



# Effectiveness of Interventions to Improve Emergency Department Efficiency: An Evidence Map

September 2017

## Prepared for:

Department of Veterans Affairs  
Veterans Health Administration  
Quality Enhancement Research Initiative  
Health Services Research & Development Service  
Washington, DC 20420

## Prepared by:

Evidence-based Synthesis Program (ESP) Center  
West Los Angeles VA Medical Center  
Los Angeles, CA  
Paul G. Shekelle, MD, PhD, Director

## Investigators:

### Principal Investigator:

Paul Shekelle, MD, PhD

### Co-Investigators:

Melinda Maggard Gibbons, MD, MSHS  
Isomi M. Miake-Lye, PhD  
Chris P. Childers, MD  
Sean M. O'Neill, MD, PhD

### Research Associates:

Selene Mak, MPH, PhDc  
Roberta Shanman, MLS  
Jessica M. Beroes, BS



## PREFACE

The VA Evidence-based Synthesis Program (ESP) was established in 2007 to provide timely and accurate syntheses of targeted healthcare topics of particular importance to clinicians, managers, and policymakers as they work to improve the health and healthcare of Veterans. QUERI provides funding for four ESP Centers, and each Center has an active University affiliation. Center Directors are recognized leaders in the field of evidence synthesis with close ties to the AHRQ Evidence-based Practice Centers. The ESP is governed by a Steering Committee comprised of participants from VHA Policy, Program, and Operations Offices, VISN leadership, field-based investigators, and others as designated appropriate by QUERI/HSR&D.

The ESP Centers generate evidence syntheses on important clinical practice topics. These reports help:

- Develop clinical policies informed by evidence;
- Implement effective services to improve patient outcomes and to support VA clinical practice guidelines and performance measures; and
- Set the direction for future research to address gaps in clinical knowledge.

The ESP disseminates these reports throughout VA and in the published literature; some evidence syntheses have informed the clinical guidelines of large professional organizations.

The ESP Coordinating Center (ESP CC), located in Portland, Oregon, was created in 2009 to expand the capacity of QUERI/HSR&D and is charged with oversight of national ESP program operations, program development and evaluation, and dissemination efforts. The ESP CC establishes standard operating procedures for the production of evidence synthesis reports; facilitates a national topic nomination, prioritization, and selection process; manages the research portfolio of each Center; facilitates editorial review processes; ensures methodological consistency and quality of products; produces “rapid response evidence briefs” at the request of VHA senior leadership; collaborates with HSR&D Center for Information Dissemination and Education Resources (CIDER) to develop a national dissemination strategy for all ESP products; and interfaces with stakeholders to effectively engage the program.

Comments on this evidence report are welcome and can be sent to Nicole Floyd, ESP CC Program Manager, at [Nicole.Floyd@va.gov](mailto:Nicole.Floyd@va.gov).

**Recommended citation:** Miake-Lye IM, O’Neil S, Childers C, Gibbons M, Mak S, Shanman R, Beroes JM, Shekelle PG. Effectiveness of Interventions to Improve Emergency Department Efficiency: An Evidence Map. VA ESP Project #05-226; 2017.

This report is based on research conducted by the Evidence-based Synthesis Program (ESP) Center located at the **West Los Angeles VA Medical Center, Los Angeles, CA**, funded by the Department of Veterans Affairs, Veterans Health Administration, Office of Research and Development, Quality Enhancement Research Initiative. The findings and conclusions in this document are those of the author(s) who are responsible for its contents; the findings and conclusions do not necessarily represent the views of the Department of Veterans Affairs or the United States government. Therefore, no statement in this article should be construed as an official position of the Department of Veterans Affairs. No investigators have any affiliations or financial involvement (eg, employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties) that conflict with material presented in the report.

## ABSTRACT

### **Objective**

Emergency departments are seeking ways to improve efficiency, but to be useful to decision-makers, studies of such interventions should report information on utilization, cost, and quality of care. Previous systematic reviews have been limited to specific intervention types, and have not assessed implementation costs. We used evidence mapping to assess knowledge gaps and highlight research priorities.

### **Methods**

A systematic literature scan identified studies testing the effect of an improvement intervention on at least one ED utilization measure (*eg*, length of stay (LOS), waiting-room time (WT), left-without-being-seen (LBWS)). Cost, quality impact, and resource requirement (additional resources needed, existing resources sufficient, unclear) data were abstracted. Studies limited to specific clinical conditions (*eg*, sepsis, acute myocardial infarction) were excluded. Evidence maps were constructed to illustrate intervention type, resource use, data reporting, and effect size graphically.

### **Results**

From 139 titles, N=97 publications were included, describing 17 types of interventions, most commonly physician triage (n=32), nursing scope of practice expansion (n=23), and fast track (n=12). Studies varied in reporting utilization metrics (LOS 69%, WT 38%, LWBS 35%) and implementation costs (20%). Only 3 of 97 studies reported on utilization, resource requirements, costs, and quality measures.

Improvements ranged between 5%-20% for LOS, 10%-50% for WT, and -0.5% to 64.7% for LWBS.

### **Conclusions**

Few studies reported the types of data needed to fully assess the effectiveness of efficiency improvement interventions. Future research should emphasize consistent reporting of resource requirements, cost and quality impact data, and how to achieve efficiency improvements without investing new resources. Filling these gaps will make ED efficiency studies more useful to decision-makers.

## TABLE OF CONTENTS

Abstract .....	ii
Evidence Report.....	1
Introduction.....	1
Methods.....	2
Topic Development.....	2
Search Strategy .....	2
Inclusion/Exclusion Criteria .....	2
Study Selection and Data Abstraction .....	2
Quality Assessment.....	3
Data Synthesis.....	3
Narrative Synthesis .....	3
Technical Expert Panel .....	3
Peer Review .....	4
Results.....	5
Literature Flow.....	5
Utilization, Quality, and Safety Reported.....	8
Costs and Resource Use Reported .....	8
Description of Resource Use by Intervention Type.....	10
Effect on Length of Stay by Intervention Type .....	11
Effect on Wait Time by Intervention Type.....	13
Effect on LWBS by intervention Type .....	15
VA publications .....	17
Summary and Discussion.....	17
Limitations .....	17
Future work.....	18
References.....	19
Appendix A. Search Strategy.....	21
Appendix B. Study Selection Criteria.....	28
Appendix C. Peer Review Comments/Author Responses .....	30
Appendix D. Citations of Included Publications .....	36
Appendix E. Citations of Full Text Excludes .....	42
Appendix F. Unabridged Examples of Text Counted as “Quantifying Costs” .....	45

**TABLES**

Table 1. Descriptive Information about the Studies .....	7
Table 2. Abridged examples of Key Text Counted as “Quantifying Costs” .....	8

**FIGURES**

Figure 1. Literature Flow Chart .....	6
Figure 2. Intervention Type with Costs Quantified .....	10
Figure 3. Evidence Map Displaying Amount of Literature by Intervention and Resource Use Reported (n=97).....	11
Figure 4. Evidence Map Displaying Improvement in Length of Stay (Percent Change from Baseline) .....	12
Figure 5. Evidence Map Displaying Improvement in Wait Time (Percent Change from Baseline).....	14
Figure 6. Evidence Map Displaying Change in Left Without Being Seen Rate (Percent Change from Baseline) .....	16

**APPENDICES**

Appendix A. Search Strategy.....	21
Appendix B. Study Selection Criteria.....	28
Appendix C. Peer Review Comments/Author Responses .....	30
Appendix D. Citations of Included Publications .....	36
Appendix E. Citations of Full Text Excludes .....	42
Appendix F. Unabridged Examples of Text Counted as “Quantifying Costs”.....	45

# EVIDENCE REPORT

## INTRODUCTION

### Background

Overcrowding in the emergency department (ED) negatively affects patient outcomes, limits effective treatment for time-sensitive conditions such as pneumonia and sepsis, and reduces the safety and timeliness of care.<sup>1-3</sup> “Efficiency” in ED care is often assessed by using measures of utilization (*eg*, length of stay [LOS] or waiting time), but in order to be relevant to policymakers needs also to include a measure of the unit of resources expended (*eg*, physician full-time-equivalents) to implement the intervention, and some assessment of quality (*eg*, the same or fewer harms and errors). Many ED efficiency interventions have been described, ranging from structural redesign (*eg*, “fast track” units) or staffing changes (*eg*, medical scribes) to technological solutions (*eg*, point-of-care lab testing).

### Importance

Given the large number and breadth of interventions described, a systematic scoping review describing the full range of the evidence would be helpful to clinicians, administrators, and researchers. Previous reviews limited their focus to one or several intervention types, such as physician triage<sup>4</sup> or expanding nurses’ scope of practice.<sup>5</sup> Some reviews included multiple types<sup>6</sup> but none have sought to purposefully include a broad range of interventions. Simulation of ED throughput is a robust field of inquiry, but few of these models are implemented and tested in real-world settings.<sup>5,7</sup>

### Goals of this Investigation

In order to make decisions on strategic priorities, ED leaders need efficiency intervention studies to be clear and specific, to reflect tests in real-world settings, to define the organizational context of the intervention, and to report utilization outcomes, costs, and impacts on quality of care such as harms or errors. We sought to broadly describe a range of ED efficiency improvement studies using evidence mapping. This approach identifies gaps in knowledge by presenting results in a graphical format to highlight future research needs.<sup>8</sup>

## METHODS

### TOPIC DEVELOPMENT

This topic was developed in response to a nomination by Dr. Michael Ward on behalf of Dr. Chad Kessler, National Director of the VA Emergency Medicine Field Advisory Committee. This report contributed to the Field Advisory Committee's conference "Toward a VA Emergency Medicine Research Agenda: Setting Priorities to Improve the Health of Veterans Seeking Emergency Care." The scope was further developed with input from the topic nominators, the ESP Coordinating Center, the review team, and the technical expert panel (TEP).

The scope of this report includes the following:

- An evidence map that provides a visual overview of the distribution of evidence (both what is known and where there is little or no evidence base) for interventions to improve emergency department (ED) efficiency.
- An accompanying narrative that helps stakeholders interpret the state of the evidence to inform policy and clinical decision-making.

### SEARCH STRATEGY

A literature search conducted by the VA Evidence-Based Synthesis Program (ESP) Coordinating Center identified peer-reviewed journal articles reporting ED efficiency improvement interventions, including systematic reviews, which were mined for references. Multiple databases were included: Cochrane Database of Systematic Reviews: Protocols and Reviews (2005 through July 20, 2016), MEDLINE (1996 through July 21, 2016), as well as sources of gray literature (see Appendix A for full search strategy).

### INCLUSION/EXCLUSION CRITERIA

To be considered as evidence for inclusion in the evidence map, each study must have tested the effectiveness of an intervention on one or more specific measures of ED utilization, including, but not limited to, length of stay (LOS), waiting room time (WT), or left without being seen (LWBS) rate. These include both randomized controlled trials and observational studies, and comparisons across institutions or within an institution over time. Studies not providing data on outcome measures, focusing only on a single clinical condition (*eg*, acute myocardial infarction), and simply using inpatient units to offload ED functions (*eg*, condition-specific, short-term observation units) were excluded. Studies published more than 20 years ago were excluded.

### STUDY SELECTION AND DATA ABSTRACTION

All citations were reviewed by 2 independent reviewers (PGS/SMO or MMG/CPC). Data extraction and full-text review were completed in duplicate as well. Discrepancies were resolved with discussion among the reviewer pairs. Full study selection criteria and data abstraction fields are listed in Appendix B.

We abstracted: unit of analysis, sample size, country, hospital teaching status, type(s) of utilization, cost and quality impact measures reported, and baseline and post-intervention results.

Relative improvement in outcomes was calculated as a positive percentage improvement over baseline (*eg*, a reduction in LOS from 90 minutes to 60 minutes would be a  $([90-60]/90 = 33\%$  improvement). If studies presented multiple versions of a particular outcome, we defined LOS as the total time from ED bed assignment to final disposition (*eg*, discharge or transfer to an inpatient unit), WT as the total time from arrival in the waiting room to ED bed assignment, and LWBS rate as the percentage of all analyzed visits in which a patient leaves from the ED before being seen by a physician. While there was heterogeneity in the use of these terms by study authors, we used the data provided by the authors if they reported using the same term.

We identified the measures of implementation cost that were reported and quantified (*eg*, full-time-equivalents [FTEs] added, equipment costs). If costs weren't quantified, we ascertained whether implementation was described as being accomplished by reallocating existing resources, or whether it was described as requiring new resources. Studies that described both reallocation of existing resources and new resources were classified as requiring new resources.

Studies were classified by intervention, each study was assigned to one intervention type to produce exhaustive and mutually exclusive categories. In cases where studies could overlap categories, best fit was determined with group review. We used categories from previous systematic reviews when possible and pile sort techniques otherwise.

## QUALITY ASSESSMENT

This is not applicable for an evidence map.

## DATA SYNTHESIS

An evidence map is a systematic search of a broad field to identify gaps in knowledge and future research needs, which presents the results in a user-friendly format, often a visual figure or graph, or a searchable database.<sup>8</sup> In our case, an overview map plotted the distribution of intervention types (x-axis) with resources required for implementation (y-axis). Studies were grouped according to these dimensions and plotted as bubbles, the size of which represented the number of studies in that group. The color of the bubble additionally corresponds to the nature of resource use of a study.

A second set of evidence maps illustrated intervention types (x-axis, major sections), resources required for implementation (color and x-axis, minor sections), effect size (y-axis), and study size (diameter of markers). These maps are not intended to pool data, but to illustrate the evidentiary landscape in regard to interventions to improve ED efficiency. Findings from these maps were derived through observation and discussion among co-authors.

## NARRATIVE SYNTHESIS

The narrative synthesis complements the visual evidence maps to provide more details from the included literature.

## TECHNICAL EXPERT PANEL

The technical expert panel (TEP) for the project included: Chad S. Kessler, MD, National Program Director, VA Emergency; Michael Ward, MD, Department of Emergency Medicine,

Vanderbilt University Medical Center, VA; Kristina Cordasco, MD, Core Investigator, VA Greater Los Angeles Center for the Study of Healthcare Innovation, Policy and Practice.

## **PEER REVIEW**

A draft version of the report was reviewed by technical experts and clinical leadership. Reviewer comments and our responses are documented in Appendix C.

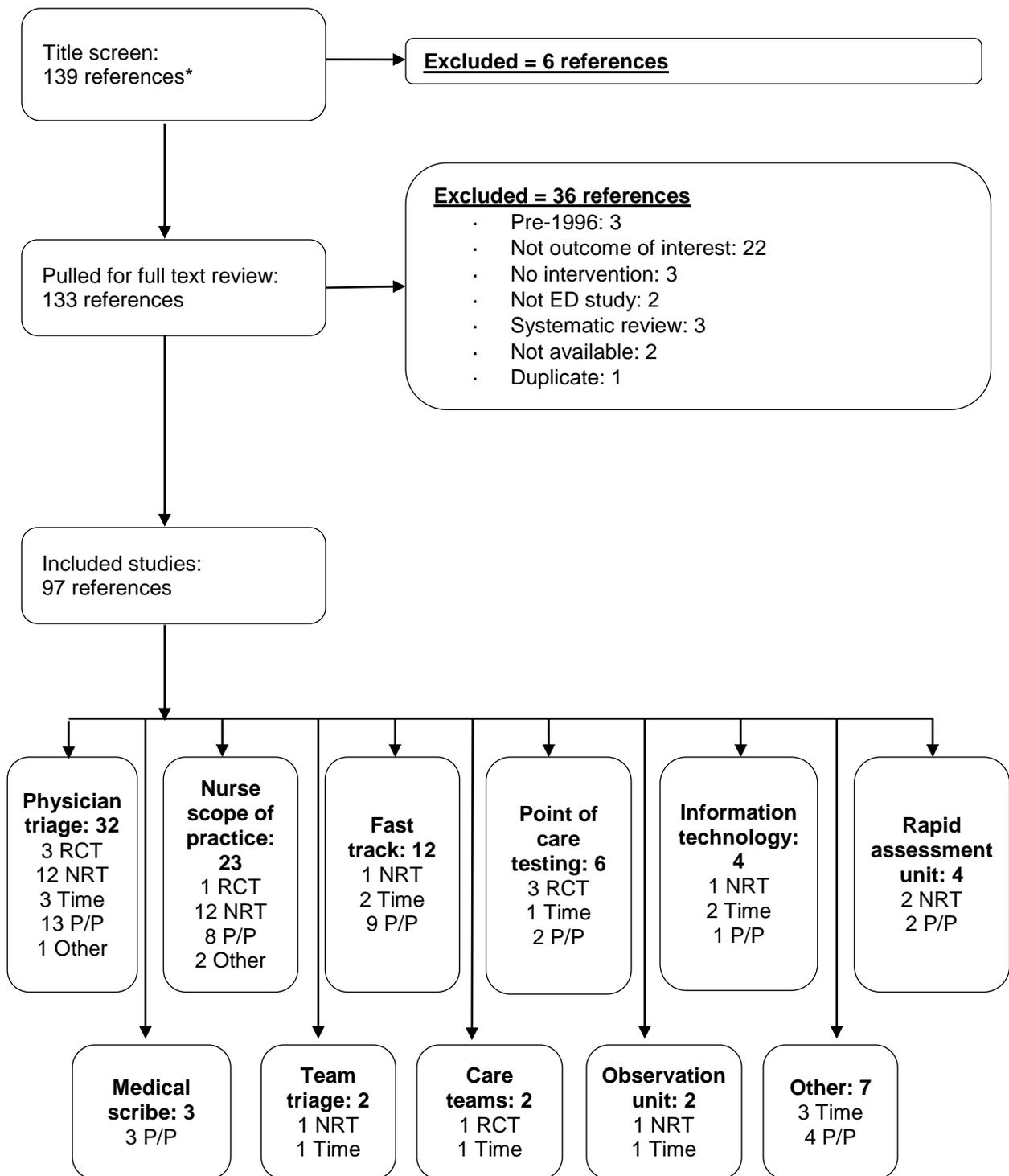
## RESULTS

### LITERATURE FLOW

Our literature searches identified 139 titles as potentially relevant for this evidence map. From these titles, 133 references were included for full-text review. Six were excluded from full-text review because 5 were pre-1996 and one was unavailable. When reviewing full texts, 36 publications were rejected for the following reasons: 3 were pre-1996; 15 did not have an outcome of interest (*ie*, study focused on improvements for a single condition only or no ED outcome was measured); 12 did not include an ED efficiency intervention; 3 did not have an intervention; 2 were not an ED study; 3 were systematic reviews; 2 were not retrievable; and one was a duplicate of another publication included for review. A full list of studies excluded at full-text review is included in Appendix E.

The 97 included publications described 11 categories of interventions: 32 described triage by a physician, 23 described expanding nurse scope of practice (SOP), 12 described fast track interventions, 6 described point of care (POC) testing, 4 described information technology-based (IT) interventions, 4 described rapid assessment units, 3 described the use of medical scribes, 2 described observation units, 2 described team triage, and 7 described other interventions that only appeared once. Examples of intervention types reported in one study each included sharing individual performance data to all providers, intensive bed occupancy tracking, geriatric focused areas, and comprehensive department re-engineering. A full list of included studies is included in Appendix D. See Figure 1 for the Literature Flow.

**Figure 1. Literature Flow Chart**



RCT = randomized controlled trial  
 NRT = non-randomized concurrently controlled trial  
 Time = time-series  
 P/P = pre/post

Table 1 presents descriptive information about the 97 included studies. Studies originated from the United States (41%), Australia (19%), Canada (11%), the United Kingdom (9%), and 13 other nations (19%). Studies were usually located at academically affiliated sites (73%), and 93% were single-site interventions. Samples sizes ranged, with 60% of studies including more than 1,000 patients, 37% of studies including more than 10,000 patients, and 14% of studies using shifts or facilities as the unit of analysis. Only one study was at a VA site. The most common study design was pre/post design (43%).

**Table 1. Descriptive Information about the Studies**

<b>Country of Origin</b>		Sample size = 97
USA		40
Australia		19
Canada		11
UK		9
Other		18
<b>Site Academically Affiliated</b>		
Yes		69
No		11
Both		2
Not reported		15
<b>Sites Involved</b>		
One site		90
Multi-site		6
Not reported		1
<b>Sample Sizes</b>		
>10,000 patients		36
1,000-9,999 patients		22
500-999 patients		7
100-499 patients		16
Other unit (shift, facility)		14
Unclear		2
<b>VA Setting</b>		
No		96
Yes		1
<b>Study Design</b>		
Randomized controlled trial		7
Non-randomized concurrently controlled trial		31
Time series		14
Pre/post		42
Other		3

## UTILIZATION, QUALITY, AND SAFETY REPORTED

Reporting of ED utilization outcomes varied, with LOS reported by 69% (n=67), WT by 38% (n=37), and LWBS by 35% (n=34). Other outcomes reported included the inpatient admission rate (33% of studies, n=32), other clinical outcomes such as unplanned revisit rate (13%; n=13), and clinical harms (8%; n=8). In terms of data showing impact on clinical quality, 13% reported clinical measures (eg, health status or patient satisfaction). 13% reported unplanned revisit rates, and 8% reported clinical harms.

## COSTS AND RESOURCE USE REPORTED

Reporting of costs was limited, as 20% of studies provided a quantitative estimate of implementation requirements (n=19). We were necessarily generous when determining that studies met the criterion for quantifying costs. Table 3 presents abridged examples of actual text from articles, while Appendix F presents the unabridged examples. These varied from formal cost-effectiveness analyses, such as in the study by Soremekun,<sup>9</sup> to stating a physician was added and what amount of time was necessary (such as in the study by Han<sup>10</sup>). In reporting implementation resource requirements: 44 studies described adding new resources (45%), 18 studies described reallocating existing resources (19%), and 35 studies were unclear in regard to net resource expenditure (36%, lacked sufficient description).

**Table 2. Abridged Examples of Key Text Counted as “Quantifying Costs”**

Fernandez, 1996 <sup>11</sup>	Prior to the present study, no nurse was assigned solely to the FT area. "... addition of an extra admitting clerk; ... addition of an FT nurse; ... we expanded our FT area to include more rooms and stretchers, ... having a full-time FT nurse"
Partovi, 2001 <sup>12</sup>	"The cost of additional faculty coverage was estimated to be \$11.98/patient seen in ED. ... If this is to be implemented on a fulltime basis, the cost per patient would rise to \$19.35. The annual cost will be more than a million dollars for full-time faculty triage."
Ardagh, 2002 <sup>13</sup>	"an additional nurse and an additional ED registrar were rostered"
Richardson, 2004 <sup>14</sup>	"... it was necessary to increase the evening consultant cover from one to two consultants... Staff were educated... the department was modified to include a desktop working area for the MDT doctor and a mini assessment/treatment cubicle behind the triage desk... A diagnostic set and X-ray viewing box was installed on the wall."
Terris, 2004 <sup>15</sup>	"Funding was allocated for senior clinicians (medical and nursing) to staff the triage area for 16 hours per week for three months. An emergency medicine consultant and a senior ED nurse (G or F grade) were chosen as the preferred team."
Rodi, 2006 <sup>16</sup>	"The only new cost of the intervention was hiring a dedicated technician to support the PA."
Levsky, 2008 <sup>17</sup>	"...an emergency physician or physician's assistant, a registered nurse, and a medic or civilian emergency medical technician... During the intervention, the TNT team was used 4 days a week: Monday, Tuesday, Thursday, and Sunday from 10:00 a.m. to 6:00 p.m. ...Specifically, during PI, five new registered nurses were hired, as were three new medical support assistants (clerks), which increased nurse and clerk coverage by approximately 7% and 15%, respectively. No ED operations or staffing changes occurred between P2 and P3, other than the addition of TNT."
Ieraci, 2008 <sup>18</sup>	"The net result of the remodelling was a reduction in the total number of treatment spaces (beds plus chairs) from 25 to 24... Separate clinical resources were provided"

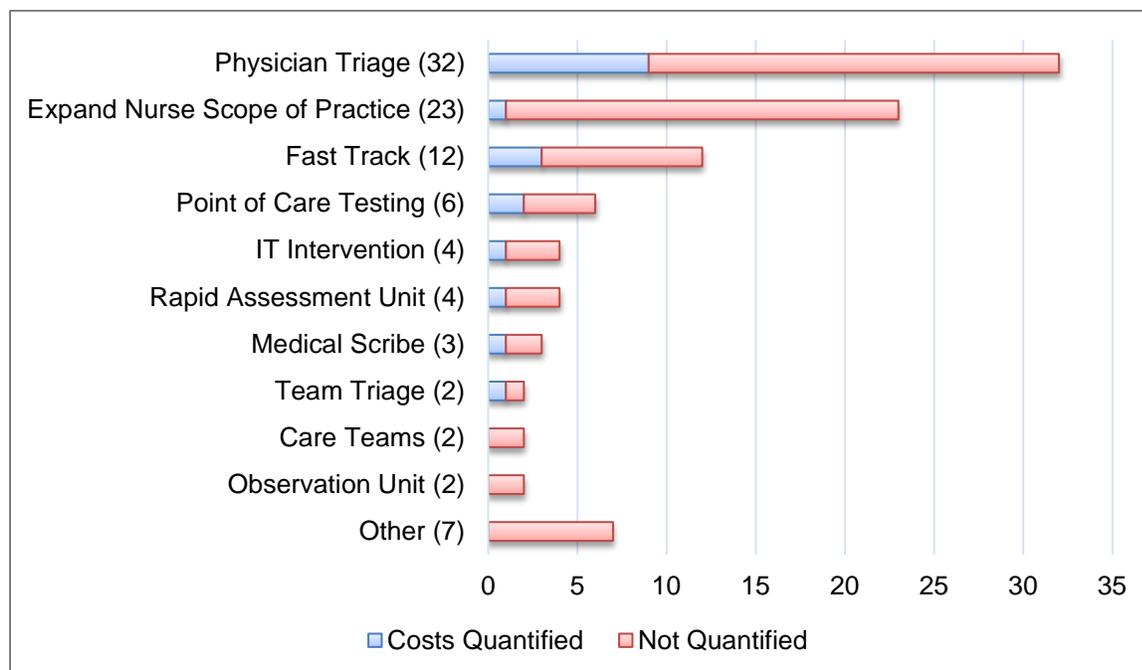
	to staff the FT area with two nurses round the clock, and one senior doctor (career medical officer, CMO) for 16 h/day."
Singer, 2008 <sup>19</sup>	"The third phase involved hiring seven personnel, at a laboratory technologist level, so that a new workstation could be covered 24 hours per day in the central laboratory, 7 days per week. It also involved the purchase of new analyzers, at a cost of about \$46,000, and installation of a dedicated pneumatic tube, at a cost of about \$150,000."
Gerton, 2009 <sup>20</sup>	"The PIT provided additional coverage that replaced a triage nurse, but did not change the physician staffing of the ED... During PIT hrs, 11.5 RVUs more were billed on average than without PIT (384 vs. 373; 95% CI +/-41). With RVU estimated at \$38.08, charges increased by \$438 / 8hr shift. If PIT were 5 d/wk for 1 yr, increased billing would be \$118,000. This would not offset the cost of a physician."
Arya, 2010 <sup>21</sup>	"The scribe training program is 60 hours in length." "The RVU/hr increased by 0.18 (95% confidence interval [CI] = 0.04 to 0.32, p = 0.0067) units when the percentage of a shift for which a scribe was utilized increases by 10%... If a physician in our department changed from 0% to 100% of the patients seen with a scribe, 0.8 additional patients per hour can be evaluated in a 10-hour shift, and 24 (2.4/hr) additional RVUs would be generated... Based on the 2008 Medicare RVU reimbursement rate of \$38 for one RVU, a scribe being utilized to full capacity, resulting in an additional 2.4 RVUs/hr generated, could result in an additional 91 billed dollars per hour. Scribes at our institution are salaried at approximately \$16–\$19 per hour..."
Han, 2010 <sup>10</sup>	Physician triage was initiated on July 11, 2005, 7 days a week from 1:00 p.m. to 9:00 p.m. A dedicated board certified or board-eligible emergency physician initiated diagnostic evaluation and treatment of patients in the waiting room after the triage nurse performed his or her initial evaluation. The triage physician was an additional physician to the existing staffing model.
Fry, 2011 <sup>22</sup>	"The TENP role, in July 2006, commenced with the employment of 3 full time equivalent positions, which provided a TENP on duty for 15 h a day Monday—Sunday (eight o'clock am to eleven o'clock pm)." (TENP = Transitional Emergency Nurse Practitioner)
Imperato, 2012 <sup>23</sup>	"...required the addition of two full-time equivalent attending physicians, at a total cost of \$490,000 in additional salary costs per year plus fringe benefits. The nurse and technician assigned to the PIT were reallocated from another part of the ED, so no additional nursing staffing cost was incurred."
Soremekun, 2012 <sup>9,24</sup>	"Three components of the financial impact of the physician triage were considered: revenue, operational costs, and capital expenditure... The incremental revenue and operational expense projection generated from physician screening using aforementioned assumptions are depicted in Table 4. In year 1, the estimated ED contribution margin from discharged patients is \$1 324 338 (growth in medium acuity patients, \$1 137 234; LWBS patients, \$187 104) and the estimated contribution margin from admitted patients is \$1 384 718. The estimated operational expense associated with the physician screening system at year 1 is \$1 864 104 (\$1 624 104 in salary costs; \$240 000 in depreciation costs). The total earnings and CF projection at year 1 are \$844 952 and \$1 084 952, respectively. Based on the CF projections and a discount rate of 5%, the NPV of physician screening was \$2 816 263 and the internal rate of return is 85%, with time to break even of 13 months."
Soremekun, 2014 <sup>25</sup>	"The midtrack area, however, was staffed with two additional registered nurses (RNs) for an additional 16 hours or a 3.4% increase in total nursing clinical hours per day."
Inokuchi, 2015 <sup>26</sup>	"... the system can be built for less than 5000 US dollars"

Utilization data, resource requirements, quantifiable input costs, and quality outcome measures were reported together by 3 of 97 studies (3%). All three were single-site studies, and all three required the addition of new resources. A pre/post study of emergency nurse practitioners from an Australian academic medical center<sup>22</sup> required the addition of 3 FTE nurse practitioners, and yielded a 3% improvement in LOS (207 vs 213 minutes,  $p < .0001$ ), a 36% improvement in WT (38 vs 60 minutes,  $p < .000$ ), and a 44% reduction in LWBS (8.1% vs 4.5%,  $p < .0001$ ). Of 5,248 patients seen by nurse practitioners, there was one case of missed early appendicitis, and one case of missed nondisplaced hand fracture, but no adverse outcomes. A fast track intervention, using a pre/post study design at an Australian academic medical center<sup>18</sup> required an increase in total staff time of 16%, and yielded an 19% improvement in LOS (194 vs 241 minutes,  $p < .001$ ), a 42% improvement in WT (32 vs 55 minutes,  $p < .001$ ), and a 50% improvement in LWBS (3.1% vs 6.2%,  $p < .001$ ). However, re-presentation to the ED within 48 hours increased slightly (4.4% vs 3.7%,  $p = .056$ ). A new EMR deployment at a Japanese academic medical center<sup>26</sup> yielded a 19% reduction in length of stay (108 mins vs 134 mins,  $p < .001$ ), with no significant change in 28-day mortality (0.4% vs 0.7%,  $p = .62$ ). This study used a crossover design to provide a concurrent comparison group.

## DESCRIPTION OF RESOURCE USE BY INTERVENTION TYPE

Physician triage was the most commonly studied intervention, and nearly half of the studies where costs were quantified were from physician triage studies (47%, see Figure 2). Expanding nurses' scope of practice was the next most common intervention, but only one study quantified costs.

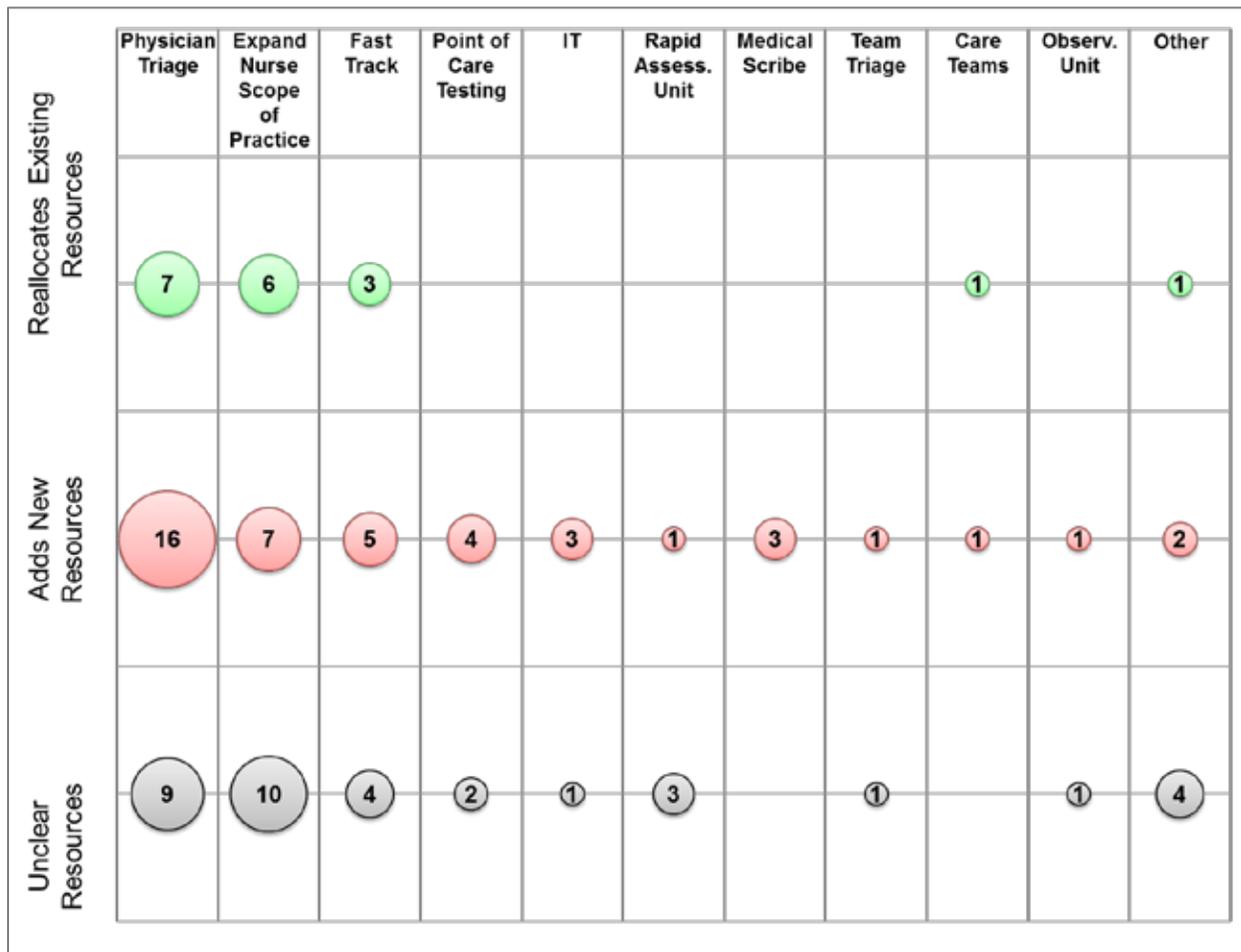
**Figure 2. Intervention Type with Costs Quantified**



Our first evidence map presents the studies by intervention type and description of resource use (Figure 3). Four intervention types (physician triage, expanding nurses' scope of practice, fast track, and care teams) were implemented at least once without requiring the

addition of new resources to the ED. However, for each of these types, it was more commonly reported that additional resources were required. There were 6 intervention types that were never implemented through reallocating existing resources only: point of care testing, rapid assessment units, information technology (IT) interventions, medical scribes, team triage, and observation units.

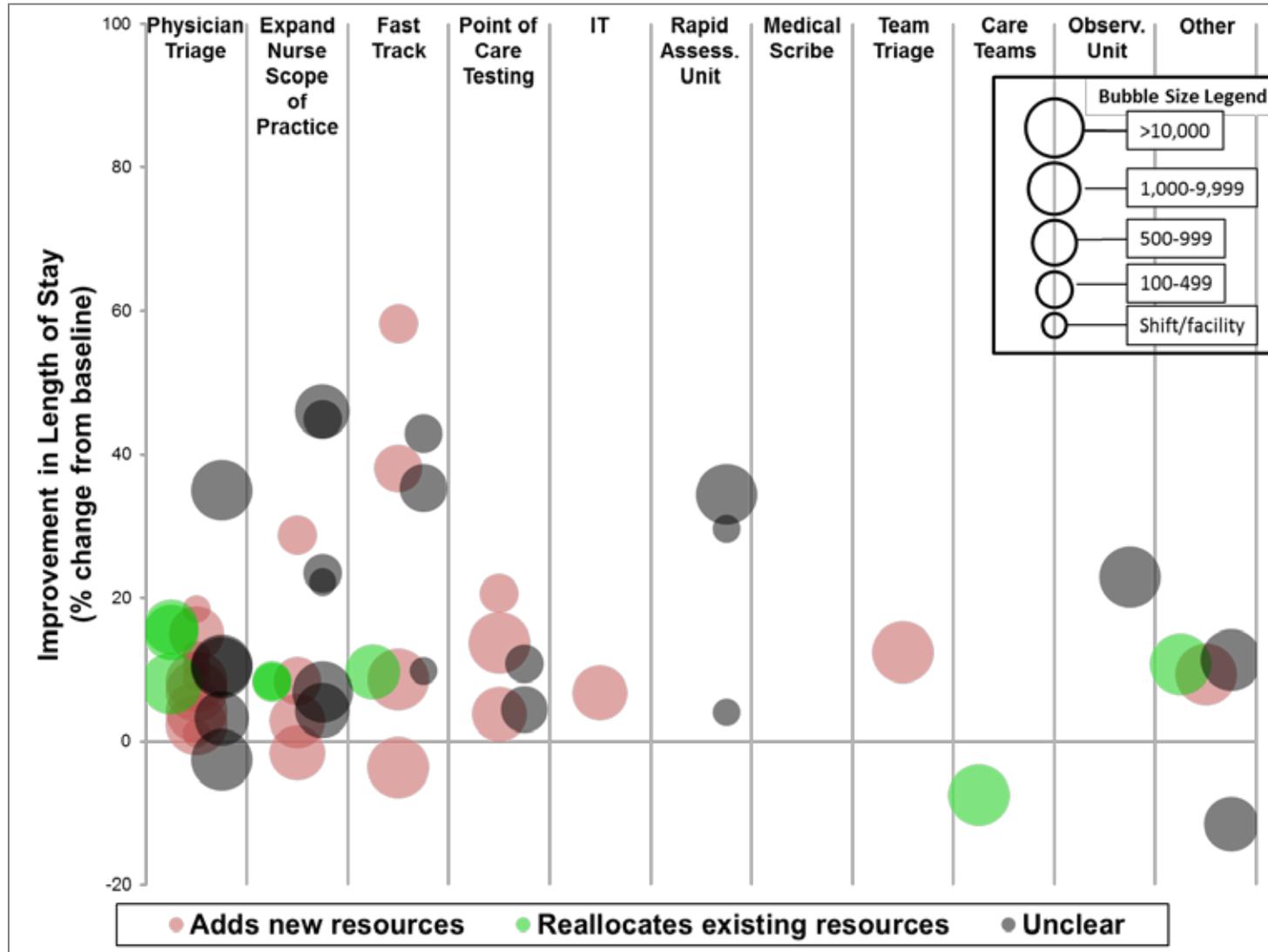
**Figure 3. Evidence Map Displaying Amount of Literature by Intervention and Resource Use Reported (n=97)**



### EFFECT ON LENGTH OF STAY BY INTERVENTION TYPE

Most studies that reported changes in length of stay (n=67) improved mean LOS by between 10 and 40 minutes. When these improvements are displayed as a percentage relative to baseline LOS, improvements tended to range between 5% and 20% (Figure 4). Fast Track and Nurse Scope of Practice interventions had the highest frequency of studies that were able to yield improvements greater than 30%. No Medical Scribe studies reported Length of Stay outcomes.

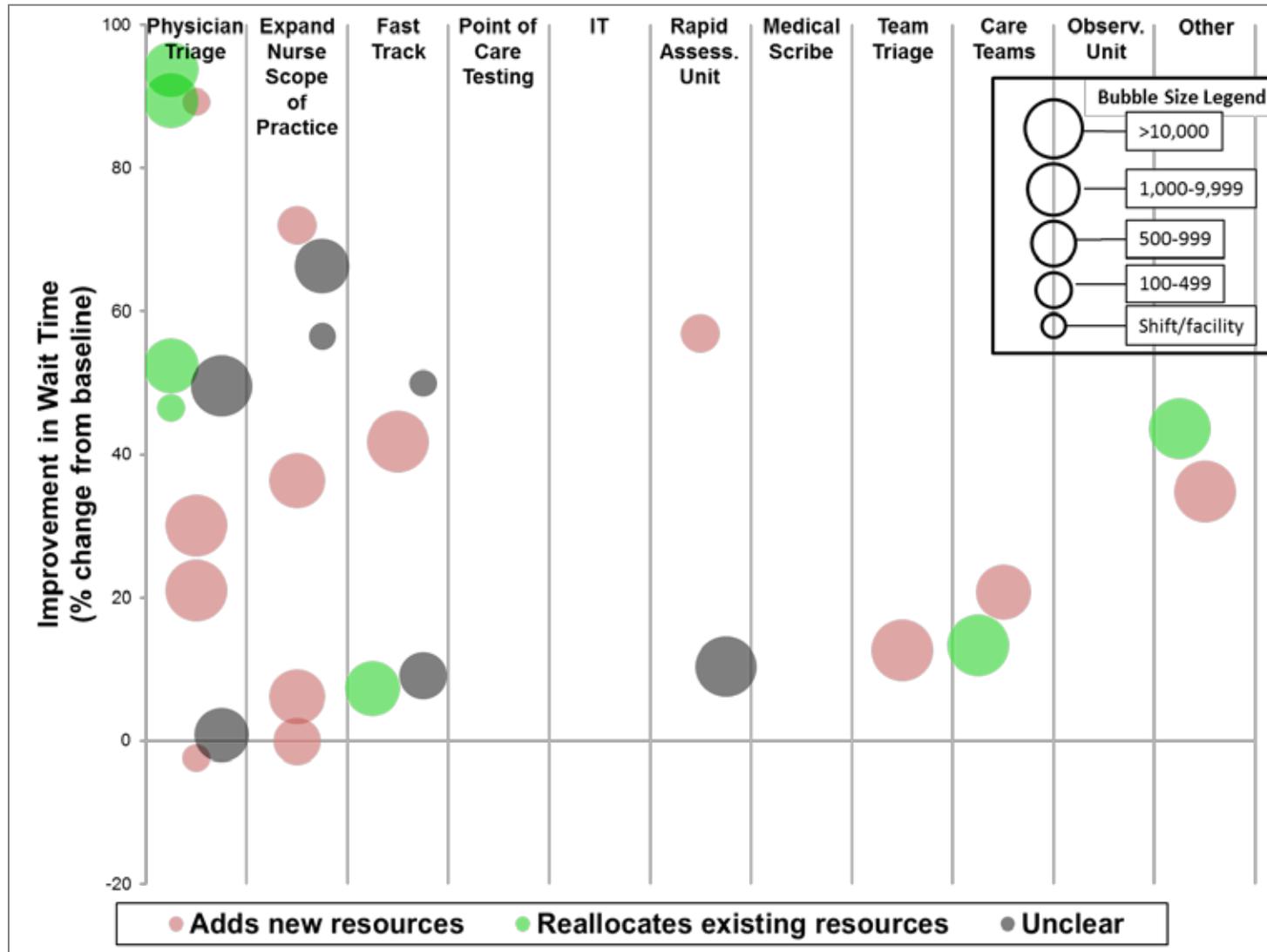
Figure 4. Evidence Map Displaying Improvement in Length of Stay (Percent Change from Baseline)



## **EFFECT ON WAIT TIME BY INTERVENTION TYPE**

Improvements in wait time tended to range between 10 and 40 minutes, or 10% to 50% of baseline (Figure 5). Physician Triage and Nurse SOP had the highest number of studies with very high improvements of more than 60%. No IT, Medical Scribe, Observation Unit, or Point of Care Testing interventions reported effects on Wait Time.

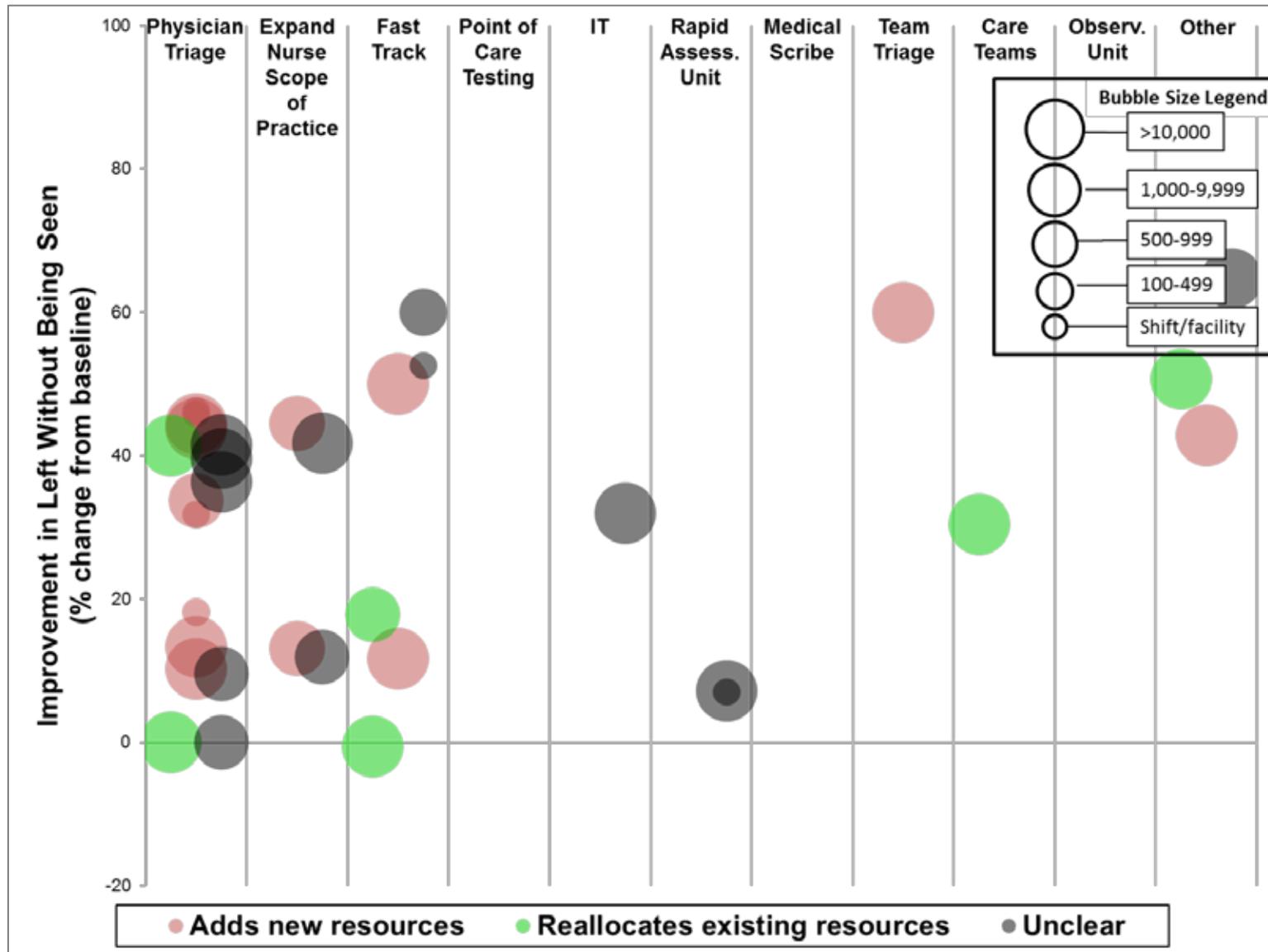
Figure 5. Evidence Map Displaying Improvement in Wait Time (Percent Change from Baseline)



## EFFECT ON LWBS BY INTERVENTION TYPE

Most interventions yielded reductions in LWBS ranging between 0 and 5 absolute percentage points from their baseline rate. Compared to baseline LWBS, improvements ranged from -0.5% to 64.7% (Figure 6). Physician Triage and Nurse Scope of Practice had the most number of consistently positive results. Fast Track yielded both strongly positive and negative results. No Medical Scribe, Observation Unit, or Point of Care Testing interventions reported effects on LWBS rate.

Figure 6. Evidence Map Displaying Change in Left Without Being Seen Rate (Percent Change from Baseline)



## VA PUBLICATIONS

Of the 97 included publications, there was one study conducted in the VA from the St. Louis VA Medical Center.<sup>27</sup> This single-site study included 2,194 patient visits pre-intervention and 2,154 patient visits post-intervention and describes the reassignment of a physician and nurse practitioner to triage, as well as the results of a discrete event simulation modelling the same conditions. The modelling accurately predicted the effect of the intervention, which decreased the daily mean LOS from 247 to 210 minutes ( $p < .001$ ) and the number of patients with LOS above 6 hours from 19.9 percent to 14.3% ( $p < .0001$ ).

## SUMMARY AND DISCUSSION

This review illustrates several gaps in the evidence base for interventions improving ED efficiency. First, very few studies reported utilization, cost, and quality of care outcomes together. Two-thirds of studies reported data for LOS, and less than half reported data for WT or LWBS. Only a small fraction reported on patient harms or medical errors. When authors do not provide a full accounting of an intervention's effects, this limits the ability of other leaders to apply the findings of an improvement study.<sup>3</sup>

Second, only a minority of studies quantified the resources required to implement an intervention. One-third were unclear even as to whether additional resources would be needed. Costly interventions are not necessarily more effective in improving efficiency. For example, simply increasing ED capacity is thought to be a straightforward fix for overcrowding, but this is expensive, rarely practical in the short-term, and not always beneficial.<sup>28</sup> As ED leaders and decision-makers are often faced with resource constraints, more accurate reporting of resource requirements is imperative.

Lastly, we found 7 studies that demonstrated improvements in efficiency outcomes solely through reallocating existing resources. These studies represented 4 different intervention types (physician triage, fast track, nurse scope of practice expansion, and care teams). Researchers should prioritize understanding how these interventions effected improvements at relatively little cost. Generalizing these lessons could be transformative in improving ED throughput. That said, most studies using these 4 intervention types actually added resources, emphasizing the need to describe organizational context in better detail. If more resources were needed, why? And if existing resources could be reallocated, what factors within the organization helped facilitate this? The SQUIRE guidelines for quality improvement interventions provide a model for reporting contextual information.<sup>8</sup>

## LIMITATIONS

Several factors may limit interpretation of this report. We excluded simulation studies from the evidence map, as we focused on interventions tested in the real world, which are likely more useful to decision-makers. Additionally, the results of simulation studies are not directly comparable to results from implementations in practice, as a recent review of operations research/operations management (OR/OM) in regard to ED overcrowding suggests that a disconnect between theory and practice remains,<sup>5</sup> and it would be inappropriate to display them together in the evidence map. Regardless, simulation and OR/OM approaches have been beneficial for predicting the effects of policy changes, especially in resource-poor environments like EDs that may not have the resources to formally test many interventions or policies. For

example, a recent simulation study based on one urban level 1 trauma center with 85,000 annual visits examined the effect of “flexing” a certain number of Fast Track beds (where Fast Track can be used to accommodate higher-acuity patients according to operational demands) on ED LOS.<sup>29</sup> For their 50-bed ED with a 10-bed Fast Track, they found that allowing up to 3 Fast Track beds to be “flexed” resulted in an optimal improvement in ED LOS. There is a role for simulation approaches, provided that the findings can be subsequently tested in actual practice settings.

The outcome measures included in this synthesis raise challenges as well. Outcomes like LOS can be measured in different ways (e.g., bed assignment to final disposition, arrival-to-exit, *etc*), introducing issues with cross-study comparisons. The included publications varied both in the extent to which they provided definitions for the outcome measures they used, and in how they measured outcomes when this was reported. Outcomes that are relatively rare, such as LWBS, or outcomes that may have distributional challenges such as outliers, require additional consideration. Inspecting both the definitions of outcome measures and the measures of variability would be important data to gather in a formal systematic review, but would require detailed reading of each included study that goes beyond the scope of the data abstraction for an evidence map. This type of analysis would typically focus on a more narrow scope, such as a particular intervention or particular outcome.

While data limitations and the broad scope of inquiry for this mapping synthesis prevent us from performing statistical tests of publication bias, such bias is almost certainly present, as ED efficiency is an issue fundamental to the operations of any ED, and it is unlikely that all experiences have been written up for publication. Less successful implementations of interventions to improve ED efficiency may be the most vulnerable to being excluded from formal publication and consequently from our synthesis, but even successful implementations may not be published, so we cannot speculate as to how these interventions might impact the findings we present. Also, while the evidence map approach can generate insights into the state of the literature, they are not an exhaustive systematic review or meta-analysis, and do not provide the degree of comprehensiveness or statistical precision expected of those types of reviews. Despite these limitations, this review has highlighted several important gaps in the literature and identified priorities for future research efforts.

## **FUTURE WORK**

To better understand the value of ED efficiency interventions, increased measurement and reporting of costs or value-related data is necessary. The large variability in wait times and length of stay data also suggest that these may be measured different ways in different studies, and standardization in future work, or more detailed description about these calculations, would also be helpful. Most data came from single sites, which may have unique circumstances, so larger studies of multiple sites would also increase knowledge in this area. In addition, to better connect theory and practice, a greater understanding of why particular interventions are expected to improve efficiency is needed. Finally, because VA is a unique context with only one publication describing an ED efficiency intervention, more work within VA would be helpful in understanding which of the various interventions might work best in VA’s particular circumstances. As health care needs continue to increase, EDs are likely to face ever-growing patient loads, so finding and describing the best practices for optimizing ED efficiency remains imperative.

## REFERENCES

1. Bernstein SL, Aronsky D, Duseja R, et al. The effect of emergency department crowding on clinically oriented outcomes. *Acad Emerg Med*. 2009;16(1):1-10.
2. Asplin BR, Magid DJ, Rhodes KV, Solberg LI, Lurie N, Camargo CA, Jr. A conceptual model of emergency department crowding. *Ann Emerg Med*. 2003;42(2):173-180.
3. Doupe M, Chateau, D., Derksen, S., Sarkar, J., de Faria, R. L., Strome, T., Soodeen, R., McCulloch, S., Dahl, M. *Factors Affecting Emergency Department Waiting Room Times in Winnipeg*. Manitoba Centre for Health Policy;2017.
4. Abdulwahid MA, Booth A, Kuczawski M, Mason SM. The impact of senior doctor assessment at triage on emergency department performance measures: systematic review and meta-analysis of comparative studies. *Emerg Med J*. 2016;33(7):504-513.
5. Saghafian S, Austin, G., & Traub, S. J. Operations research/management contributions to emergency department patient flow optimization: Review and research prospects. *IIE Transactions on Healthcare Systems Engineering*. 2015;5(2):101-123.
6. Elder E, Johnston AN, Crilly J. Review article: systematic review of three key strategies designed to improve patient flow through the emergency department. *Emerg Med Australas*. 2015;27(5):394-404.
7. Miake-Lye IM, Hempel S, Shanman R, Shekelle PG. What is an evidence map? A systematic review of published evidence maps and their definitions, methods, and products. *Syst Rev*. 2016;5:28.
8. Ogrinc G, Davies L, Goodman D, Batalden P, Davidoff F, Stevens D. SQUIRE 2.0 (Standards for QUality Improvement Reporting Excellence): revised publication guidelines from a detailed consensus process. *BMJ Qual Saf*. 2016;25(12):986-992.
9. Soremekun OA, Biddinger PD, White BA, et al. Operational and financial impact of physician screening in the ED. *Am J Emerg Med*. 2012;30(4):532-539.
10. Han JH, France DJ, Levin SR, Jones ID, Storrow AB, Aronsky D. The effect of physician triage on emergency department length of stay. *J Emerg Med*. 2010;39(2):227-233.
11. Fernandes CM, Christenson JM, Price A. Continuous quality improvement reduces length of stay for fast-track patients in an emergency department. *Acad Emerg Med*. 1996;3(3):258-263.
12. Partovi SN, Nelson BK, Bryan ED, Walsh MJ. Faculty triage shortens emergency department length of stay. *Acad Emerg Med*. 2001;8(10):990-995.
13. Ardagh MW, Wells JE, Cooper K, Lyons R, Patterson R, O'Donovan P. Effect of a rapid assessment clinic on the waiting time to be seen by a doctor and the time spent in the department, for patients presenting to an urban emergency department: a controlled prospective trial. *N Z Med J*. 2002;115(1157):U28.
14. Richardson JR, Braitberg G, Yeoh MJ. Multidisciplinary assessment at triage: a new way forward. *Emerg Med Australas*. 2004;16(1):41-46.
15. Terris J, Leman P, O'Connor N, Wood R. Making an IMPACT on emergency department flow: improving patient processing assisted by consultant at triage. *Emerg Med J*. 2004;21(5):537-541.

16. Rodi SW, Grau MV, Orsini CM. Evaluation of a fast track unit: alignment of resources and demand results in improved satisfaction and decreased length of stay for emergency department patients. *Qual Manag Health Care*. 2006;15(3):163-170.
17. Levsky ME, Young SE, Masullo LN, Miller MA, Herold TJ. The effects of an accelerated triage and treatment protocol on left without being seen rates and wait times of urgent patients at a military emergency department. *Mil Med*. 2008;173(10):999-1003.
18. Ieraci S, Digiusto E, Sonntag P, Dann L, Fox D. Streaming by case complexity: evaluation of a model for emergency department Fast Track. *Emerg Med Australas*. 2008;20(3):241-249.
19. Singer AJ, Viccellio P, Thode HC, Jr., Bock JL, Henry MC. Introduction of a stat laboratory reduces emergency department length of stay. *Acad Emerg Med*. 2008;15(4):324-328.
20. Gerton JS, E.; Pimentel, L.; Ercolano, P.; Browne, B.; Barrueto, F. When is a physician in triage a financially viable option? *Acad Emerg Med*. 2009;16(4):S272.
21. Arya R, Salovich DM, Ohman-Strickland P, Merlin MA. Impact of scribes on performance indicators in the emergency department. *Acad Emerg Med*. 2010;17(5):490-494.
22. Fry MF, J.; Asha, S.; Arendts, G. A 12-month evaluation of the impact of Transitional Emergency Nurse Practitioners in one metropolitan Emergency Department. *Australasian Emergency Nursing Journal*. 2011;14(1):4-8.
23. Imperato J, Morris DS, Binder D, et al. Physician in triage improves emergency department patient throughput. *Intern Emerg Med*. 2012;7(5):457-462.
24. Soremekun OA, Capp R, Biddinger PD, et al. Impact of physician screening in the emergency department on patient flow. *J Emerg Med*. 2012;43(3):509-515.
25. Soremekun OA, Shofer FS, Grasso D, Mills AM, Moore J, Datner EM. The effect of an emergency department dedicated midtrack area on patient flow. *Acad Emerg Med*. 2014;21(4):434-439.
26. Inokuchi R, Sato H, Iwagami M, et al. Impact of a New Medical Record System for Emergency Departments Designed to Accelerate Clinical Documentation: A Crossover Study. *Medicine*. 2015;94(26):e856.
27. Day TE, Al-Roubaie AR, Goldlust EJ. Decreased length of stay after addition of healthcare provider in emergency department triage: a comparison between computer-simulated and real-world interventions. *Emerg Med J*. 2013;30(2):134-138.
28. Saghafian S, Hopp WJ, Van Oyen MP, Desmond JS, Kronick SL. Patient streaming as a mechanism for improving responsiveness in emergency departments. *Operations Research*. 2012;60(5):1080-1097.
29. Laker LF, Froehle CM, Lindsell CJ, Ward MJ. The flex track: flexible partitioning between low-and high-acuity areas of an emergency department. *Annals of emergency medicine*. 2014;64(6):591-603.