# The Effects of Ambulance Diversion: A Comprehensive Review

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## Abstract

***Objectives:*** To review the current literature on the effects of ambulance diversion (AD).

***Methods:*** The authors performed a systematic review of AD and its effects. PubMed, EMBASE, the Cochrane database, societal meeting abstracts, and references from relevant articles were searched. All articles were screened for relevance to AD.

***Results:*** The authors examined 600 citations and reviewed the 107 articles relevant to AD. AD is a common occurrence that is increasing in frequency. AD is associated with periods of emergency department (ED) crowding (Mondays, mid-afternoon to early evening, influenza season, and when hospitals are at capacity). Interventions that redesign the AD process or that provide additional hospital or ED resources reduce diversion frequency. AD is associated with increased patient transport times and time to thrombolytics but not with mortality. AD is associated with loss of estimated hospital revenues. Short of anecdotal or case reports, no studies measured the effect of AD on ED crowding, morbidity, patient and provider satisfaction, or EMS resource utilization.

***Conclusions:*** Despite its common use, there is a relative paucity of studies on the effects of AD. Further research into these effects should be performed so that we may understand the role of AD in the health system.

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The emergency department (ED) plays a unique role in the U.S. health system. As the so-called safety net of the system, the ED is expected to care for any patient, at any time, under any circumstance. Implicit in this role as a safety net is the concept that EDs have surge capacity, or the ability to effectively care for patients despite volume, severity of illness, or resource utilization that is above the usual daily ED practice. Surge capacity may be required in predictable patterns (daily or seasonal variation in ED volume) or in unpredictable, large mass-casualty events (natural and unnatural).

Surge capacity involves more than a single hospital or ED. Part of this capacity is the ability to redistribute resources and patients between EDs, hospitals, cities, municipalities, and even states. During unpredictable, large mass-casualty events, resources generally are redistributed to the areas of need. During predictable daily and seasonal surge events, patients may be redistributed among facilities. One method of redistributing patients between EDs is ambulance diversion (AD). In periods of surge, the emergency medical services (EMS) system adapts to redistribute, as well as transport, patients. However, there is recent concern about the effectiveness of AD in even predictable surge occurrences, not to mention unpredictable events.

In 1990, Lagoe and Jastremski first described AD as a novel strategy to help alleviate crowding of their city's EDs.[1] As ED visits have increased through the years, AD and ED crowding have been characterized as a national crisis.[2–7] In many health systems, AD has evolved into standard practice.[8]

AD, the practice of rerouting ambulances away from the closest ED, is used for a variety of reasons. In some instances, individuals may request to be diverted to a specific facility for personal preferences (e.g., insurance, primary-care physician, regional specialist). Institutions may divert ambulances if they do not have the appropriate

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facilities (e.g., computed tomography scanner, blood bank, operating room, intensive care unit [ICU]) or trained personnel (e.g., trauma team, neurosurgeons, on-call specialists) to care for specific patient populations. Commonly, AD is used by medical facilities when their ED or hospital is perceived to have exceeded its capacity to care for patients. AD is assumed to reduce ED crowding. As a result, diversion is considered a safety measure for the patients currently in the ED, as well as for those being diverted away. Because of their close relationship, researchers and policy makers often use AD as a surrogate marker for ED crowding.

Recent literature suggests that AD may not achieve some of these presumed benefits. ED crowding is a complex problem with multiple causes, and it is not clear that AD alone reduces this problem. Many studies use AD as a surrogate for ED crowding because the data are easily, and often routinely, collected. However, AD may not be a valid marker given that criteria for diversion are often loosely defined, subjective in nature, and inconsistently implemented between and within EMS systems. With regard to patient safety, AD may delay patient arrival to the ED and reduce ambulance availability for other patients.[9,10] There even are anecdotal reports of harm related to AD.[11–13]

To clarify some of these issues, we performed a systematic review of the literature to summarize the effects of AD and diversion reduction policies.

## METHODS

### Search Strategy

We performed a comprehensive search of the medical literature to identify all studies related to ground AD. PubMed was searched for English language citations from January 1, 1965 to April 13, 2006 by using the following Medical Subject Heading (MeSH) and specific text word terms: *("Ambulances"[MeSH] OR "*Transportation of Patients"[MeSH] OR "Emergency Medical Services/*organization and administration"[MeSH]) AND (diver* OR bypass*)*. We searched EMBASE using the following subject terms: *"Ambulance diversion" OR "hospital bypass" OR "emergency services bypass" OR "emergency services diversion" OR "emergency medical service bypass" OR "emergency medical service diversion" OR "transport of patients,"* with English and human limits. We also searched the Cochrane database using the following search terms: *"emergency medical system" OR "ambulance" OR "diversion" OR "bypass."* In addition, we hand-searched the references of all identified articles for relevant citations. Finally, to minimize publication bias, abstracts presented at major societal meetings (American College of Emergency Physicians, Society for Academic Emergency Medicine, National Association of EMS Physicians) during the last five years were hand-searched.

### Article Screening and Inclusion and Exclusion Criteria

Two of three reviewers (JCP, RP, or MGM) independently evaluated the titles and abstracts of all citations for relevance. The third reviewer resolved any discrepancies. The articles were screened in a two-stage process. During the initial screen, articles were evaluated for any relevance to ground AD. The full text of all articles with relevance to ground AD was reviewed in the secondary screen. For abstracts, primary authors were contacted and additional data and study details were solicited. During the secondary screen, articles were categorized according to the outcome that was measured. Editorial, review, or position-statement articles, defined as those not presenting original data, were excluded from the review.

## RESULTS

### Study Selection

The initial search identified 600 citations (377 from PubMed, 107 from EMBASE, 106 from the Cochrane database, 5 from conference abstracts, and 5 from reference search). After accounting for 17 duplicates, 583 titles and abstracts were reviewed. The primary screen excluded 476 articles that did not relate to ground AD, leaving 107 articles for full-text review. There was 95% (568/600) agreement between initial reviewers. Of the 107 articles, 52 (49%) were editorial or review articles. Only 23% (n = 25) of the articles measured the effect of AD on an outcome, and 34% (n = 36) of the articles measured the effect of other variables on AD. A flow chart of the article selection process is shown in Figure 1.

### Ambulance Diversion and ED Crowding

Any discussion on the effects of AD must account for its intricate and complex relationship to ED crowding. Crowding is a potential confounder between AD and its effects because ED crowding is related to the predictor (pathway C, Figure 2) and to the outcome (morbidity, mortality, costs, satisfaction, and so on; pathway A, Figure 2), yet is outside the causal pathway (pathway B, Figure 2).[14] Therefore, it is important to keep in mind that unless ED crowding is controlled for, studies evaluating the cause and effects of AD likely are evaluating the cause and effects of ED crowding as well. In some studies, it explicitly is clear that AD is used as a marker of ED crowding; in other studies, this relationship is implied.

### Prevalence of Ambulance Diversion

The available evidence suggests that AD is a common occurrence that is increasing in frequency. Locally, AD occurred as much as 51% of the time (1,381/2,688 hours) in a four-hospital system in Syracuse, NY.[15] Across the United States, AD use occurred about 1 d/wk (5.2 d/mo) among 238 academic EDs,[16] and in about half of EDs (45%) in general.[17] The U.S. point prevalence of AD at 7:00 PM on Monday, March 12, 2001 was 11%.[18] In 2003, there were an estimated 501,000 ambulances diverted (one ambulance per minute).[17] AD increased 123% between 1996 and 1999 in the four-county midsized metropolitan area around Portland, OR.[19] In Los Angeles County (CA), AD hours increased from 57 h/mo in 1998 to 190 h/mo in 2004 ($p < 0.05$).[20]

### Predictors of Ambulance Diversion

Several cross-sectional studies have identified risk factors associated with AD. Temporally, AD is most common on Mondays, in the mid-afternoon to early

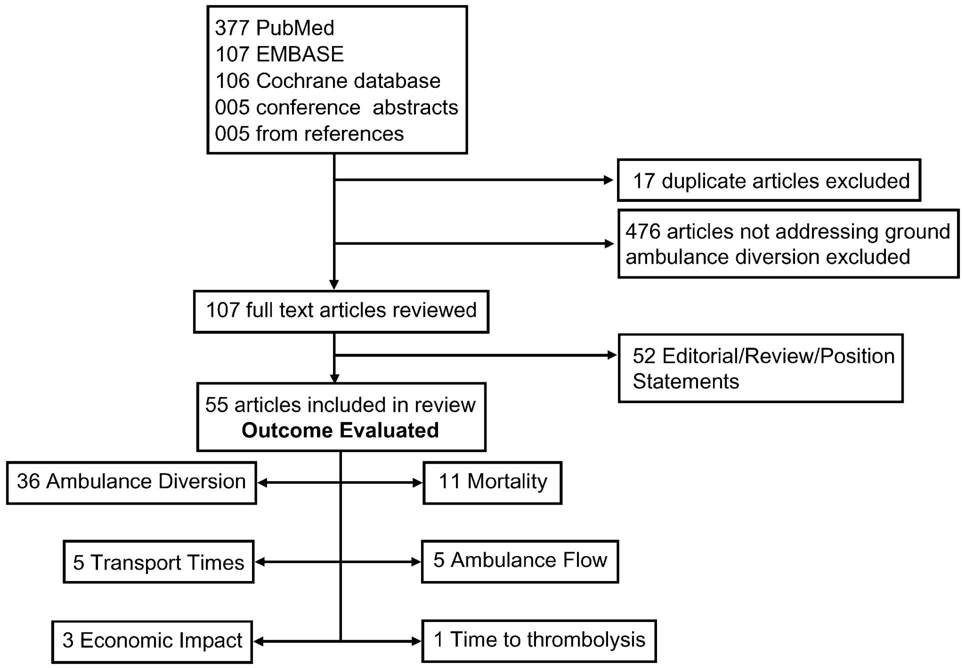


**Figure 1. Flow diagram of article selection process and outcomes. The sum of outcomes is greater than 57 because some articles measured more than one outcome.**

evening, and during influenza season.[21–23] Locally, AD frequency is associated with the number of available hospital beds,[19] number of admitted patients, number of admitted patients waiting in the ED,[21,24] volume of ambulance arrivals, and time to physician assessment.[25] Regionally, higher AD hours are associated with county hospitals, trauma centers, and hospital closures.[20] Because most of these were studies of ED crowding, they suggest that AD is predicted by the same factors as crowding.

### Interventions to Reduce Ambulance Diversion

Studies evaluating interventions to reduce AD can be classified into two groups. The first group of nine studies involves changing or strictly enforcing the criteria for implementing AD (pathway C in Figure 2). These studies

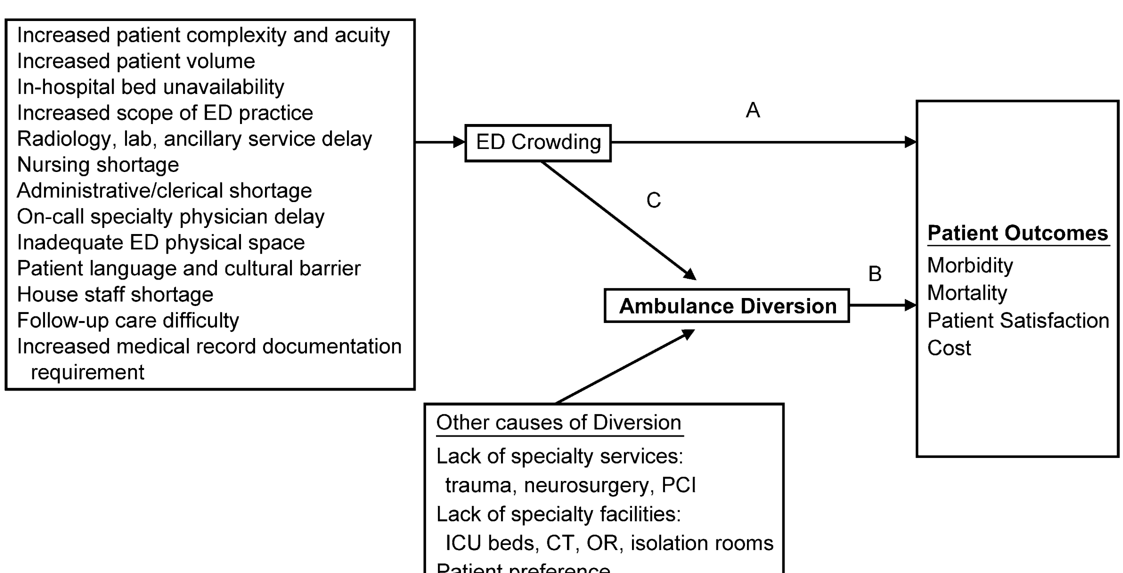


**Figure 2. Conceptual model of relationship between emergency department (ED) crowding, ambulance diversion, and patient outcomes. A, causal pathway whereby ED crowding leads to outcomes. B, causal pathway whereby ambulance diversion leads to outcomes. C, causal pathway whereby ED crowding leads to ambulance diversion. C + B, the pathway whereby ED crowding leads to patient outcomes through ambulance diversion. Causes of ED crowding are from Derlet and Richards.[61]**

demonstrate that strictly enforcing revised AD guidelines,[26–31] limiting time on diversion (1-hour increments[26,27] or 3-hour increments[28]), or implementation of a regionwide AD monitoring system[26,29–32] was associated with decreases (68%–76%) in AD rates. Two other studies examined the effect of completely stopping ADs. In a two-hospital system in San Diego, CA, total AD hours were reduced at one institution (19.7 to 1.4 hours) when a study hospital completely stopped diversions. This also stopped the oscillatory phenomenon of one ED, causing another to go on diversion as a result of increased traffic. This was accomplished for a single week by increasing staffing at the study hospital.[33] In an anecdotal report from Memphis, TN, stopping AD for the entire EMS region decreased turnaround time for ambulances from 90 to 30 minutes.[34] These eight studies demonstrate that limiting the criteria for AD can reduce its frequency. However, none of the studies examined the effect of these changes on patient outcomes (satisfaction, safety, morbidity, mortality) or ED crowding.

A second group of seven studies evaluated the effect of adding new resources aimed at reducing ED crowding on AD. One study used a 51-intervention program involving changes in “ED management, elective surgery, capacity management, and subacute process” that resulted in a 50% reduction in diversion episodes.[35] These interventions included providing additional personnel resources and care coordinators for the ED; reviewing operating room utilization, delays, and scheduling; and adding discharge coordinators for the wards. Increasing ICU capacity (47 vs. 67 beds) or implementing a 14-bed short-stay unit was associated with reductions in AD hours (3.8 vs. 1.4 h/d[36] and 6.7 vs. 2.8 hours per 100 patients,[37] respectively) at two academic centers. In anecdotal reports, implementation of an ED clinical laboratory[38] and of a 24-hour bed management team[39] reduced AD hours as well. Among 21 Australian hospitals, bonus payments were provided for adhering to specific guidelines pertaining to AD episodes, patient waiting times, and admission waiting times. This system resulted in an 83% reduction in AD episodes and an improvement in patient waiting times but in no reduction in admission waiting times.[40] In a descriptive case study, Schneider et al. presented a ten-year experience with efforts to reduce ED crowding and AD in Rochester, NY.[2] ED-based efforts (AD and short-stay or observational units) in the first ten years had little effect. Hospital-based efforts (additional cardiac telemetry monitors, float teams of registered nurses, revised AD policies, transition teams) resulted in a decrease in diversion hours and EMS turnaround time in the last two years.

These studies demonstrate that AD rates can be reduced by adding resources to decrease ED crowding or by closely controlling the use of AD. Interventions that address ED crowding improve the underlying causes of AD and its potential patient outcomes. However, interventions that merely change or limit AD use may or may not affect ED crowding or patient outcomes.

### Ambulance Diversion and ED Flow

The goal of AD is to reduce ambulance flow to the ED. In a four-hospital system of university and community hospitals, ambulance flow was reduced by 0.3 to 0.7 patients per hour when on diversion. This estimate varied by season.[1,15] The effect of AD also varies by diversion type and community characteristics. Scheulen et al. reported their experience with three regions (urban, suburban, rural) and two types of diversion: yellow alert (related to ED capacity limitations) and red alert (related to inpatient electrocardiogram-monitored bed limitations).[41] Red alert reduced ambulance flow in all three regions by about 0.4 patient per hour. Yellow alert reduced flow to urban areas by 0.13 patient per hour and suburban areas by 0.16 patient per hour but did not significantly change flow to rural areas.

### AD and Transport and Treatment Times

One potential problem with AD is a delay in transport or treatment that is associated with transporting patients to a more distant hospital. The following five studies demonstrated a delay in transport times from 1.7 to 5 minutes (Table 1) associated with AD. Two Canadian studies evaluating chest-pain patients found an increase in transport times. Both studies evaluated the Toronto EMS system, which serves four quadrants with three to six EDs each. In the first study, a period of high diversion (1999)

Table 1
Association between Ambulance Diversion and Out-of-hospital Intervals

| Study | Design | Population | Comparison Group | Country | Region | TPI (min) | TI (min) | OSI (min) |
|---|---|---|---|---|---|---|---|---|
| Sloan et al.[44] | Observational, prospective | Trauma | Concurrent | USA | Urban | +3.0 | +3 | — |
| Neely et al.[43] | Observational, prospective | ALS | Concurrent | USA | Urban | — | +5 | — |
| Redelmeier et al.[12] | Observational, prospective | EMS | Concurrent | USA | Urban | — | +1.7 | +1.1 |
| Silka et al.[42] | Observational, retrospective | ALS | Concurrent | USA | Urban | +3.0 | +2.4 | — |
| Schull et al.,[9] crowding | Observational, retrospective | Chest pain | Concurrent | CAN | Urban | — | +1.9 | −2.3 |
| Schull et al.,[10] gridlock | Observational, retrospective | Chest pain | Concurrent | CAN | Urban | — | +3.8 | — |

All studies showed an increase in transport interval (TI). All differences are statistically significant at $p < 0.05$.
OSI = on-scene-interval; TPI = total out-of-hospital interval; ALS = advanced life support.

was compared with one of low diversion (1997). The period of high diversion was associated with an increase in transport interval (TI; time from departure to arrival at hospital) but decrease in on-scene interval (OSI; the time from arrival on scene to departure from scene).[9] The study controlled for day of the week, time of the day, geographic location, dispatch priority, case severity, return priority, and number of other patients. In a second article, so-called gridlock (all EDs in a given quadrant being on diversion) was associated with an increase in TI. The study controlled for severity of illness.[10]

Three studies evaluating the association between AD and transport times in a general population also found an increase in transport times. A cohort of patients in Northern California between 1986 and 1989 had longer TI and OSI while on diversion.[12] Of the 2,534 ambulance runs in southern California between August and October of 1997, diverted patients had a longer total out-of-hospital interval (TPI; time from leaving the station to arriving at the hospital) and TI. In this study, diverted cases were matched 2:1 to nondiverted controls by advanced life support transport unit, chief complaint, and time period.[42] The most common reason for diversion in this patient population was special request (patient, family, private-physician request, or patient in custody), not ED crowding. A second case–control study in Portland, Oregon between 1991 and 1992 demonstrated that diverted patients had longer TI and traveled further than did those not diverted. Diverted patients were compared with a 5% random sample of nondiverted patients.[43]

The practice of diverting seriously injured patients to a specialty trauma center was associated with an increase in TPI and TI among 137 patients. This population of level I (life- or limb-threatening injury, or field trauma score of 12 or less) patients were not diverted because of overcapacity but because of requirement for specialty trauma services.[44]

These studies demonstrate that for a variety of patient populations (chest pain, general EMS, trauma), severity of illnesses, and reasons for diversion, AD increases EMS transport times. All of the studies demonstrated the increase in transport time to be five minutes or less.

One study demonstrated that periods of moderate (1% to 60% of EDs in system) and high (>60% of EDs in system) AD were associated with an increase in time to thrombolysis in patients with acute myocardial infarction. The median door-to-needle time was 40, 45, and 47 minutes for periods of no, moderate, and high AD, respectively ($p < 0.001$).[45] This study demonstrates the difficulties in drawing conclusions about the effects of AD. The delay to thrombolysis found in this study may be a result of ED crowding (pathway A in Figure 2). However, because in this study AD was used as a surrogate measure for ED crowding, one may be tempted to conclude that AD led to a delay in treatment (pathway B in Figure 2). Yet, this ignores the possibility that AD may not be an appropriate marker for ED crowding, because there are other causes for AD (e.g., lack of subspecialty care). Moreover, AD may be considered an effect of ED crowding, and thus, it may not be AD per se that is the cause of the treatment delay.

### Ambulance Diversion and Mortality

Several anecdotal or case reports have attributed AD to patient deaths. All five of these cases involved the deaths of critically ill patients and resulted in lawsuits or criminal charges.[11,13,46–48] These reports raise the hypothesis of an association between AD and mortality.

In a retrospective cohort study of 18,888 trauma patients from Houston, Texas, AD was not associated with a change in mortality (3.9% vs. 3.3%). AD was defined as days on which both level I trauma centers were on diversion for more than 8 hours. Mortality was defined as death before hospital or hospice-care discharge. The study controlled for severity of illness and transfer status.[49]

Two studies of general EMS patients found AD to be associated with lower mortality. In Santa Clara County, California, there was an almost 80% risk reduction of death for diverted patients (relative risk [RR], 0.22; 0.4% vs. 1.8%) compared with nondiverted ones.[12] In Australia, patients treated during periods of AD had a lower rate of hospital death (incidence rate ratio, 0.72; 95% confidence interval [CI] = 0.61 to 0.95) than did those treated during periods of nondiversion.[50] The authors of one study attributed this difference to "regulations preventing critically ill patients from being diverted." In an attempt to control for this confounder, they evaluated an indirect measure of mortality, annual death rate. They compared the annual death rate for 1986, a period of low AD (718 diversions) with that for 1989, a period of high AD (3,973 diversions). In this analysis, high AD was not associated with a change in mortality (0.460 vs. 0.464 deaths per 1,000 population).[12]

Three additional studies found no statistically significant association between transport times and increased mortality.[44,51,52] However, these studies dealt only with a subpopulation of patients diverted because of specific clinical conditions to a specialized care center (trauma and neurosurgical), and not as a result of crowding. The risks-to-benefits ratio of this practice are outside the scope of this review.

There are several possible reasons that the current literature does not demonstrate an association between AD and mortality (Table 2). First, it is possible that no such association exists. Second, any such detrimental effect of AD may be mitigated by patient safety practices. In most systems, critically ill patients are transported to the nearest hospital regardless of the divert status of that hospital. Finally, the current literature may not be measuring the appropriate timeframe for mortality. For example, delays in thrombolysis as a result of diversion may affect 5-week mortality, not ED mortality.[53]

### Economic Effects of Ambulance Diversions

It has been suggested that hospitals lose revenue when their EDs are on AD. These models estimate lost revenue through potential lost admissions, based on patients transported to a different facility while hospitals are on AD. One formula for calculating such a model is presented in Figure 3.[54] While on AD, an urban teaching hospital was estimated to lose $1,186/h (95% CI, $696–$1,598).[54] In a similar analysis at a suburban teaching hospital, AD was estimated to lose the hospital $5,845/h.[55]

Table 2
Association between Ambulance Diversion and Mortality

| Study | Design | Population | Comparison Group | Country | Region | Mortality of Control | Mortality of Diverted |
|---|---|---|---|---|---|---|---|
| Redelmeier et al.[12] | Observational, prospective | EMS | Concurrent | USA | Urban | 1.8% | 0.4% |
| Redelmeier et al., secondary analysis | | | | | | 0.460 death per 1000 persons | 0.464 death per 1000 persons |
| Begley et al.[49] | Observational, retrospective | Trauma | Concurrent | USA | Urban | 3.3% (480/14,038) | 3.9% (120/2947) |
| Fatovich[50] | Observational, retrospective | EMS | Concurrent | AUS | Urban | 1.34% (73/5445) | 1.87% (154/8245) |

Both studies demonstrated no difference in mortality between diverted and nondiverted patient population. Differences not statistically significant, $p > 0.05$.

Neither study collected data on actual revenues billed or recovered.

Because diversion is brought about by ED crowding, lost revenue is likely a result of crowding rather than diversion. Interventions directed at recovering this lost revenue have addressed crowding rather than AD. Anecdotal reports suggest that addressing these causes (lack of hospital beds, inefficient throughput system, and so on) can reduce AD and ED crowding and therefore, lost revenue.[56]

The economic impact of AD for an individual hospital likely depends on the payer mix of diverted patients. If the diverted patients are mostly underinsured or uninsured, a hospital may actually gain revenue from AD. Further research into the economic impact of AD on different hospital types is needed.

## DISCUSSION

This comprehensive review demonstrates that AD has the following characteristics: 1) it is a common phenomenon that is increasing in frequency; 2) it is associated with ED crowding; 3) it can be reduced by process redesign or additional resources; 4) it is associated with a small increase in patient transport and treatment times; 5) it slightly decreases ambulance flow to the ED; 6) it does not appear to be associated with mortality; and 7) it appears to be associated with estimated losses to hospital revenue.

Two groups of interventions to decrease AD were identified. The first involves manipulating AD guidelines: strictly enforcing established guidelines, limiting the amount of time allowed on AD, using a web-based AD monitoring system, and stopping AD altogether. The second involves adding more facility and human resources (usually at the hospital level) to reduce ED crowding: adding more critical-care beds, adding an observation unit, establishing an ED-based laboratory, establishing a bed-management team, increasing RN float teams, and financially rewarding efficient EDs.

Lost Revenue = Hours on Diversion **X**
Ambulance Patient Arrival/hr **X**
Proportion of Ambulance Patients Admitted **X**
Hospital Revenue/admission

**Figure 3. One model of estimating hospital lost revenue as a result of ambulance diversion.**

This review uncovered significant gaps in our knowledge of AD. First, the effect of AD on ED crowding remains uncertain. None of the studies evaluated AD's effect on a validated indicator[4,57–59] of ED crowding. Diversion slightly decreases ambulance flow to the ED, but it does not have a known effect on the many other factors that affect ED crowding (walk-in patients, critically ill ambulance patients not eligible for diversion, hospital census, ICU bed availability, transfer delays, patient population, consultant availability, and so on). The effect of diversion on ED crowding is important because resources spent on building, monitoring, and enforcing AD systems might better be spent on other factors that directly influence ED crowding. Second and perhaps more important, few studies have addressed AD's effect on patient outcomes. AD slightly increases treatment and transport times, but the impact of these delays is mostly unknown. Although AD does not appear to increase mortality, it may affect morbidity end points such as patient and provider satisfaction, intubation rates for asthma patients, and so on. Because of its frequent use, the effect of AD on patient outcomes, both for those in the ED and those who are being diverted, deserves to be explored further. Finally, the effect of AD on the cost and efficiency of the EMS system warrants further research. As ambulances are diverted between hospitals, increasing transport times, there may be a requirement to increase the number of ambulances to meet response time goals. This is compounded by the delay in EMS turnaround intervals that are associated with ED crowding.[60]

## CONCLUSIONS

Ambulance diversion is a commonly used tool in the management of ED crowding and daily surge capacity. Although we have a good understanding of the causes of AD, our understanding of its direct effects is less clear. The available evidence suggests that diversion has a small impact on transport and treatment times but perhaps no impact on mortality. This suggests that during times of increased surge, there may be little risk to diverting ambulances from hospitals with significant crowding to those with less crowding. Further research into the effects of AD on patient outcomes should be performed so that we may better understand the role of diversion in the health system.

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