Obstacles to emergency medical services system design and operational features

David M Williams, PhD, executive director, the Institute for Healthcare Improvement, Cambridge, MA.
Email for correspondence: dwilliams@IHI.org

Abstract

Objective: There is a paucity of global research regarding emergency medical services (EMS) systems. EMS system processes and outcomes vary by model and jurisdiction. This study explores the individual, organisational, and system obstacles to 15 features of EMS systems.

Methods: Using a multi-case study, five US EMS systems, representing five major design models, were studied. Data collection included: i) data metrics, ii) document review, iii) interviews, and iv) archival records.

Results: EMS system performance and adoption of the 15 features varies. A total of 582 independent obstacles in 39 distinct categories were identified. The top obstacles included: cost/funding, measurement, process/outcome focus, systems view, public information/education, understanding productivity, training, will, data definitions, and culture/tradition.

Conclusions: Variation in performance exists across EMS system provider models. Adoption of the 15 features studied was not universal. Reported obstacles are opportunities for further investigation and action.

Key words
●Ambulance service ●Emergency medical services systems ● Evidence-based practice ●Paramedic ●Pre-hospital emergency care

Accepted for publication 6 November 2015

The US Institute of Medicine report, *Emergences Medical Services: At the Crossroads*, and the *National EMS Research Agenda* sponsored by the US National Highway Traffic Administration, both cite a paucity of peer-reviewed research on EMS systems and how little remains known about system features that make a difference (National Highway Traffic Safety Administration, 2001; Institute of Medicine, 2006). Published research frequently focuses on a single feature: not taking a systems view, and are not designed to look at the complexity of EMS systems (Spaite et al, 1995). Professional organisations have made the case for design concepts like competitive procurement or a preferred ambulance provider model, but evidence is absent to support or refute their advocacy (Williams, 2006; International Association of Firefighters, 2007; American Ambulance Association, 2008). More needs to be understood about EMS systems.

Comparison of EMS systems is one approach to understanding variation and potential best practices (Stout, 1997). Several benchmark projects exist but the results are not published in peer-reviewed journals (Center for Leadership, Innovation and Research in EMS, 2005; Overton and Anderson, 2006; Ward, 2013). One challenge is absence of uniform measurement definitions and an executable data collection strategy (Dunford et al, 2002; Myers et al, 2008; National Highway Traffic Administration, 2009). A concurrent challenge is limited universal agreement on key quality characteristics of an EMS system or evidence to support them, although there is developing consensus on clinical care pathways including ST segment elevation myocardial infarction, trauma, stroke, and sudden cardiac arrest (National EMS Advisory Council, 2003; Myers et al, 2008; Siriwardena et al, 2010).

The objective of this study was to compare EMS systems across common provider models in the US using a selection of metrics, and identify the adoption of 15 EMS system design features identified in the literature (see *Table 1*). Senior clinical and operational leaders were also interviewed to discover obstacles to adopting the features in the systems of study. The *New Oxford American Dictionary* defines an obstacle as a 'thing that blocks one's way or prevents or hinders progress.' Understanding perceived obstacles may identify opportunity for future study and provide additional understanding of the complex issues influencing EMS system design and operations.

Table 1. Potential features of EMS system design and operations

- All advanced life support
- Alternative transport destinations
- Balanced scorecard
- Customer satisfaction measurement
- Demand-based deployment
- Economic efficiency
- EMS health monitoring and intervention
- Full service (emergency and non-emergency)
- No call screening
- Outcome-based performance measurement
- Preparedness
- Public intervention
- Quality improvement
- Reduction of call time in ST-elevation myocardial infarction (STEMI), stroke and traumatic injury patients
- Response time reliability

Methods

Study design

This was a qualitative embedded multi-case study (Scholz and Tietje, 2002; Yin, 2003). Five mini cases that represent different urban (>100 000 population) provider models (i.e. fire, third service, public utility model, private, hospital-based) in the US are presented. The cases relied on multiple sources of data including: i) data metrics, ii) document review, iii) interviews, and iv) archival records. Data was self-reported by executive leadership from each participating EMS system.

Population and setting

All participating provider organisations served urban centres with populations greater than 100 000 citizens. Design considerations and opportunities for the provision of ambulance service vary dramatically when discussing urban versus rural settings. The scale of geographic coverage, volume of requests for service and transport, available resources, and options for increasing efficiency and productivity are significantly different in an urban system (Stout, 1994). EMS systems were selected to represent examples of the five most common provider types found in urban centres in the US (Williams and Ragone, 2010). Executive leaders interviewed included the physician medical director and senior operational leaders (i.e. chief executive officer, deputy chief) from each location. In the public utility model system, the chief executive of the authority and the chief executive of the contracted, private provider were interviewed.

Human subjects review

The research protocol was reviewed and approved by the Saybrook University Institutional Review Board. Objectives of the research study and description of how the data would be used were presented to the participants verbally and in writing in advance and at the start of the interviews. Written permission from each participant was obtained in advance using a consent form.

Participants were advised of all data collection methods (e.g. recorded telephone line). Complete transcripts and any written interpretations were made available to the participant at his or her request. Best interests of the participant's rights and confidentiality took priority when considering the reporting of data. Participants had the power to dictate their level of anonymity (Miller, 1992).

Experimental protocol

Fifteen potential design and operational features of an EMS system were identified by the author through a literature search (see *Table 1*). The search included government reports, peer-reviewed journal research, dissertation research, and non-peer reviewed EMS publications.

A survey was distributed by email to an executive leader at each EMS system (http://bit.ly/1PJyK4A). The survey was administered using a cloud-based survey tool (SurveyMonkey.com, Palo Alto, CA, USA). Completed survey results were downloaded to an Excel file (Excel 12.0 for Macintosh, Microsoft, Redmond, WA, USA). Submitted data was reviewed for omissions and potential data entry errors. Data in question was returned to the submitter for completion or confirmation of accuracy.

Interviews were conducted by telephone using voice-over-IP (Skype, Luxembourg City, Luxembourg) and recorded to mp3 files with an add-on programme: Call Recorder (Ecamm. North Andover, MA, USA). Participants were informed in advance and at the start of the interview of the audio recording and all granted their consent. Completed interviews were transcribed. Participants

Figure Legend—Interview Coding Legend		
Number	**Code**	**Code description**
1	ACC	Access
2	CAP	Capacity
3	CHAMP/SPON	Champion/sponsor
4	COMP	Compliance
5	CONC	Consensus
6	COST/FUND	Cost/Funding
7	CULT/TRAD	Culture/Tradition
8	DATA-DEF	Data Definition
9	DATA-KNOW	Data Knowledge
10	DATA-MEAS	Data Measure
11	GOVN	Governance
12	HRM-GEN	Human Resource General Management
13	HRM-LAB	Human Resource Management Organised Labour
14	HRM-REC/RET	Human Resource Management Recruitment/Retention
15	HRM-SAT	Human Resource Management Satisfaction
16	INDCP	Interdependent Components
17	KN/UN-GEN	Knowledge/Understanding—General
18	KN/UN-GOVN	Knowledge/Understanding—Governance
19	KN/UN-PROD	Knowledge/Understanding—Productivity
20	LIAB/RISK	Liability/Risk
21	MEN MOD	Mental Models
22	ORG SYS	Organisational System
23	OTH	Other
24	PI/PE	Public Information/Education
25	PROC/OUTC	Process/Outcome Focus
26	PSYCH	Psychology
27	PT	Patient(s)
28	PUR/MIS	Purpose/Mission
29	REG	Regulatory
30	RES/EVD	Research/Evidence
31	ROLE/ID	Role/Identity
32	STAKE-IN	Stakeholders—Internal
33	STAKE-OUT	Stakeholders—Out
34	STAND	Standardisation
35	SYS V/D	Systems View/Design
36	TECH	Technology
37	TRNG/EDU	Training/Education
38	UTI	Utilisation
39	WILL	Will

were provided an electronic copy of their transcribed interview to confirm the accuracy of the transcription and to consider adding or modifying comments. No requests were made to alter the transcript after review.

Each transcript (n=11) was reviewed and obstacles described by participants were highlighted in the text using the Microsoft Word (Microsoft Word 12.0 for Macintosh, Microsoft, Redmond, WA, USA) comments feature. An outside reviewer independently coded a stratified sample of the clinical and operational leader (n=6; 54.5%) interview transcripts. The independent coder received an example of a coded transcript and a list of codes to use. Additional codes could be added at the reviewer's discretion. Inter-rater reliability was high with only one missed obstacle identified by the external reviewer.

Each obstacle was recorded in a Bento Database version 3.0.3 (Filemaker, Inc, Santa Clara, CA, USA). Each record entry cited the i) name of participant, ii) system model identifier (e.g. hospital-based), iii) participant position/role (e.g. clinical or operational), iv) transcript location by page number and line number, v) type of obstacle, vi) description of the obstacle, and vii) number identifying the obstacle (Dean, 2004).

The participants identified 582 obstacles to the 15 features. Obstacles were initially summarised into a few descriptive words (e.g. not sure alternative transport destinations are less expensive). Then each description was assigned a broad theme (e.g. unclear cost savings). Finally, an affinity process was used to group obstacles into similar coding, resulting in 39 coded categories (e.g. cost/funding) (see *Figure Legend*) (Langley et al, 2009). The codes were rank ordered by frequency overall, which allowed for an analysis of a Pareto distribution showing the most frequently identified obstacles (Kenett, 1991). Analysis of the obstacles across features was conducted with the same approach.

Results

Case studies

The five cases where compared using five bundles of metrics, including i) socioeconomic indicators, ii) system design, iii) system activity, iv) performance measures, and v) financial measures.

Socioeconomic indicators across cases

The city populations ranged from 101 365–709 893; the median population was 537 734. The metropolitan statistical area populations ranged from 1 206 142–5 376 285, with a median of 1 652 602. Land area of the cities ranged from only 6 square miles to as much as 606 square miles; the

Table 2. System design features present in cases

System design feature	Case 1: fire service	Case 2: governmental third service	Case 3: private service	Case 4: hospital-based service	Case 5: public utility model
Advanced life support	Yes	Yes	Yes	Yes	Yes
Alternative transport destinations	No	No	No	No	No
Balanced scorecard	Limited	Limited	Limited	Limited	Yes
Customer satisfaction measurement	No	No	Yes	No	Yes
Demand-based employment	No	No	Yes	Yes	Yes
Economic efficiency	No	No	Yes	Limited	Yes
EMS health monitoring	No	Limited	Limited	No	
Full service	No	No	Yes	Yes	Yes
No call screening	Yes	Yes	Yes	Yes	Yes
Outcome-based performance measures	No	Limited	Limited	Limited	Limited
Preparedness	Limited	Limited	Limited	Limited	Limited
Public intervention	No	Limited	Limited	No	Limited
Quality improvement	Yes	Yes	Yes	Yes	Yes
Reduced call cycle time	Limited	Limited	Limited	Limited	Limited
Response time reliability	No	No	Yes	No	Yes

median was 251 square miles. Population density, or the number of people per square mile, ranged from 833.8 to 15 762.8 persons per square mile; the median was 2610.4 persons per square mile.

The percentage of the population identifying as White ranged from 33.2%–68.4%; the median was 65.4%. The percentage of persons aged 25 years or older reported as high school graduates ranged from 76.4%–89.5%; the median was 81.3%. The percentage of persons aged 65 years old or older ranged from 6.7%–11.5%; the median was 9.7%.

Per capita income ranged from $17 838–$31 156; the median was $24 163. The median household income ranged from $32 285–$47,979; the median for the five cities was $34 947.

Comparison of system design across cases

Three of the EMS systems were full service—providing both emergency 911 and non-emergency, interfacility ambulance service. One (the public utility model) was the exclusive provider of emergency and non-emergency ambulance service in its jurisdiction. The two governmental EMS systems (the fire service and the third service) were the only systems that exclusively served emergency 911 patients. In these two cases, non-emergency, interfacility ambulance service was provided by other organisations.

All five case cities were advanced life support (ALS) systems with a paramedic-level ambulance going on every emergency call. All but one EMS system staffed the paramedic ambulance with one paramedic and one EMT; the governmental third service staffed with two paramedics. Three EMS systems had medical first response at the ALS level: one was at the basic life support level and one was at the intermediate life support level. All five systems used a commercial protocol-based dispatch process for 911 caller interrogation and triage.

Response time goals for life-threatening emergencies ranged from 7 minutes 59 seconds to 9 minutes 59 seconds. All five systems measured reliability in achieving this goal at 90%. All but one of the EMS systems measured response times with the clock starting at some trigger for call receipt (e.g. phone pick up, first keyboard key stroke, etc.) and ending when the ALS ambulance arrived at the curb of the call location. The fire service system started the clock later in the call process (at the time the ambulance was dispatched) and did not include the call processing time.

Three of the five EMS systems have ambulances

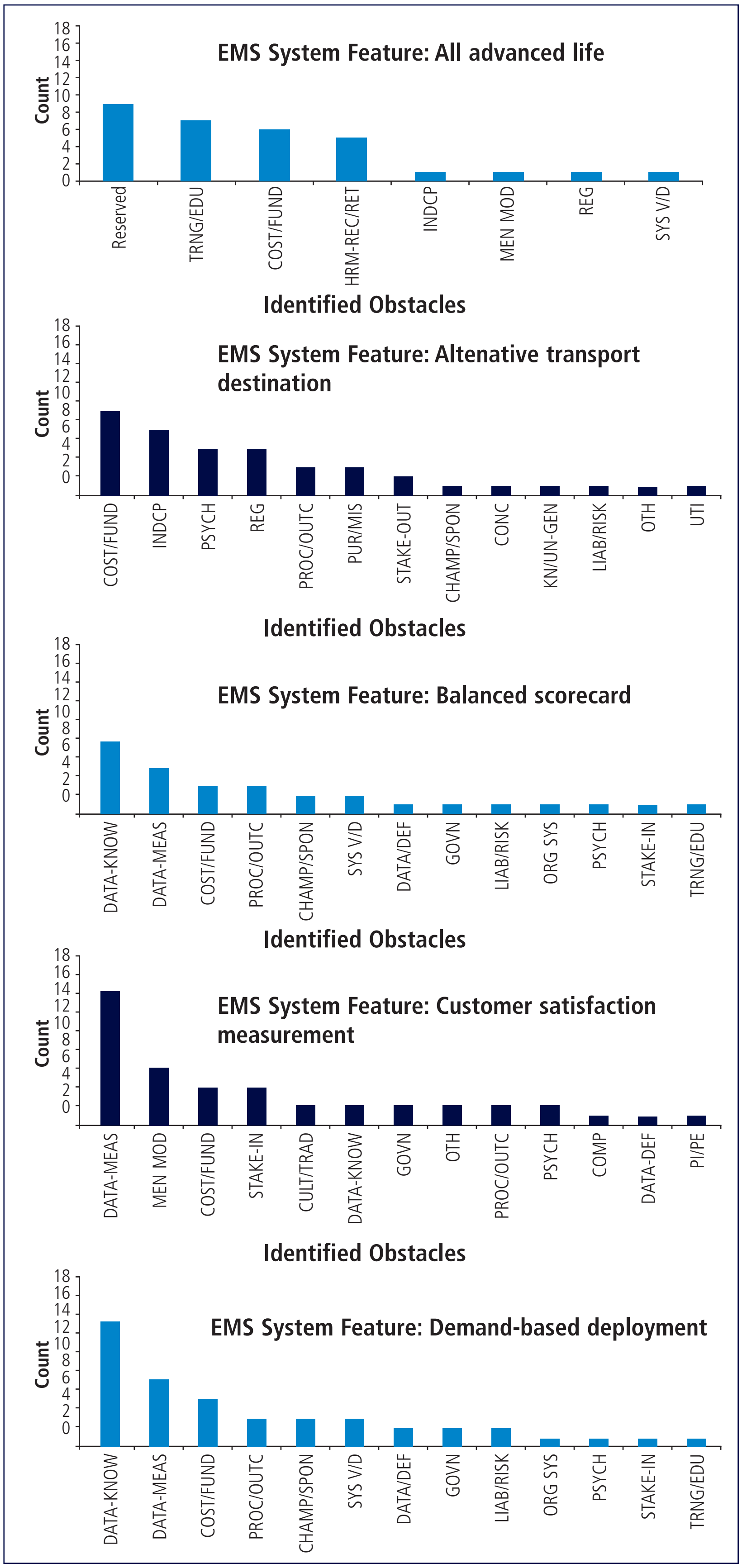

Figure 1. Small multiples of obstacles stratified by EMS system feature (pareto charts)

fully deployed at temporary locations throughout their service area such as key intersections able to respond quickly or relocate as coverage requirements dictate. One EMS system used a hybrid approach to deployment, mixing ambulances stationed in fixed locations (e.g. fire stations) with temporary locations. One EMS system used fixed posting locations only (e.g. fire stations).

Comparison of system activity across cases

Annual responses ranged from 21 000–97 000; the median was 73 845. Annual transports ranged from 16 000–68 000, with a median of 59 000. The percentage of patients transported ranged from 67%–76%, with a median of 73%. Non-transport rates ranged from 24%–33%, with a median of 27%.

The response unit hour utilisations range from 0.27–0.67, with a median of 0.52. Transport unit hour utilisations ranged from 0.20–0.47, with a median of 0.39.

Comparison of performance measures across cases

All cities reported a response time goal of 90% compliance. Four of the five EMS systems measured the time from call receipt at the medical dispatch centre to ambulance arrival at the call location. Compliance ranged from 85.9%–93.0%, with a median of 89.0%. Two EMS systems (governmental third service and the hospital-based service) were not in compliance with their goal at the time of the survey.

Cities reported data on one clinical outcome measure: the percentage of patients in sudden cardiac arrest (SCA) transported to the emergency department resuscitated with return of spontaneous circulation (ROSC). Four case cities reported data and the percentage ranged from 15%–50%, with a median of 20.23%. Cities reported data on three process measures related to the cycle time in STEMI, strokes, and life-threatening trauma. Two case cities reported the mean cycle time from symptom onset to percutaneous coronary intervention in STEMI patients, where the goal is 90 minutes. The mean times were 34 minutes 5 seconds and 42 minutes 2 seconds. Two case cities reported data on the mean cycle time from onset of stroke symptoms to emergency department arrival to enable the hospital to achieve the goal of intervention within 3 hours of onset of symptoms. The mean times were 38 minutes 47 seconds and 30 minutes 44 seconds. Two case cities reported data on the mean on-scene time in trauma patients with life-threatening injuries, where the goal is 10 minutes or less. The mean times were 17 minutes 5 seconds and 9 minutes 57 seconds.

Comparison of financial measures across cases

Annual EMS operating budgets in the four case cities reporting ranged from US$7 200 000–US$42 000 000. The median was US$23 180 033. The fire service case was excluded because it was an integrated department serving both a fire suppression mission and EMS service. It was not possible within the scope of this research to reliably determine cost of EMS delivery alone. The percentage of the annual EMS operating budget coming from tax subsidy ranged from 0%–36%, with a median of 10%. Two EMS systems received no community tax support and operated exclusively on user fee revenue.

The cost per capita ranged from US$43.97–US$71.03, with a median of US$45.21. The cost per unit hour ranged from US$147.26–US$178.43, with a median of US$149.34. The cost per response ranged from US$220.49–US$568.76, with a median of US$325.58. The cost per transport ranged from US$220.49–US$568.76, with a median of US$436.63.

Comparison of cases to the EMS system features

Table 2 summarises the case cities' adoption of the 15 EMS System features. All five case systems had adopted two design features: no call screening and all ALS. None of the systems had adopted alternative transport to destinations other than the emergency department. The public, exclusively 911 case systems had adopted the fewest system design features with just three: no call screening, all ALS, and quality improvement. The public utility model system and private provider systems exhibited adoption of the most system design features, with 10 and 8 features respectively. Five design features had 'limited' or no adoption: public intervention, reduced call cycle time, outcome-based performance measures, preparedness, and EMS health screening. The public utility system was the only case system to adopt a balanced scorecard.

Qualitative interviews

Interviews were conducted with senior clinical and operational leadership in each case EMS system, and a total of 582 obstacles were identified. Obstacles were organised into 39 categories and ranked from most commonly noted to the least common and displayed in a Pareto chart (*Figure 2*). *Figure 3* displays the number of obstacles identified per EMS system feature and *Figure 1* presents the obstacles to each EMS system feature in individual Pareto charts.

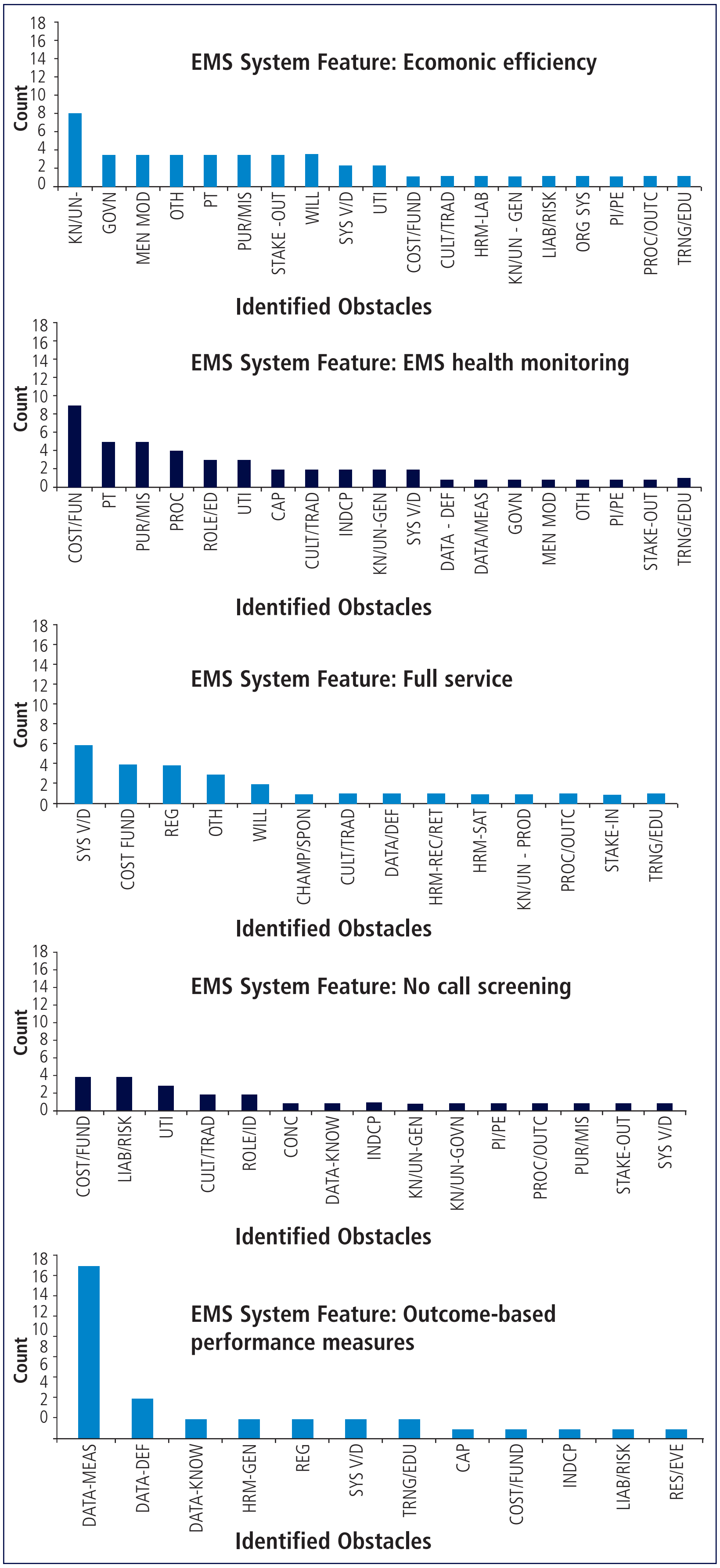

Figure 1. Continued

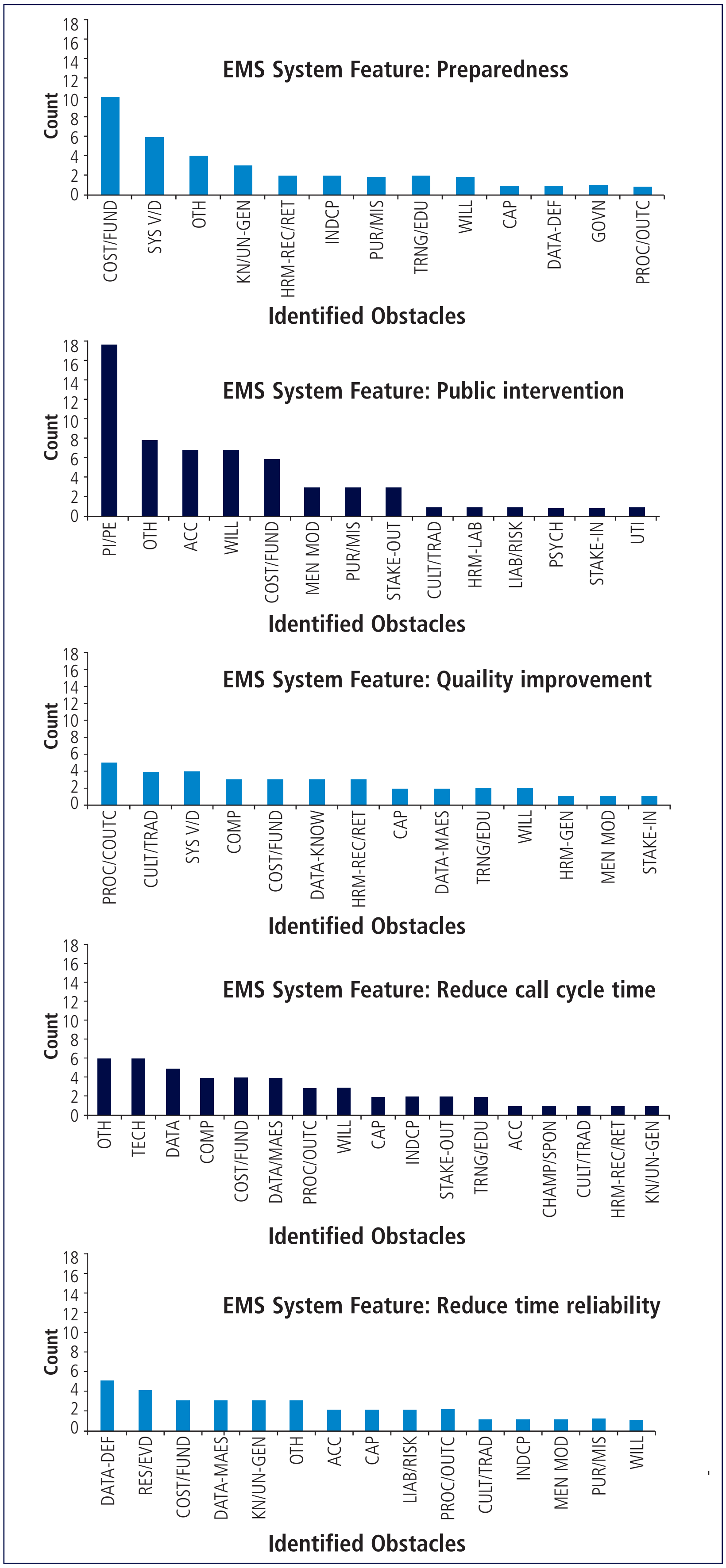

Figure 1. Continued

The top 10 categories represented 50.4% (293) of the total obstacles identified and were as follows: 1) cost and funding (70, 12.0%), the perception that adding a feature meant additional cost and required additional funding; 2) data measurement (46, 7.9%), the need to establish data collection methods and measure data effectively; 3) process and outcome focus (31, 5.3%), focusing on what the EMS system is aiming to achieve and then creating reliable processes to deliver the results; 4) systems view or design (26, 4.5%), appreciating an EMS system as interdependent parts working in concert and designed to produce the desired outcomes; 5) public information and education (22, 3.8%), increasing public awareness and knowledge about what the EMS system does, what citizens can do to help during life-threatening emergencies, and understanding the value of an effective EMS system; 6) knowledge or understanding of productivity (21, 3.6%), internal appreciation for the theories and methods of production strategies; 7) training or education (20, 3.4%), additional staff development is required to implement a feature; 8) will (20, 3.4%), individuals require the will to implement; 9) data definitions (19, 3.3%), a need for universal, operational definitions for measurement indicators; and 10) culture or tradition (18, 3.1%), requires overcoming the status quo or embedded professional culture.

Discussion

The case study comparisons showed variation in practices and results similar to those noted in other comparisons in trade magazines and peer-reviewed journal articles (Nichol et al, 2008; Ward, 2013). Features like not screening calls, all advanced life support staffing, and use of quality improvement methods were present. Features not universally adopted included areas of focus from healthcare reform and the Institute for Healthcare Improvement's Triple Aim, such as assuring access with response time reliability and matching supply and demand, the ability to monitor and improve care quality with measurement of key care pathways, understanding customer experience, or practices to produce per capita cost (Berwick et al, 2008).

The study results are consistent with the findings of several reports published in recent years around cost and funding. Dean (2004) found EMS systems' stakeholders identified funding as a significant obstacle, but that EMS systems that had less funding had more of the quality factors in place than those with more funding. The author suggested that funding

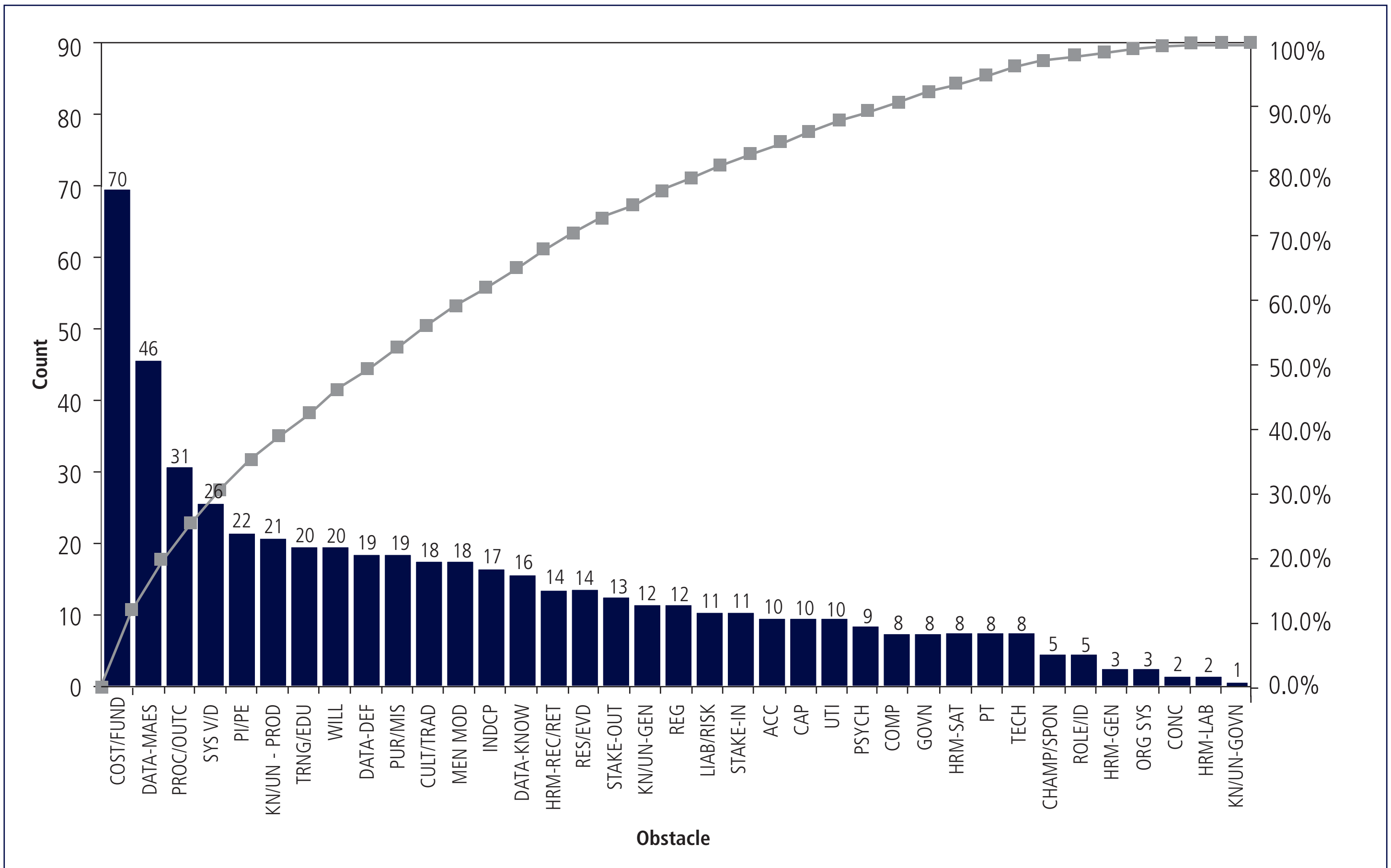

Figure 2. Summary of Obstacles Identified by EMS Leaders (Pareto Chart)

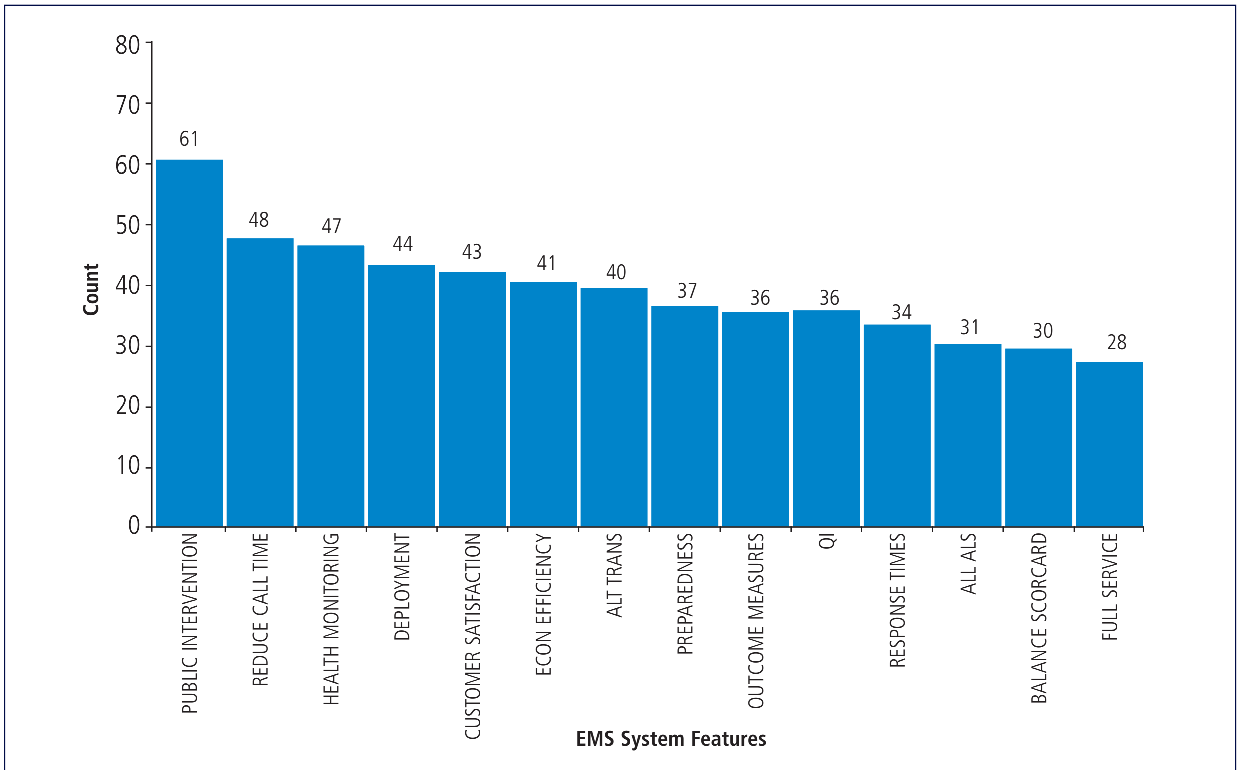

Figure 3. Obstacles Identified per Feature (Pareto Chart)

Key points

- There is a paucity of global research on emergency medical services (EMS) systems.
- Perceived cost or issues with funding are identified as a barrier to features but more efficient systems report more features in place.
- There is a limited research culture in EMS. Leaders rely on personal experience more than published research.
- Features related to the Institute for Healthcare Improvement's Triple Aim—patient experience, quality of care, cost—were not universally in place.
- Universal agreement on EMS measurement limits benchmarking.

might not be as significant a barrier as perceived. The Institute of Medicine report—*EMS at the Crossroads*—discussed funding issues and highlighted the difficulty in quantifying the cost of service delivery across diverse system types and the limitations of the funding model to ensure the cost of readiness (Institute of Medicine, 2006). The Government Accounting Office has published two reports showing wide variation in ambulance provider costs and the difficulty of accounting for costs in fire-based EMS systems (Government Accountability Office, 2007; 2012).

Data collection and measurement issues are now actively being addressed, with recommendations for key care pathways to measure, published draft measure definitions, and work underway with the National Health Service Ambulance Trusts in England (Myers et al, 2008; National Highway Traffic Administration, 2009; Siriwardena et al, 2010). The measures mainly cover clinical care and some limited operational processes. Healthcare improvement can provide best practice examples for data reporting and display (i.e. time series charting) to enable improvement and reliability and understanding and reduction of variation (Perla et al, 2011; Provost and Murray, 2011).

Education of the public to improve awareness was identified as an obstacle. The Institute of Medicine report advocated development of stronger accountability, with the public dissemination of performance data helping justify the case for EMS system change and improvement. Increasing bystander willingness or comfort to intervene in emergencies remains an ongoing challenge (Sasson et al, 2013).

Reports in Canada, Ireland, Australia, and the US all cite limited EMS research. The Canadian Research Agenda summarises the major themes for clinicians and leaders to act including improving EMS data, enhancing research education, building a research culture, and fostering partnerships to enhance the 'research enterprise' (Jensen et al, 2013). Further, conducting and publishing studies specific to EMS system structures, processes, and outcomes (Donabedian, 1988) may support removing obstacles and improving quality.

An overarching perception from the qualitative interviews was an absence of consistent knowledge of existing research and present gaps in the evidence base. Leaders relied on their own experience and understanding, and there was varying will to locally study and disseminate data driven learning of what works and what does not. This perception is consistent with the theme or opportunity to develop a research culture described in the Canadian *National EMS Research Agenda*. Clinicians and leaders can improve knowledge and systems through inquiry to understand the structures required and processes necessary to improve outcomes. This requires an appreciation of systems and the interdependency of linked processes (Maccoby et al, 2013). There may be no single EMS system design that is better than another, but a systems view of improvement and continuous research supports improving health, enhancing patient experience, and reducing per capita costs.

Limitations

This study does have several limitations:

The multi-case study represents a small sample of urban EMS systems only and the case sites are all within the US. To understand whether these findings are relatively universal would require a larger sample of EMS systems representing broader demographics.

Uniform and universally accepted outcome and process measure are not defined and operationalised across EMS systems. The lack of an accepted data dictionary makes lateral comparison difficult. Data was self-reported and not independently validated.

The data analysis of identified obstacles relied on self-reported experiences or perceptions. The interview participants included clinical and operational leaders only. Adding in care providers, middle managers, support staff, and policy maker perspectives may produce additional insights.

The 15 features were identified through a literature review and the experience of a single researcher. A cohort of researchers may identify additional or different features worthy of consideration and further exploration.

Conclusions

Research on EMS systems is limited and no study has looked at obstacles to adoption of specific features of an EMS system. The five case studies show variability in metrics, including operating cost, clinical performance, and economic efficiency. The clinical and operational interviews reveal 582 independent obstacles in 39 distinct categories to achieving the 15 features. More research is needed to define attributes of patient-centric EMS systems and the barriers to reliably achieving them across diverse provider models.

Conflict of interest: none declared

References

American Ambulance Association (2008) *EMS structured for Quality: Best Practices in Designing, Managing and Contracting for Emergency Ambulance Service*. American Ambulance Association, McLean, VA

Berwick DM, Nolan TW, Whittington J (2008) The triple aim: care, health, and cost. *Health Aff (Millwood)* **27**(3): 759–69. doi: 10.1377/hlthaff.27.3.759

Center for Leadership, Innovation and Research in EMS (2005) *Benchmarking*. www.clirems.org/Benchmarking (accessed 7 December 2015)

Dean SF (2004) A study of the political and economical obstacles to improvement of emergency medical services systems. Unpublished doctoral dissertation. University of Maryland, Baltimore County

Donabedian A (1988) The quality of care. How can it be assessed? *JAMA* **260**(12): 1743–8. doi: 10.1001/jama.1988.03410120089033

Dunford J, Domeier RM, Blackwell T et al (2002) Performance measurements in emergency medical services. *Prehosp Emerg Care* **6**(1): 92–8

Government Accountability Office (2007) *Ambulance Providers: Costs and Expected Medicare Margins Varied Greatly*. Government Accountability Office, Washington, D.C.

Government Accountability Office (2012) *Ambulance Providers: Costs and Medicare Margins Varied Widely; Transports of beneficiaries have increased*. Government Accountability Office, Washington, D.C.

Institute of Medicine (2006) *Emergency Medical Services: At the Crossroads*. National Academies Press, Washington D.C.

International Association of Fire Fighters (2007) *Prehospital 911 Emergency Medical Response: The Role of the United States Fire Service in Delivery and Coordination*. International Association of Fire Fighters, Washington D.C.

Jenson, JL, Blanchard, IE, Bigham, BL et al (2013) *Canadian National EMS Research Agenda*. EMS Chiefs of Canada, Ottawa

Kenett RS (1991) Two methods for comparing Pareto charts. *J Qual Technol* **23**(4): 287–95

Langley GJ, Nolan KM, Nolan TW, Norman CL, Provost LP (2009) The Improvement Guide: A Practical Approach to Enhancing Organizational Performance. 2nd edn. Jossey-Bass, San Francisco

Maccoby, M, Norman, CL, Norman, CJ, Margolies R (2013) *Transforming Health Care Leadership: A Systems Guide to Improve Patient Care, Decrease Costs, and Improve Population Health*. Jossey-Bass, San Francisco

Miller DL (1992) The experiences of a first-year college president: an ethnography. Unpublished doctoral dissertation, University of Nebraska, Lincoln

Myers JB, Slovis CM, Eckstein M et al (2008) Evidence-based performance measures for emergency medical services systems: A model for expanded EMS benchmarking. *Prehosp Emerg Care* **12**(2): 141–51. doi: 10.1080/10903120801903793

National EMS Advisory Council (2003) *EMS Makes a Difference: Improved Clinical Outcomes and Downstream Healthcare Savings*. National EMS Advisory Council, Washington, D.C.

National Highway Traffic Safety Administration (2001) *National EMS Research Agenda*. National Highway Traffic Safety Administration, Washington D.C.

National Highway Traffic Safety Administration (2009) *Emergency Medical Services Performance Measures: Recommended Attributes and Indicators for System and Service Performance*. National Highway Traffic Safety Administration, Washington, D.C.

Nichol G, Thomas E, Callaway CW et al (2008) Regional variation in out-of-hospital cardiac arrest incidence and outcome. *JAMA* **300**(12): 1423–31. doi: 10.1001/jama.300.12.1423

Overton J, Anderson D (2006) *High performance and EMS: Market study 2005*. Coalition of Advanced Emergency Medical Systems, Richmond, VA

Perla RJ, Provost LP, Murray SK (2011) The run chart: A simple analytic tool for learning from variation in healthcare processes. *BMJ Qual Saf* **20**(1): 46–51. doi: 10.1136/bmjqs.2009.037895

Provost LP, Murray SK (2011) *The Health Care Data Guide: Learning from Data for Improvement*. Jossey-Bass, San Francisco

Sasson C, Meischke H, Abella BS et al (2013) Increasing cardiopulmonary resuscitation provision in communities with low bystander cardiopulmonary resuscitation rates: a science advisory from the American Heart Association for healthcare providers, policymakers, public health departments, and community leaders. *Circulation* **127**(12): 1342–50. doi: 10.1161/CIR.0b013e318288b4dd

Scholz RW, Tietje O (2002) *Embedded Case Study Methods: Integrating Quantitative and Qualitative Knowledge*. Sage Publications, Inc, London

Siriwardena AN, Shaw D, Donohoe R, Black S, Stephenson J, National Ambulance Clinical Audit Steering Group (2010) Development and pilot of clinical performance indicators for English ambulance services. *Emerg Med J* **27**(4): 327–31. doi: 10.1136/emj.2009.072397

Spaite DW, Criss EA, Valenzuela TD, Guisto J (1995) Emergency medical services systems research: problems of the past, challenges of the future. *Ann Emerg Med* **26**(2): 146–52. doi: 10.1016/S0196-0644(95)70144-3

Stout JL (1994) System financing. In: Roush W, ed. *Principles of EMS Systems*. 2nd edn. American College of Emergency Physicians, Dallas: 451–71

Stout JL (1997) How benchmarking can improve your ambulance service: capture the competitive edge. *JEMS* **22**(9): 50–1, 53–6

Ward MJ (2013) Forecast for the future? JEMS 200-city survey shows recession continues to affect EMS in 2012 and beyond. *JEMS* **38**(2): 28–35

Williams DM (2006) The myth of the perfect model. *Emerg Med Serv* **35**(9): 90–8, 100–2

Williams DM, Ragone M (2010) 2009 JEMS 200-city survey: Zeroing in on what matters. *JEMS* **35**(2): 38-42. doi: 10.1016/S0197-2510(10)70040-1

Yin RK (2003) Case Study Research: Design and Methods. 3rd edn. Sage Publications, Inc. Thousand Oaks, CA