

# Optimizing Emergency Department Front-End Operations

Jennifer L. Wiler, MD, MBA  
 Christopher Gentle, MD  
 James M. Halfpenny, DO  
 Alan Heins, MD  
 Abhi Mehrotra, MD  
 Michael G. Mikhail, MD  
 Diana Fite, MD

From the Division of Emergency Medicine, Washington University in St. Louis School of Medicine, St Louis, MO (Wiler); the Department of Emergency Medicine, Christiana Care Health Services, Newark, DE (Gentle); Forrest Hills Hospital, Forrest Hills, NY (Halfpenny); the Department of Emergency Medicine, University of South Alabama College of Medicine and Medical Center, Mobile, AL (Heins); the Department of Emergency Medicine, University of North Carolina, Chapel Hill, NC (Mehrotra); the Department of Emergency Medicine, St. Joseph Mercy Hospital, Ann Arbor, MI (Mikhail); and the Department of Emergency Medicine, University of Texas Medical School at Houston, Houston, TX (Fite).

As administrators evaluate potential approaches to improve cost, quality, and throughput efficiencies in the emergency department (ED), “front-end” operations become an important area of focus. Interventions such as immediate bedding, bedside registration, advanced triage (triage-based care) protocols, physician/practitioner at triage, dedicated “fast track” service line, tracking systems and whiteboards, wireless communication devices, kiosk self check-in, and personal health record technology (“smart cards”) have been offered as potential solutions to streamline the front-end processing of ED patients, which becomes crucial during periods of full capacity, crowding, and surges. Although each of these operational improvement strategies has been described in the lay literature, various reports exist in the academic literature about their effect on front-end operations. In this report, we present a review of the current body of academic literature, with the goal of identifying select high-impact front-end operational improvement solutions. [Ann Emerg Med. 2010;55:142-160.]

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## INTRODUCTION

### Emergency Department Crowding and the Need for Operational Improvement Strategies

For nearly 2 decades, emergency department (ED) crowding has been recognized as a growing problem. From 1995 through 2005, the annual number of ED visits in the United States increased nearly 20%, from 96.5 million to 115.3 million, yet the number of hospital EDs decreased nearly 10% during this same period.<sup>1</sup> The American Hospital Association reports that 69% of urban hospital EDs and 33% of rural hospital EDs are operating at or over capacity. Crowded conditions have resulted in prolonged ED ambulance diversions in 70% of urban hospitals and 74% of teaching hospitals.<sup>2</sup> Timeliness of care has a strong correlation to patient satisfaction,<sup>3,4</sup> with wait time to be treated by a physician having the most powerful association with satisfaction.<sup>5</sup>

Much has been published in the academic and lay literature about the negative consequences of ED crowding. Prolonged patient wait times,<sup>6,7</sup> increased patient complaints,<sup>6,8,9</sup> decreased staff satisfaction,<sup>7</sup> and decreased physician productivity<sup>6,10,11</sup> are examples of the negative ramifications of ED crowding. More worrisome is a burgeoning volume of literature linking ED crowding to suboptimal patient outcomes.<sup>6,12-18</sup>

Optimizing ED throughput is one means by which to handle the increased demands for ED services. The Joint Commission

has emphasized the need for smoothing ED patient flow and, in January 2005, implemented a new leadership standard, managing patient flow, which mandates that hospitals “. . .develop and implement plans to identify and mitigate impediments to efficient patient flow throughout the hospital.”<sup>19</sup> Other organizations, including the Institute for Medicine, Agency for Healthcare Research and Quality Improvement, and Institute for Healthcare Improvement, have also emphasized the valuable effect streamlining ED operations has on hospital operations and patient outcomes.

ED activities occurring during the front-end processing of patients can vary from one ED to another; however, they typically include initial patient presentation, registration, triage, bed placement, and medical evaluation. When these processes do not occur simultaneously or in immediate succession, a patient is typically required to wait in a queue. The time needed to complete these front-end processes contributes to the ED total length of stay. The design, implementation, and assessment of innovative throughput solutions are the building blocks of departmental quality and operational performance improvement efforts. No one front-end process solution is likely to be optimal for all EDs, but the contribution of select tactics may help bring the patient and ED provider together more expeditiously. As a result, in October 2006 the American College of Emergency Physicians (ACEP) Council passed a resolution directing the “development of a position paper which

- Immediate bedding
- Bedside registration
- Advanced triage protocols and triage-based care protocols
- Physician/practitioner at triage
- Dedicated “fast track” service line
- Tracking systems and “white boards”
- Wireless communication devices
- Kiosk self check-in
- Personal health record technology (“smart cards”)
- Team approach patient care (“Team Triage”)
- Resource-based triage system(s)
- Waiting room design enhancements
- Full / surge capacity protocols
- Incentive based staff compensation
- Time to evaluation guarantee
- Referral to next-day care (“deferral of care”)

**Figure.** Strategies to improve ED front-end processing.

defines optimal emergency care related to the front-end processing of patients presenting to the ED.<sup>20</sup> Subsequently, an Emergency Medicine Practice Subcommittee was appointed to develop a comprehensive information article summarizing the basic lay and academic literature with regard to ED front-end operations. The identified potential strategies are listed in the Figure and published on the American College of Emergency Physicians Web site.<sup>21</sup> Thereafter, a focused critical analysis of potential high-impact strategies studied in the academic literature was undertaken by the authors as an extension of the subcommittee’s original work and is presented in this report.

### SELECT ED FRONT-END PROCESSES

Attempts have been made to standardize the language of ED operations<sup>22</sup>; however, we could find no consensus definition of the ED “front-end.” For this discussion, we define it as the patient care processes that occur from the time of a patient’s initial arrival to the ED to the time an ED health care provider formally assumes responsibility for the comprehensive evaluation and treatment of the patient, which typically includes the accepted metrics of “patient arrival to triage,” “triage time,” “triage to registration,” “registration time,” “registration to bed placement,” “door to physician,” and “bed placement to physician/provider evaluation.”<sup>22-24</sup>

In an attempt to eliminate non-value-added steps in the ED front-end process, from patient arrival to ED bed placement, “immediate bedding” has been offered as a potential solution. Immediate bedding eliminates all steps between patient arrival and placement in a patient care room, thereby bypassing triage. Immediate bedding typically implies that bedside registration, initial nursing evaluation, and medical provider greeting begin

simultaneously on the patient’s arrival to the ED treatment area. The primary nurse for the patient performs the initial nursing assessment as opposed to a triage nurse. This practice of immediate bedding is in definite contrast to the traditional ED triage system, which is a prioritization tool used to determine the order in which patients need to be evaluated.<sup>25</sup> Immediate bedding requires bedside registration. Although the converse is not obligatory, many published reports<sup>26-31</sup> discuss the implementation of both simultaneously as a process improvement strategy. “Bedside registration” typically involves an initial (“quick”) registration capturing the basic patient demographic information (eg, patient name, date of birth, social security number, and chief complaint) needed to generate an ED chart. The purpose of this process is to allow rapid intake of the patient into the ED system, thus giving staff the opportunity to immediately begin patient treatment (including the ordering of medications and laboratory and radiologic studies) during the initial encounter/greeting. This strategy takes advantage of time efficiencies from parallel processing, as opposed to the traditional serial processing of patients (ie, triage assessment of patient, then full registration, patient placement in ED examination area, primary nursing assessment, and finally provider assessment). Additional information required for a “full” registration can then be gathered at any point during the patient’s ED stay.

Triage-based care protocols, also known as advanced triage protocols, have been offered as a way to improve ED front-end throughput. These standardized pathways are developed for specific disease conditions or complaints and allow the initiation of diagnostic, therapeutic, and management regimens based on patients’ chief complaint or triage staff/primary nurse assessment when there is no immediate ED bed availability.<sup>32-40</sup>

The addition of a physician or physician extender (midlevel provider) to the triage assessment is an alternative strategy to advanced triage protocols.<sup>41-47</sup> The function of this provider is to perform a brief initial assessment/medical screening examination and initiate necessary testing and treatment directly in the triage space when patients cannot be immediately placed in a main ED treatment area bed. Those patients with only minor complaints can often be discharged directly after this evaluation in triage.<sup>41,44</sup> For more ill patients, after the triage physician interventions are initiated, patients are placed in a waiting room queue until an ED bed is assigned, where the comprehensive evaluation is to be performed, usually by a different provider. “Team triage” is an extension of this model. This team can consist of an emergency physician, nurse, registrar, technician, and scribe, or some variation thereof, to initiate a comprehensive initial evaluation and treatment of a patient on initial presentation to the ED.

Urgent care, or fast track, is an area or service line in the ED in which low-acuity patients are evaluated and treated in a separate but concurrent parallel process from individuals with more severe clinical presentations.<sup>48-58</sup> It is estimated that many EDs can treat 30% to 40% (and some up to 50%) of patients in

a fast track, with a goal of 90% of patients being discharged within 60 minutes, according to some reports.<sup>59</sup>

It has been reported that inadequate information technology is a notable source of handoff errors between medical providers.<sup>60</sup> Innovative electronic technologies have been developed as possible operational improvement solutions for ED front-end operations and patient flow issues,<sup>61</sup> with some postulating that “the use of information technologies in the emergency medicine workplace will enhance our traditional role as hands-on providers of direct patient care.”<sup>62</sup> ED information systems vary in scope and features but typically include a patient tracking module. Two types of tracking systems exist, those that require manual input of patient data (“active”) and those that monitor patients passively by wireless technology (eg, linking to electronic patient bracelet locators).<sup>63</sup> The primary goal is to capture real-time patient flow from arrival to admission/discharge, much like an electronic “whiteboard,” which can display updated patient status information, including chief complaint, patient acuity, and display nursing/physician care prompts and timers. These systems are often helpful in the collection of operational metric data for analysis.<sup>61,63-70</sup> Other common ED information systems features include triage/nursing/physician documentation, electronic prescribing, discharge instructions, clinical quality indicator tracking, vital sign monitoring, and often customizable interfaces.<sup>71</sup> Some ED information systems are integrated with the hospital information systems, which include laboratory, radiology, and previous medical record systems; others have the ability to capture prearrival information from inbound emergency medical services patients, as well as transfers from physician offices, clinics, and nursing homes.

Other innovative technology has been introduced to expedite ED front-end flow. Emergency physicians are interrupted on average 15 times per hour, limiting their productivity potential.<sup>72</sup> Mobile wireless communications devices, including 2-way radios, alpha numeric pagers, mobile badge devices (eg, Vocera, Vocera Communications, Inc., San Jose, CA), and passive infrared technology (radiofrequency identification) have been offered as communication enhancement solutions.<sup>73,74</sup> Self-service touch screen kiosks are becoming prevalent at airports, grocery stores, banks, and fast food restaurants and are now being offered to assist the intake of ED patients<sup>75,76</sup> and collect/disseminate educational information.<sup>77-79</sup> Smart cards are another emerging technology that may have an effect on ED front-end operations. Smart cards, or integrated circuit cards, are pocket-sized plastic cards embedded with a computer chip that can store important patient medical information (including medical history, allergy information, organ donor status, emergency contact information, medication, prenatal information, do not resuscitate status, and personal insurance data), which patients carry much like a driver’s license.<sup>80</sup> This information is then readily available to medical personnel to make quick and informed medical decisions.<sup>81-87</sup>

These interventions may help alleviate critical front-end operation bottlenecks, match resources to demand, decrease

operational variation, facilitate the development of an infrastructure to better track and benchmark data metrics, and improve patient flow. To better describe the magnitude of effect and assess the strength of evidence supporting these front-end interventions, we performed a critical review of the academic literature pertaining to ED front-end processes.

## MATERIALS AND METHODS

A search of MEDLINE from 1966 to January 21, 2008, was performed, using the key word “ED” as well as “triage,” “registration,” “efficiency,” “length of stay,” “urgent care,” “fast track,” “immediate bedding,” “accelerated triage,” “bedside registration,” “triage protocols,” “advanced triage protocols,” “tracking system,” “mobile phones,” “wireless telecommunication,” “kiosk,” and “smart card” (n=6,902). All abstracts related to front-end processes were reviewed and full-text articles in English obtained if experimental or quasi-experimental study design and measurable outcomes were described. Reference lists of selected articles were hand searched for additional citations. Representative articles were then critically reviewed (n=54). After discussions with institutional review board members, it was determined that institutional review board review was unnecessary, given that no human subjects were involved.

No validated decision tool exists to evaluate operational process improvement publications. Therefore, a modification of the ACEP clinical policy review format (Appendix E1, available online at <http://www.annemergmed.com>) was adopted as an evaluation tool of the academic literature.<sup>88</sup> A quality-of-evidence rank of class I (randomized controlled trial, meta-analysis of randomized controlled trial, prospective), II (retrospective observational), or III (case series or report) was assigned to each article, according to the study design and methods using this best-fit descriptive tool, as rated by 2 author raters. The strength-of-evidence class rating was downgraded at most 1 class at the reviewers’ discretion if the study methods or design had 1 or more significant methodological flaws. Disagreement about initial class ratings was discussed by the raters and the final quality-of-evidence ranking achieved by consensus. The study design, operational intervention, outcome measures, results, notable limitations, and peer review status of each reviewed publication (n=54) are presented in the Table.

## RESULTS

### Immediate Bedding and “Quick” or Bedside Registration

Although implementing immediate bedding and bedside registration has been touted to increase patient satisfaction in the lay literature,<sup>89</sup> very little has been published to prove this in the academic literature. Six studies were identified that address immediate bedding or bedside registration in the ED.<sup>26-31</sup> A synthesis of the published experiences at this point is limited but does suggest that immediate bedding may decrease waiting times,<sup>26-28</sup> shorten total ED length of stay,<sup>26-29,31</sup> decrease left without being seen rates,<sup>26,28</sup> and improve patient satisfaction.<sup>26</sup>

**Table.** Summary of current published original research pertinent to front-end ED operations.

Study	Study Cohort	Study Design	Operational Interventions	Outcome Measure	Results	Limitations	Class (I, II, III)	PRJ (Y/N)
<b>Immediate bedding and bedside registration</b>								
Spaite, 2002 <sup>26</sup>	Suburban academic center; Level I; approximately 48,000 visits	Prospective, before-after interventional	Multidisciplinary process redesign and implementation: increase in staff, immediate bedding if possible, bedside registration, and improvements in laboratory, radiology, and inpatient flow	WT, LOS, LWBS, Patient satisfaction	WT decreased from average of 31 to 4 min; ED LOS decreased from 4 h 21 min to 2 h 55 min; monthly LWBS rate decreased from 250 to 21; patient satisfaction improved.	Single site, probable observational bias, initial investment reported to be \$1 million, but no formal cost-benefit analysis performed	II	Y
Morgan, 2007 <sup>27</sup>	Suburban tertiary medical center; Level I; approximately 76,000 visits	Prospective, before-after interventional	Thorough process improvement effort: immediate bedding if possible, quick registration, dedicated FT, dedicated admission hold unit, improvements in laboratory and radiology process	Number sent to waiting room, LOS, arrival to bed time	Patients sent to waiting room decreased from 15.7% of total patient volume to 3.6%; ED LOS reduced by 14.5% for discharged patients; arrival to bed time reduced from average of 37 min to 22 min (46.6% reduction); 40.5% reduction in arrival to provider time; 14.5% reduction in LOS for discharged patients.	No specific study methodology was described, probable observational bias	III	Y
Chan, 2005 <sup>28</sup>	Urban academic center; approximately 37,000 visits	Prospective, before-after interventional	REACT protocol initiated: quick registration, immediate bedding if possible, and ancillary test ordering after brief physician assessment	WT, LWBS, ED LOS	Decrease WT 24 min; decrease LWBS 7.7% to 4.4%; decrease average LOS 31 min	Single site, probable observational bias, required investment of >\$1 million on annual basis, no formal cost-benefit analysis performed	II	Y
Bertoty, 2007 <sup>29</sup>	Urban, academic Level I trauma center; approximately 47,000 visits	Prospective, before-after interventional	Immediate bedding when available, bedside registration	LOS	Average ED LOS decrease 259 to 239 min	Single site, probable observational bias, uncertain significance of less than 10% change in LOS	III	Y

**Table.** Summary of current published original research pertinent to front-end ED operations. (continued)

Study	Study Cohort	Study Design	Operational Interventions	Outcome Measure	Results	Limitations	Class (I, II, III)	PRJ (Y/N)
Takakuwa, 2007 <sup>30</sup>	Urban adult academic center; approximately 47,000 visits	Prospective, before-after interventional	Immediate bedding when available, bedside registration	Triage-to-room time, room-to-disposition time	Initial modest, but statistically significant reductions in triage-to-room times, not sustained for all time-of-day periods (except morning)	Single site, probable observational bias	III	Y
Gorelick, 2005 <sup>31</sup>	Urban pediatric academic center; approximately 45,000 visits	Retrospective, before-after intervention	Immediate bedding when available, bedside registration	LOS	15 min (9.3%) Average decrease LOS	Single site, pediatric ED, no prospective data collection	III	Y
<b>Advanced triage protocols and triage-based care protocols</b>								
Seaberg, 1998 <sup>32</sup>	Urban academic center; approximately 42,000 visits	Prospective, before-after interventional	Implementation of test ordering guidelines for triage nurses	Correlation of triage nurse and physician test ordering	Improved correlation between physician and triage nurse test ordering (41 % to 57%, $P=.0042$ ) after test guideline implementation	Single site, criterion standard was physician ordering	II	Y
Fry, 2001 <sup>33</sup>	Urban referral hospital; 43,000 visits	Retrospective, before-after interventional	Training workshop for triage nurses on appropriate radiologic ordering	Comparison of radiograph abnormality rate: triage nurse vs physician	Similar abnormality rate between nurse- and physician-ordered radiographs	Single site, not every triage ordered radiograph tracked	II	Y
Lee, 1996 <sup>34</sup>	Not stated	Prospective, before-after interventional	Radiologic ordering guidelines for triage nurses	Physician ordering of radiograph	5.44% of radiographs considered unnecessary; decreased total LOS 18.59 min	Single site; criterion standard was attending physician, poorly defined methods	III	Y
Campbell, 2004 <sup>35</sup>	Urban academic center; 92,000 visits	Prospective, before-after interventional	Pain medication, including narcotic medication, provided at triage	Patients' reported pain levels, patient satisfaction scores	Patients' pain treated earlier; improved patient satisfaction	Single site, probable observational bias, convenience sampling of patient charts, poorly defined methods	II	Y
Macy, 2007 <sup>36</sup>	Not stated	Retrospective, before-after interventional	Implementation of RF wristbands and monitoring system for psychiatric patients at triage	Number of one-to-one patient watches	Reduction in security guard-related costs (\$30,000 during 4-mo study period)	Single site; significant technologic setup issues, making external validity difficult	III	Y

**Table.** Summary of current published original research pertinent to front-end ED operations. (continued)

Study	Study Cohort	Study Design	Operational Interventions	Outcome Measure	Results	Limitations	Class (I, II, III)	PRJ (Y/N)
Cooper, 2008 <sup>37</sup>	Urban tertiary care academic center; 57,000 visits	Protocol development, retrospective analysis, prospective validation period	Triage protocol for ordering CXR for patients with signs/symptoms of pneumonia	Time to CXR, time to antibiotics for pneumonia patients	1-h decrease in time to CXR; 0.8-h decrease in time to antibiotics	Single site, retrospective development, probable observational bias, provider variability in protocol application, needs further prospective validation	II	Y
Singer, 2000 <sup>38</sup>	Urban tertiary care academic center; 55,000 visits	Prospective, randomized, double blinded, placebo controlled	Application of LET at triage for pain management of lacerations	VAS rating of patients receiving LET vs placebo	Statistically significant (20mm visual scale) decrease in pain of lidocaine infiltration; LOS improvement postulated	Single site; LOS difference not measured	I	Y
Seguin, 2004 <sup>39</sup>	Suburban academic trauma center; 116,000 visits	Descriptive summary of process change	Advanced triage protocol providing narcotic pain medication to patients	None identified	Decreased time to pain treatment	Description of process change, no evaluation criteria	III	Y
Graff, 2000 <sup>40</sup>	Suburban academic center; 44,000 visits	Protocol development, retrospective analysis, prospective validation period	Implementation of chief complaint-based rule to perform triage ECG	Time to ECG and time to thrombolytics in patients with diagnosis of AMI	3.7-min decreased time to ECG and 10.8 min time to thrombolytic administration	Single site, diagnosis-based rule development	II	Y
<b>Physician/practitioner in triage</b>								
Terris, 2004 <sup>41</sup>	Urban academic center; London; 108,000 visits (18% pediatric)	Prospective, before-after interventional	IMPACT team assessment (ED physician and senior ED nurse) 9 AM to 5 PM M-F	WT	Significant reduction in patients waiting to be seen ( $P < .0001$ ); 48.9% of patients treated by IMPACT team were discharged home from triage	Small sample size, international	II	Y
Choi, 2006 <sup>42</sup>	Urban; Hong Kong; approximately 146,000 visits	Prospective, before-after interventional	TRIAD team: senior physician, nurse, health care assistant in triage 8 AM to 5 PM daily	WT, LOS	18-min (38%, $P < .001$ ) decrease WT; 21-min (23%) decrease LOS; 18-min (50%) decrease radiograph WT; 18% decrease LOS for patients with radiograph	No concurrent control population, international, probable observational bias, 7-day intervention	II	Y

**Table.** Summary of current published original research pertinent to front-end ED operations. (continued)

Study	Study Cohort	Study Design	Operational Interventions	Outcome Measure	Results	Limitations	Class (I, II, III)	PRJ (Y/N)
Subash, 2004 <sup>43</sup>	Urban academic; Belfast UK; 50,000 visits	Prospective, before-after interventional	Physician (physician, 1–2 residents) and nurse in triage 3 h (9 AM to noon) daily	Time to triage, physician, radiology, analgesia, discharge	Decreased time to triage (7 to 2 min; $P=.029$ ), time to physician (32 to 2 min; $P=.029$ ), time to radiology (44.5 to 11.5 min; $P=.029$ )	Small sample size, international, 4-day intervention, not standardized team or process	II	Y
Travers, 2006 <sup>44</sup>	Urban; Singapore	Prospective, before-after interventional	Senior physician and nurse triage team (SEDNT) 10 AM to 4 PM	WT	Decreased mean time to physician evaluation for nonacute (35.3 to 19 min; $P<.05$ ) and serious but not life-threatening patients (28 to 14 min); 34.8% discharged directly after triage physician evaluation	Small sample size, international, 10-day intervention	II	Y
Rogers, 2003 <sup>45</sup>	Urban academic center; Cambridge UK; 59,000 visits	Retrospective, before-after interventional	Experienced physician or NP ("see and treat" team) at secondary triage (if pt. had minor injury/illness determined by primary triage nurse then sent to S&T) 8 AM to 6 PM M-F	WT	Decrease average time to provider 56 to 30 min; decrease average LOS 1 h 39 min to 1 h 17 min	Small sample size, international, required secondary triage system, only for nonurgent patients	III	Y
Holroyd, 2007 <sup>46</sup>	Urban adult academic center; Canada; 55,000 visits	Prospective randomized control	Physician in triage 11 AM to 8 PM daily	WT, LOS, LWBS, staff satisfaction, ambulance diversion	LOS decrease 36 min ( $P=.001$ ); LWBS decrease 20% (6.6 to 5.4%); 90% nurses and physicians report improved patient care; 80% nurses and >70% physicians satisfied with process improvement.	Small sample size, international, no measure of crowding	I	Y
Partovi, 2000 <sup>47</sup>	Urban academic center Level II trauma center; 52,000 visits (17% pediatrics)	Prospective, before-after interventional	Physician added to triage team (2 nurses, 1 EMT) Mon 9 AM to 9 PM	LOS, LWBS	Mean LOS decreased 82 min (18%); LWBS decreased 46%. Cost estimated to be \$11.98/pt.	Single site, only 1 weekday (Mon) and 8-day intervention	II	Y
<b>Implementation of FT service line</b>								
Meislin, 1988 <sup>48</sup>	Urban academic center	Prospective, before-after interventional	Two-room weekend FT 2 PM to 10 PM, nurse and resident physician with PRN attending coverage	LOS, patient satisfaction	Decreased LOS 67 min; decreased patient complaints from 79% to 22%	Single site, only weekend and 10-week intervention, not standardized methods	II	Y

**Table.** Summary of current published original research pertinent to front-end ED operations. (continued)

Study	Study Cohort	Study Design	Operational Interventions	Outcome Measure	Results	Limitations	Class (I, II, III)	PRJ (Y/N)
Ieraci, 2008 <sup>49</sup>	Rural academic center; Australia; 40,000 visits	Retrospective, before-after interventional	Created new FT (3 beds, 1 treatment room, 4 recliners) staffed 16 h/day by attending physician, 2 nurses	WT, LOS, LWBS, unscheduled 48 h returns	Decreased WT 22.8 min ( $P<.001$ ), LOS 46.5 min ( $P<.001$ ), and LWBS 6.2% vs 3.1% ( $P<.001$ ); increased unscheduled 48-h return rate 0.8% ( $P<.001$ ) and total costs by 14.6%	Single site, international, not standardized methods (expanded capacity during high-volume times), cost-benefit analysis not defined	II	Y
Rodi, 2006 <sup>50</sup>	Rural academic center; 30,000 visit	Prospective, before-after interventional	Designated FT (2 beds) staffed by PA and tech 9 AM to 7 PM	LOS, patient and staff satisfaction	Significant decrease LOS (FT 53 vs 127 min main ED, $P<.001$ ); significantly improved patient satisfaction ("excellent or very good" for LOS, time with the provider, skills of the provider, personal manner, and overall satisfaction, $P=.001$ for each domain); no significant difference in staff satisfaction; significant negative correlation between LOS and overall satisfaction with visit ( $P<.001$ ).	Small sample size, preintervention data from convenience sample, postintervention data from consecutive patients, variable survey response rates, survey tool not previously validated	III	Y
O'Brien, 2006 <sup>51</sup>	Urban tertiary adult academic center; Australia; 43,000 visits	Retrospective, before-after interventional	Night and weekend dedicated (3 beds and 1 chair) FT coverage (nurse, ED resident, PRN attending back)	WT, LOS	Decreased average WT 2.1 min (3.4%); decreased average LOS for discharged patients 20 min (9.7%); decreased LWBS 17% compared to previous 12 weeks; no significant difference in WT for admitted patients	Single site, international, control group patient population 1 year and 12 weeks before, recent ED expansion 6 mo before	III	Y



**Table.** Summary of current published original research pertinent to front-end ED operations. (continued)

Study	Study Cohort	Study Design	Operational Interventions	Outcome Measure	Results	Limitations	Class (I, II, III)	PRJ (Y/N)
Sanchez, 2004 <sup>52</sup>	Urban adult academic center; 75,000 visits	Retrospective, before-after interventional	7-Bed separate FT unit seen by (1–4) MLPs 8:30 AM to 11 PM, PRN physician support	WT, LOS, LWBS, revisit rate, mortality rate	Total WT decreased 50% (102 vs 51 min, $P<.001$ ); LOS decreased 9.8% (286 vs 258 min, $P<.001$ ); LWBS decreased 52% (7.8% vs 3.7%, $P<.001$ ); no significant change in revisit or mortality rate	Number of ED beds increased during the intervention phase, control group patient population 1 year before	II	Y
Nash, 2007 <sup>53</sup>	Urban academic Level I trauma center; 80,000 visits	Retrospective, before-after interventional	FT staffed by MLPs 8 AM to 12 AM	LOS, LWBS, unscheduled 72-h returns, patient satisfaction	72-h Returns 2.3% FT vs 4.2% ED; LWBS rate FT 3.9% vs ED 6.7% ( $P<.001$ ); no significant difference in LOS; 100% patient satisfaction (care rated "good or excellent")	Satisfaction survey not previously validated, no control group, <2% response rate, pre-post comparison to minor care area with different staffing and patient acuity	III	Y
Simon, 1996 <sup>54</sup>	Urban pediatric academic center; 33,000 visit	Retrospective, before-after interventional	Dedicated fast track area attending pediatrician 4 PM to 12 AM	LOS	LOS 107 FT vs 120 min ED ( $P<.01$ )	Pediatric only, did not access WT, LWBS, unscheduled returns	III	Y
Hampers, 1999 <sup>55</sup>	Urban pediatric academic center; 39,000 visit	Prospective, before-after interventional, physicians blinded to analysis	Dedicated 4-bed FT staffed with pediatrician, nurse, clerk 5 PM to 11 PM weekdays and 11 AM to 11 PM weekends	Mean test charges, tests performed, LOS, admission rate, hydration, admission rate, unscheduled follow-up, patient satisfaction	Significant decrease test charges \$27 nonurgent patients treated in FT vs nonurgent patients treated in main ED \$52 ( $P<.001$ ); 17% fewer tests performed ( $P<.01$ ); 28 min decreased LOS ( $P<.001$ ); less intravenous hydration given ( $P<.001$ ); 2.7% decrease in admission rate ( $P=.004$ ); no change in condition improvement, unscheduled follow-up care, or satisfaction at 7 days	Not randomized, follow-up rate 64%, limited presenting complaints analyzed (fever, vomiting, diarrhea, decreased oral intake), pre-post comparison with different staffing	III	Y

**Table.** Summary of current published original research pertinent to front-end ED operations. (continued)

Study	Study Cohort	Study Design	Operational Interventions	Outcome Measure	Results	Limitations	Class (I, II, III)	PRJ (Y/N)
Kwa, 2008 <sup>56</sup>	Urban academic center; Australia; 53,000 visit (20% pediatrics)	Retrospective, before-after interventional	Patients triaged to 8-bed FT who are "likely to require only a brief ED stay without admission" staffed by attending physician, resident, 1–2 nurses, 8 AM to 10 PM daily.	WT, LOS, LWBS	WT decreased 2 min for lowest-acuity patient populations (ATS 4 $P<.001$ , ATS 5 $P<.05$ ); LOS significantly decreased only for ATS 2 patients (261 to 237 min, $P<.05$ ); no difference in the LWBS rate	No standardized triage criteria for placement in FT, clinically insignificant reduction of WT, FT only saw approximately 1 patient/h and admission rate (15%) unlikely representative of most FT, international	III	Y
Cooke, 2002 <sup>57</sup>	Urban; England	Retrospective, before-after interventional	Patients with "minor injuries" were treated in cubicle by physician with 2 waiting chairs after triage	WT	Significant improvement in WT (WT <30 min improved 8.6%, WT <60 min improved 11.1%, $P<.0001$ ).	Only 5-week intervention, international, no standardized triage criteria, care provided in cubicle	III	Y
Darrab, 2006 <sup>58</sup>	Urban academic tertiary care center; Canada; 38,000 visits	Retrospective, before-after interventional	Dedicated 4-bed FT with attending physician and nurse staffing 1 PM to 7 PM daily.	WT, LOS, LWBS	No significant decrease in WT; significant decrease in median LOS 60 min ( $P<.001$ ); LWBS decreased 3%	Small sample size, only 1-week intervention data, international	III	Y
<b>ED information systems</b>								
<b>Tracking systems and whiteboards</b>								
Gordon, 2008 <sup>63</sup>	Urban academic center; 66,000 visits	Prospective observational, partially blinded	Observer recorded timestamps of patient care in 4 rooms during random 4-h blocks over 2 mo	Compare timestamp from passive (infrared) and manual input into computer tracking system to actual time events occurred	Both active and passive systems contain flawed information (active system much lower precision than the passive system, but similar accuracy when used with a large cohort)	Manual input of timestamps by observer was control, only partially blinded cohort, noted data loss (10 of 42 shifts) from system error	I	Y

**Table.** Summary of current published original research pertinent to front-end ED operations. (continued)

Study	Study Cohort	Study Design	Operational Interventions	Outcome Measure	Results	Limitations	Class (I, II, III)	PRJ (Y/N)
Aranosky, 2008 <sup>64</sup>	Urban adult and pediatric center	Case report	Implementation of an electronic patient tracking system	None	Increased communication interprovider; improved ED workflow, research study recruitment, available administrative data, completion of registration, collection of copay process, discharge process; more consistent identification of attending of record (resulted in >\$1 million annual revenue)	No methods, no measurable outcomes	III	Y
Jensen, 2004 <sup>65</sup>	Urban center; 40,000 visits	Case report	Implementation of an electronic patient tracking system	None	Improved utilization, patient/staff and physician satisfaction; decreased ambulance diversion	No methods, no measurable outcomes	III	Y
Fisne, 1999 <sup>66</sup>	Community center; 34,000 visits	Case report	Implementation of an electronic patient tracking system	None	Increased productivity, staff morale; decreased LWBS	No methods, no measurable outcomes	III	Y
Boger, 2003 <sup>67</sup>	Not stated	Case report	Implementation of an electronic patient tracking system	LOS, LWBS, patient satisfaction	Decrease WT 0.62%; decreased LWBS 3.7%; improved patient satisfaction	No methods, no description of cohort analysis pre-post implementation	III	Y
Gorsha, 2006 <sup>68</sup>	Community academic center; 30,000 visits	Case report	Implementation of an electronic patient tracking system	None	Deemed "success" by author but no outcome measures reported	No methods, no measurable outcomes	III	Y
Horak, 2000 <sup>69</sup>	Urban level I trauma center	Case report	Designing and implementing a computerized tracking system	Observational analysis and informal interviews	Improved interstaff and interdepartmental communication about patient flow; inaccurate data collected; variable staff compliance	Observational study, not formalized survey system, no defined outcome measures	III	Y
Pennathur, 2007 <sup>70</sup>	Urban academic affiliated center	Prospective, modified crossover	Implementation of an electronic tracking system while still using whiteboard	Interviews and observations (including photographic documentation)	Providers report negative effect of computerized tracking system on interprovider communication, staff and physician workflow	Observational study, not formalized survey system, no defined outcome measures	III	N

**Table.** Summary of current published original research pertinent to front-end ED operations. (continued)

Study	Study Cohort	Study Design	Operational Interventions	Outcome Measure	Results	Limitations	Class (I, II, III)	PRJ (Y/N)
<b>Emerging technologies: Mobile wireless communication devices, kiosks and smart card</b>								
Le, 2004 <sup>73</sup>	Urban academic Level I ED; 90,000 visits	Retrospective, before-after intervention survey	Mobile phones in ED	Resident satisfaction	Improved communication; decrease missed return calls from 20.3% to 4.6%	Survey, not validated, recall and observational bias	III	Y
Walsh, 2005 <sup>74</sup>	70,000 visits	Case report	Implementation of a wearable pushbutton communication system	None	Improved communication	No methods, measurable outcomes or assessment of time savings or workflow	III	N
Porter, 2004 <sup>77</sup>	Pediatric urban academic center	Prospective convenience sample, parent survey	Implementation of a self-service kiosk for pediatric asthma patient information (symptoms and medication)	Time to completion of kiosk, parent satisfaction	Improved information collection, time to kiosk completion 11.8 min (SD 5.2 min); 95% report "kiosk was a good use of time"; wide variation of perceived technology burden	Survey, not validated, recall and observational bias, did not evaluate care outcomes	III	Y
Gielen, 2007 <sup>78</sup>	Level I pediatric trauma center	Randomized control trial	Intervention group given individualized safety instructions by kiosk, control group had general instructions, then 2- to 4-week and 4-mo follow-up interview	Effect of a self-service kiosk intervention on parent knowledge of child safety and injury prevention	Improved safety related knowledge and practices (increased reported use of child safety seats)	Use of self-reported data, recall and observational bias	I	Y
Houry, 2008 <sup>79</sup>	Urban university-affiliated center; 105,000 visits	Prospective observational convenience sample	Self service kiosk collection of intimate partner violence information	Intimate partner violence screening, data collection	No reports of any injuries or increased violence resulting from participating in the study	Survey, not validated, recall and observational bias	I	Y
Engelbrecht, 1997 <sup>81</sup>	German patients with chronic diseases	Case report, observational	DIABCARD portable electronic medical record on a smart card, 3-mo pilot, European Union sponsored	None	Not listed	No methods, measurable outcomes, international	III	Y
Cocel, 2002 <sup>82</sup>	150 Romanian cardiology clinic patients	Case report, observational	Implementation of health smart card system	None	Not listed	No methods, measurable outcomes, international	III	Y

**Table.** Summary of current published original research pertinent to front-end ED operations. (continued)

Study	Study Cohort	Study Design	Operational Interventions	Outcome Measure	Results	Limitations	Class (I, II, III)	PRJ (Y/N)
Aubert, 2001 <sup>83</sup>	299 Canadian professionals and 7,248 clients (included elderly, infants, and pregnant women)	Prospective survey, interviews	Implementation of health smart card system	Patient satisfaction	Barriers to implementation identified.	Survey, not validated, recall and observational bias, international	III	Y
Lavoie, 1995 <sup>84</sup>	Quebec patient smart card project	Case report, observational	Implementation of health smart card system	None	Not listed	No methods, measurable outcomes, international	III	Y
Naszlady, 1998 <sup>85</sup>	5,000 Chronically ill Hungarian inpatients	Case report, observational	Implementation of health smart card system	None	Not listed	No methods, measurable outcomes, international	III	Y
Paradinas, 1995 <sup>86</sup>	France	Case report, observational	Implementation of the CQL-Card smart card to use database management systems	None	Not listed	No methods, measurable outcomes, international	III	N
Quick, 1994 <sup>87</sup>	Midwestern urban area	Case report, observational	Implementation of health smart card system	None	Not listed	No methods, measurable outcomes, international	III	Y

PRJ, Peer reviewed journal; WT, wait time; LOS, length of stay; LWBS, left without being seen; FT, fast track; REACT, rapid entry and accelerated care at triage; CXR, chest radiograph; LET, lidocaine, epinephrine, and tetracaine; VAS, visual analog scale; AMI, acute myocardial infarction; TRIAD, triage rapid assessment by doctor; SEDNT, senior physician and nurse triage team; NP, nurse practitioner; PRN, as needed; MLP, midlevel provider; ATS, Australasian Triage Scale.

However, strength of evidence based on methodological quality review of all studies to this point is limited (class II<sup>26,28</sup> and class III<sup>27,29-31</sup>), despite only 1 review being a retrospective analysis.<sup>31</sup> All were performed only at a single site and used pre-post analysis, which is subject to observational bias<sup>90</sup> and the Hawthorne effect.<sup>91</sup> In addition, all studies noted that immediate bedding and bedside registration was implemented as a process redesign intervention only “when possible” (ie, did not occur when ED was at capacity); with the effect on study outcomes unclear. Only 2 studies implemented immediate bedding and bedside registration as an isolated intervention,<sup>30,31</sup> whereas the others<sup>26-29</sup> simultaneously implemented additional operational improvement strategies, which make it difficult to discern which, if any, of the improvements can be attributed to immediate bedding and bedside registration processes. The incremental contribution bedside registration and immediate bedding has on the improvement metrics seen in the multimodal process improvement efforts found in these studies is unclear.<sup>26-28</sup> Two of the studies that implemented multiprocess improvement initiatives, in addition to immediate bedding and bedside registration, speculated according to their experience that an initial<sup>26</sup> and annual investment of \$1 million<sup>28</sup> was required for implementation and maintenance of such initiatives.

Nearly all studies found initial substantial improvements in many of the outcomes measured, but only 1 discussed sustainability of these outcomes. Takakuwa et al<sup>30</sup> (class III) found that although initial bedside registration initiatives decreased the time from triage to bed placement, this was not sustained at the end of the 1-year study period. They note that lack of staff buy-in, cultural resistance, nonalignment of staff incentives with change management initiatives, and the isolated pre-post intervention model likely negatively affected sustainability.<sup>30</sup>

Initial reports are limited (classes II and III) but do suggest that implementation of immediate bedding and bedside registration during nonfull capacity periods can have a valuable effect on patient flow and thus improve patient satisfaction. The immediate bedding strategy requires considerable staff buy-in<sup>29,30</sup> and may require significant change in management efforts to create a staff paradigm shift to discern the *space* of triage from the *function* of triage. To our knowledge, at this time no study has quantified the effect these changes have on quality outcome measures, staff satisfaction and retention, or ways to ensure a culture of sustainable processes improvement with regard to the immediate bedding strategy and a comprehensive cost-benefit analysis. The limited data do suggest however, that implementation of immediate bedding and

bedside registration can have a positive effect on ED throughput if used during nonfull-capacity times of day.

### Advanced Triage Protocols and Triage-Based Care Protocols

Limited published experience about advanced triage protocol exists.<sup>32-40</sup> Protocols for medication administration (eg, oral analgesia for pain<sup>35</sup>) ordering of imaging studies (eg, radiograph for ankle injury),<sup>33,34</sup> institution of elopement precautions,<sup>36</sup> and initial management for disease-specific states (eg, pneumonia<sup>37</sup>) have been studied. Before the implementation of advanced triage protocol, one institution recorded only a 41% agreement between physician-directed test ordering and tests ordered by a triage nurse, with notable nurse overordering (35%) and underordering (37%) compared with that of sample physicians (class II).<sup>32</sup> Implementation of advanced triage protocol improved the correlation between triage nurse and physician test ordering to 57% ( $P=.0042$ ). However, triage nurse overordering (34%) and underordering (24%) still occurred. Despite advanced triage protocol implementation, 37% of triage nurses deviated from the practice guidelines, which the authors speculated was either an education or buy-in issue.

In the literature, advanced triage protocols have been reported to decrease patient length of stay,<sup>34,38</sup> decrease the time to pain treatment,<sup>35,39</sup> increase patient comfort,<sup>35,38</sup> decrease time to antibiotics in patients admitted with pneumonia,<sup>37</sup> decrease delays in performing ECGs and administering thrombolytic agents for myocardial infarction,<sup>40</sup> and decrease costs associated with patients requiring one-to-one monitoring,<sup>36</sup> as well as improve throughput and employee satisfaction and decrease medical errors.<sup>59</sup>

Unfortunately, many of these studies are retrospective analyses<sup>33,36,37,40</sup> (with its previously documented methodological limitations<sup>92</sup>), have poorly defined methods (class II or III),<sup>32-37,39,40</sup> or are anecdotal reports in the non-peer-reviewed literature.<sup>59</sup> Only 1 study, completed by Singer and Stark,<sup>38</sup> was randomized, double blind, and placebo controlled (class I). They reported a statistically significant decrease in pain at laceration repair when lidocaine, epinephrine, and tetracaine was placed at triage by the nurse and postulate that it may decrease the total length of stay for the patient.

Clearly, decreasing patients' pain and improving systems to expedite recognition of time critical diagnosis is valuable. However, the unintended consequences of unnecessary radiation and medication exposure (empiric antibiotics for pneumonia for instance), and the associated cost inefficiencies have yet to be fully explored. That being said, some limited evidence-based advanced triage protocols appear to have a valuable effect on daily ED operations (eg, acetaminophen for fever if no contraindications, ECG for cardiac-related complaints), but barriers to standardized implementation need to be addressed. At this time, more rigorous multi-institutional prospective well-designed studies are needed to assess the effect

advanced triage protocols have on patient clinical and quality outcomes, ED costs, and throughput.

### Physician/Practitioner in Triage

Various study protocols with a clinician in triage have been reported,<sup>28,41-47</sup> with most describing experience in the international setting.<sup>41-46</sup> To date, the studies report a decreased door-to-medical assessment time,<sup>41-45</sup> reduced ED length of stay,<sup>28,42,45-47</sup> decreased LWBS rates,<sup>28,46,47</sup> and "high" nursing and physician satisfaction with the process.<sup>46</sup> One study reported that 90% of physicians and nurses thought that overall patient care was "improved" with placing a provider in triage (class I),<sup>46</sup> but clinical practice variability in the triage role and measurable clinical care quality outcomes were not addressed.

Many of the published reports have some notable limitations. Only 1 published report was a prospective randomized trial (class I),<sup>46</sup> with the others being prospective before-and-after (class II)<sup>41-44,47</sup> or retrospective reports (class III).<sup>45</sup> All study interventions (provider in triage) occurred only at limited times per during the day,<sup>28,41-47</sup> with some ending the study trial if the main ED was overwhelmed and the triage physician was needed for bedside ED patient care.<sup>28,43</sup> Implementation times were noted to be selected because they were historically "high volume times," but no validated data about time selection was provided for any study. Each institution reported having access to preexisting physical space for the triage clinician to do an assessment; as such, limited to no construction capital costs were required. Only 1 study estimated the faculty physician costs associated with implementing a provider in triage, \$11.98 per patient (class II).<sup>47</sup> But none calculated direct and indirect costs with regard to items such as additional ancillary staffing resources, increased potential reimbursement from reduction in LWBS rates, and goodwill from improved patient satisfaction.

Researchers have yet to address the quality or quantity of care provided by triage physicians. No study has adequately addressed the issue of limitations created by performing only a brief clinical assessment in triage or the effect of clinical practice variations inherent to various providers (ie, physician extender versus senior versus junior physician) models and the subsequent effect on patient and operational outcome measures (cost, quality, etc). Nor has the medicolegal risk of the triage provider been discussed or quantified. Improvement of LWBS rates has some risk management benefits,<sup>47</sup> but at times when demand outstrips capacity and patients are in queue for an ED bed, it is not clear whether a physician or other provider in triage ameliorates risk in the event of a bad patient outcome.

For crowded EDs, placing a provider in triage may be a solution to expedite patient care according to the limited research available. However, many variables, including resources, practice variation, and risk tolerance, need to be considered.

### Implementation of “Fast Track” Service Line

The effect of instituting a fast track service line on ED throughput has been investigated in a wide variety of clinical settings: rural<sup>49,50</sup> and urban areas,<sup>48,51-58</sup> pediatric centers,<sup>54,55</sup> and international EDs,<sup>49,51,56-58</sup> and with care being supplied by either a physician<sup>48,49,51,54-58</sup> or midlevel provider.<sup>50,52,53</sup> These studies reported that establishment of a fast track service line decreased patient wait times,<sup>49,51,52,56,57</sup> increased throughput of lower-acuity patients,<sup>49-52,54,55,58</sup> reduced LWBS rates,<sup>49,51-53,58</sup> decreased hospital admissions,<sup>55</sup> decreased testing and costs,<sup>55</sup> increased available provider time for higher-acuity patients,<sup>54</sup> shortened overall ED length of stay,<sup>48-52,54-56,58</sup> improved patient satisfaction,<sup>48,50,53</sup> and did not negatively affect clinical outcomes (unscheduled ED return visits or mortality rate).<sup>52,53,55</sup> All studies were rated as being class II or III strength of evidence, the exception being one Australian study that reported a small but statistically significant (0.8%) increase in the unscheduled 48-hour return rate after implementation of a fast track (class II).<sup>49</sup>

The lack of methodological standardization and retrospective pre- and postcohort assessments<sup>49,51-54,56-58</sup> limits the external validity of the aforementioned enhancements to ED front-end processing. Cohort data were obtained from the general ED population weeks,<sup>48,51,57,58</sup> months,<sup>49,50,53-56</sup> or years<sup>51,52</sup> before and after fast track was implemented, and in some instances, different staffing patterns<sup>49,53</sup> and patient acuity designations were also used after the fast track was instituted.<sup>49,53,56</sup> In addition to these conflicting cohorts, various fast track times of operation (per day or per week) were used without standardized agreement or discussion about how these hours were determined. Thus, these methodological flaws limit applicability of the results. Furthermore, the institution of a fast track depends on having a sufficient low-complexity patient volume; a decision tool to determine this threshold population volume has not been provided in any study published to date, to our knowledge. Nor has a thorough cost-benefit analysis, including the potential capital improvement costs required to create a fast track space, been detailed because all reports thus far had a preavailable or predesignated area for fast track operations. Only 1 study discussed the increased staffing costs associated with implementation of a fast track (total increase 14.6%) (class II),<sup>49</sup> and none compared the cost, quality, or satisfaction measures associated with physicians versus physician extenders. Finally, an adequate assessment of staff satisfaction was notably absent in the current academic literature.

The current body of research concerning the implementation of a fast track service line has some noteworthy limitations; however, it suggests that a designated fast track within the ED service line may prevent the reprioritization of higher-acuity patients over those with minor issues and can have a positive effect on ED throughput and patient satisfaction. More multicenter randomized controlled trials need to be performed to validate these preliminary findings. Further investigation

should examine the role that episodic care of nonurgent ED patients plays within the health care system in terms of cost and clinical and quality health outcomes. Administrators should consider the demand for nonacute ED patient care services, staffing availability, and financial resources before implementing a fast track service line, recognizing that no validated decision tool currently exists to aid this process.

### ED Information Systems and Communication Tools

**Tracking Systems and Whiteboards.** It has been reported that implementation of computerized tracking systems improves patient flow,<sup>64-67</sup> shortens patient wait times,<sup>67</sup> decreases LWBS rates,<sup>26,66,67</sup> reduces ambulance diversion,<sup>65</sup> and improves revenue,<sup>64</sup> patient satisfaction,<sup>65,67</sup> staff satisfaction,<sup>65,66</sup> and communication.<sup>60,64,69</sup> However, many of these studies are case reports with limited methods and poorly defined outcome measures.<sup>64-70</sup> Electronic tracking systems may be a useful adjunct to ED performance improvement initiatives not only to streamline communication but also to capture automated flow metric data to be used as part of an evaluation tool.<sup>61</sup> However, a recent study found that timestamp data collected by both passive and active tracking systems may not be accurate,<sup>63,69</sup> and yet another cautions that data gathered from tracking systems require an independent validation before being used for policy or research purposes.<sup>93</sup> Other important limitations of computerized tracking systems, identified in the non-peer-reviewed literature (class III), claim that computerized tracking systems can impede flow and communication because of logistic barriers related to accessing patient data with password log-ins and limited information display because of computer screen size.<sup>70</sup> This diversion from patient care activities has recently been validated in the peer-reviewed literature.<sup>94</sup>

A flawed ED patient flow structure will not be corrected with the implementation of an electronic tracking system. Rather, optimal performance from a tracking system requires a strategic, comprehensive, team-based, change-management initiative to have a positive effect on ED front-end operations, in the authors' experience. If this initiative is undertaken, intra- and interinstitutional compatibility, staff training, and buy-in, in addition to capital and maintenance costs, including technology support, enhancements, and upgrades, need to be considered. One author notes that the first step is to improve your throughput processes and then to computerize them.<sup>71</sup> Clearly, more research is needed to understand the role that ED tracking systems play in data gathering and operational analysis.<sup>95</sup>

**Emerging Communication Technologies: Mobile Wireless Devices, Kiosks, and Smart Cards.** Publication in the academic medical literature concerning emerging communication technologies has been sparse, with little more published in the health care-related literature. The studies thus far are typically either case reports<sup>74,81,82,84-87</sup> or surveys<sup>77,83</sup> with poorly defined outcome measures. Although the current reports have notable methodological flaws, 2 studies note that various mobile devices improve ED communication (class III).<sup>73,74</sup> Despite the potential communication enhancement

benefits these devices may have on patient flow, reports in the critical care setting identify potentially hazardous interference of these devices with medical equipment, including ventilators, infusion pumps, and external pacemakers, which is concerning.<sup>96,97</sup> Self-service kiosks in the ED waiting area have been advertised in the lay press<sup>75</sup> as a way to streamline front-end operations. A recent news article reported that Parkland Hospital patients took an average of 8 minutes to enter basic demographic and chief complaint information, which improved ED front-end processing.<sup>76</sup> The only reports in the academic literature describing the use of kiosks are for collecting historical medical information of pediatric ED asthma patients and allocation of appropriate discharge instructions (class III),<sup>77</sup> disseminating pediatric patient safety education (class I),<sup>78</sup> and screening for domestic violence (class I).<sup>79</sup> No studies to date have directly addressed the effect these kiosks may have on ED throughput metrics. Smart cards are another emerging technology that may have an effect on ED front-end operations. To date, only case reports<sup>81,82,84-87</sup> and surveys<sup>83</sup> describing preliminary experiences in non-ED clinical settings, both abroad<sup>81-86</sup> and the United States,<sup>87</sup> have been reported. Clearly, the use of these emerging technologies in the ED setting and their effect on ED operations and outcomes have yet to be fully elucidated.

## CONCLUSION

As ED crowding worsens, it is important for departments to improve operations to promote patient throughput. No doubt operational bottlenecks at the “back-end” of the ED will ultimately lead to front-end delays. However, proficient patient processing at the ED front-end may minimize wait times, decrease the total ED length of stay, and improve patient satisfaction. This critical review of the academic medical literature reveals that few and often methodologically limited studies have been published concerning front-end operational improvement strategies. Of those published, only a handful noted the effect these strategies had on patient quality outcomes,<sup>35,37-40,46,49,52,53,55</sup> only 3 were randomized controlled trials,<sup>38,46,78</sup> none was a multi-institutional trial, and few commented on the total cost of implementation and maintenance of the operational change.<sup>26,28,36,49,55,64</sup> Currently, there exists a knowledge gap about what the optimal ED front-end strategy is, with the need for more well-designed trials identified. Although an optimal approach to streamline front-end operations for all EDs has not yet been identified, the strategies presented here may be important components of change management initiatives for individualized EDs to improve front-end operations and throughput.

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*Address for correspondence:* Jennifer L. Wiler, MD, MBA, Washington University School of Medicine in St. Louis, Campus Box 8072, 660 S Euclid Avenue, St. Louis, MO 63110; 314-747-9949, 716-390-1288, or 314-256-9202, fax 314-362-0419; E-mail [wilerj@wusm.wustl.edu](mailto:wilerj@wusm.wustl.edu).

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**Appendix E1.**

Literature classification schema.\*

<b>Design/Class</b>	<b>Therapy<sup>†</sup></b>	<b>Diagnosis<sup>‡</sup></b>	<b>Prognosis<sup>§</sup></b>
1	Randomized, controlled trial or meta-analyses of randomized trials	Prospective cohort using a criterion standard	Population prospective cohort
2	Nonrandomized trial	Retrospective observational	Retrospective cohort Case control
3	Case series Case report Other (eg, consensus, review)	Case series Case report Other (eg, consensus, review)	Case series Case report Other (eg, consensus, review)

\*Some designs (eg, surveys) will not fit this schema and should be assessed individually.

<sup>†</sup>Objective is to measure therapeutic efficacy comparing greater than or equal to 2 interventions.

<sup>‡</sup>Objective is to determine the sensitivity and specificity of diagnostic tests.

<sup>§</sup>Objective is to predict outcome including mortality and morbidity.