $1–15 copayment group (CI = 0.96–99) 0.96 for $20–50 (CI = 0.94–0.97)	Not reported	• No significant change in hospitalizations, ICU admission, and deaths with higher copayment rates except the following: • In commercially insured group, death rate was significantly higher in lowest copayment level of $1–$5 compared to no copayment with RR = 1.09 (CI = 1.02–1.16) • In Medicare group, highest copay level ($20–$50) with decreased mortality rate (RR = 0.87, CI = 0.83–0.91)
Lowe et al. (2008)[47]	Before-and-after observational study United States 48 months	26 EDs, purposive sample of the state Intervention group: post–Oregon health plan cutbacks Control group: pre–Oregon health plan cut-backs Five groups of patients based on the class of payer: • Commercially insured • Oregon health plan • Uninsured • Medicare	Medicaid cutback, Oregon: the beneficiaries of the Oregon health plan receive new policy changes that include copayment for most of the health services (PCP visits, ED use, and hospitalization); decreased enrollment in health plan with increased number of uninsured patients	• Oregon health plan 20% reduction in ED visits/month (CI = 13–18) • Uninsured 20% increase in ED visits/month (CI = 13 to 18)	Not reported	Hospitalization from ED visit (adjusted ORs): • Commercial 0.99 (CI = 0.95–1.04) • Oregon health plan 1.09 (CI = 1.03–1.16) • Uninsured 1.50 (CI = 1.39–1.62) • Medicare 1.10 (CI = 1.06–1.13)

Author (Year)	Design	Population	Cost Intervention	Effect on ED Use	Effect on Non-ED Use	Other Outcomes
		• Others payers				
Lowe et al. (2010)[40]	Before-and-after study United States 2001–2004	State population study Intervention group: Medicaid enrollees with the standard plan Control group: Medicaid enrollees with the plus plan (not affected by cutbacks)	Medicaid cutback, Oregon: The beneficiaries of the Oregon health plan receive new policy changes that include copayment for most of the health services (PCP visits, ED use, and hospitalization and eliminated outpatient behavioral health services	Decrease in ED use rates (RR = 0.84; 95% CI = 0.83–0.86). Compared to Plus Plan members, use also decreased (RR = 0.82; 95% CI = 0.80–0.84) Injury-related visits also decreased ($p < 0.001$).	Not reported	ED visits leading to hospital admission also decreased: (RR = 0.83; 95% CI = 0.79–0.86). Compared to Plus Plan members, utilization also decreased (RR = 0.85; 95% CI = 0.82–0.89).
Mortensen (2010)[48]	Quasi experimental, pre–post design (differences-in-differences methodology) 24 months Risk adjusted	State-level study among Medicaid enrollees in 29 states. Intervention group: Medicaid enrollees in states with copayment increase (nine states) Control group: Medicaid enrollees in states without no copayment or no copayment change (20 states)	• Medicaid ED visit copayment increase in nine states, ranging from $3 to $50	Significant increase in probability of any ED visits in a year (33.1 per person-month for change group vs. 24.7 for control group, $p = 0.000$)	Not reported	Not reported
O'Grady et al. (1985)[41]	Randomized controlled trial United States	State-level among six geographic areas in four states Intervention group: 3,973 persons were assigned randomly to different fee-for-service insurance plans with copayment rates of 0, 25, 50, or 95%	A coinsurance rate of 25, 50, or 95%—up to maximum of $1,000 as out-of-pocket costs	The probability of ED use among the copayment groups was fewer than the free group • 25% copayment group fewer by 15% ($p = 0.05$) • 50% copayment group fewer by 8% • 95% copayment group fewer by 30% ($p = 0.01$) • Individual-deductible plan fewer by 19% ($p = 0.05$) The ED use among the copayment groups was fewer than the free group • 25% copayment group fewer by 21% ($p = 0.01$)	Not reported	The ED visit resulting in hospitalization among the copayment groups was fewer than the free group • 25, 50, and 95% copayment groups fewer by 33% ($p < 0.05$)

Author (Year)	Design	Population	Cost Intervention	Effect on ED Use	Effect on Non-ED Use	Other Outcomes
				• 50% copayment group fewer by 18% • 95% copayment group fewer by 35% (p = 0.01) • Individual-deductible plan fewer by 20% (p = 0.05)		
Selby et al. (1996)[42]	Matched cohort study Risk adjusted	Group-model HMO, 15 medical centers Intervention group: 30,276 patients Control group: 60,408 patients (matched for age, sex, and location); second group 37,539 patients (matched for same + employer)	Introduction of a $25–$35 copayment for ED use in an HMO	• Absolute decrease in ED usage by 28 visits/100 person-year in copayment group • Risk-adjusted decrease in ED visits 14.6% more in copayment group than either control group (p < 0.001) • Significant decreases in visits for less emergent conditions compared to emergent	• No significant change in urgent care use and pediatric office visits over time between groups • 4.4% decrease in rate of adult office visits in copayment group	• Nonsignificant reduction in potentially avoidable hospitalizations in copayment group compared to control groups • Significantly lower adjusted mortality rate in the copayment group (1.6/1,000) than in control group1 (2.2/1,000, p = 0.001) and control group2 (2.6/1,000, p = 0.06)
Wallace et al. (2008)[43]	Retrospective cohort study, difference-in-differences methodology United States 2001–2004	State population study, propensity score matched population Intervention group: Medicaid enrollees with the Standard Plan, 10,176 subjects Control Group: Medicaid enrollees with the Plus Plan, 10,319 subjects	Addition of $50 copayment for ED visits that did not result in admission. Intervention also included elimination of certain benefits (dental, mental health, etc.) as well as other copayments (outpatient visits, inpatient admissions, pharmacy, etc).	ED visits decreased by 7.9% (p = 0.03) in the standard (copayment) group relative to the plus group. ED visit expenditures by user increased 7.9% (p = 0.03) over the same time period despite the decrease In visits.	Pharmacy: decrease in use and expenditures (−2.2%, p < 0.001; −10.5%, p < 0.001). Inpatient: increase in use and expenditures (+27.3%, p < 0.001; +20.1, p < 0.001) Hospital outpatient: increase in use and expenditures (+13.5%, p < 0.001; 19.7%, p < 0.001) Ambulatory: decrease in use (−7.7%, p < 0.001) but increase in	Total expenditures (+2.2%, p = 0.47) by person unchanged despite overall reduction in use (−2.2%, p < 0.001)

Author (Year)	Design	Population	Cost Intervention	Effect on ED Use	Effect on Non-ED Use	Other Outcomes
					expenditures by user (+6.6%, p = 0.75)	
					expenditures by user (+6.6%, p = 0.75)	
			Intervention: HDHP			
Waters et al. (2011)[45]	Retrospective cohort study Risk adjusted	Major insurer in single state, propensity score matched sample Intervention group: 1,354 HDHP group initially in PPO, then switched and maintained in HDHP for all 3 study years Control group: 1,354 members of enrolled in PPO plan	HDHP with deductibles ranging from $1,700 to $6,000 vs. PPO plan. HDHP enrollees used standard PPO contracted amounts before meeting their deductible.	HDHP enrollees had lower probability of use and level of use (p < 0.05)	HDHP enrollees appeared to have decreased primary care use (p < 0.01), but greater specialty physician use (p < 0.05)	HDHP enrollees had significantly higher prescription drug utilization and expenditures (p < 0.05)
Wharam et al. (2007)[44]	Before-and-after study United States 2001–2005	Single-state, single-insurance carrier offering HDHP and HMO plans Intervention group: 8,724 enrollees with HDHP for at least 6 months, after 1 year of traditional HMO Control group: 59,557 enrollees with traditional HMO, matched on adult/child status.	Individuals in the HDHP group have annual individual deductibles ranging from $500 to $2,000. If the expenditure exceeds the deductible, individuals pay a copayment ($100) for each ED use. Individuals in the intervention group had copayment for each ED ($20-$100) and outpatient visit ($5–$25).	ED visits with 10.0% relative decrease (absolute change, 20.2 visits per 1,000) in the HDHP group compared with controls from baseline to follow-up (95% CI = −16.6% to −2.8%; p = 0.007)		ED visits resulting in hospitalizations with 24.7% relative decrease (with an absolute rate difference of −2.6% in the HDHP group (95% CI = −41.0% to −3.9%; p = 0.02) ED expense per HDHP member decreased from $75 in the baseline year to $36 in the follow-up period, an absolute decline of $52, representing a 58.5% relative decline (95% CI = −64.4% to −51.5%; p <0.001)
			Intervention: Health Savings Account			
Wilson et al. (2008)[46]	Multiyear cross-sectional study United States 2004–2006 Risk adjusted	Commercial insurance plan with both comprehensive major medical and CDHP Intervention group: enrollees of CDHP plan for the study year Control group: enrollees of traditional comprehensive major medical plan	CDHP includes a variety of products including health reimbursement accounts and health savings accounts, which are portable if an employee leaves his or her employer. All offer first-dollar coverage for preventive services.	After risk adjustment, CDHP plan members had 129.1 vs. 141.2 ED visits/1,000 members/year		

CDHP = consumer-driven health plan; HDHP = high-deductible health plan; HMO = health maintenance organization; ICU = intesive care unit; PCP = primary care provider; PPO = preferred provider organization; RR = rate ratio.

Table 6

Quality Assessment of Selected Observational Studies on Non-ED Interventions to Reduce ED Utilization Using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) Criteria

Possible limits of observational studies

1. **Failure to develop and apply appropriate eligibility criteria (inclusion of control population)**
2. **Flawed measurement of both exposure and outcome**
3. **Failure to control confounders and to measure all known prognostic factors**
4. **Imprecision of outcomes (i.e., wide CIs)**
5. **Incomplete follow-up**

First Author (Reference)	Existing Limitations	Overall Quality of Evidence
Patient education		
Glavan (10)	1, 3, 4	Very low
McWilliams (11)	1, 3	Very low
Schonlau (13)	1, 3	Very low
Non-ED capacity increase		
Chalder (22)	1, 2, 3	Very low
Hsu (24)	1, 3, 4	Very low
Hudec (15)	1, 3, 4	Very low
O'Kelly (16)	1, 2, 3, 4	Very low
Philips (23)	1, 2, 3	Very low
Rust (19)	1, 2, 3	Very low
Solberg (20)	1,2,3	Very low
Solberg (21)	1,2,3,4	Very low
van Uden (17)	1, 2, 3	Very low
Wang (18)	2, 3	Very low
Prehospital diversion		
Schaefer (25)	1, 3, 5	Very low
Managed care		
Badgett (27)	1, 3, 4	Very low
Catalano (28)	1, 3	Very low
Catalano (29)	1,3, 4	Very low
Dickey (30)	1, 3, 4	Very low
Franco (31)	1, 2, 3	Very low
Glazier (32)	1, 3	Very low
Hurley (33)	1, 2, 3, 4	Very low
Josephson (34)	1,3, 4	Very low
Murphy (35)	1, 3	Very low
Piehl (36)	3, 4	Very low
Price (37)	2, 4	Very low
Patient financial incentives		
Hsu (39)	3	Very low

Possible limits of observational studies

1. **Failure to develop and apply appropriate eligibility criteria (inclusion of control population)**
2. **Flawed measurement of both exposure and outcome**
3. **Failure to control confounders and to measure all known prognostic factors**
4. **Imprecision of outcomes (i.e., wide CIs)**
5. **Incomplete follow-up**

First Author (Reference)	Existing Limitations	Overall Quality of Evidence
Lowe (47)	1, 2, 3	Very low
Lowe (40)	2, 3	Very low
Mortensen (48)	1, 2, 3, 5	Very low
Selby (42)	3	Very low
Wallace (43)	3	Very low
Waters (45)	2, 3,4	Very low
Wharam (44)	1,3,5	Very low
Wilson (46)	2, 3	Very low