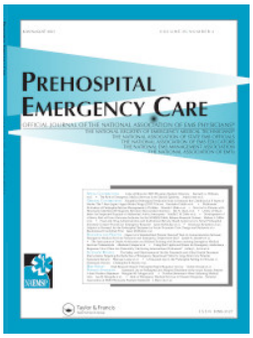

Prehospital Emergency Care

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ipec20

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To cite this article: Melissa L. Miller, Erin W. Lincoln & Lawrence H. Brown (2021) Development of a Binary End-of-Event Outcome Indicator for the NEMSIS Public Release Research Dataset, Prehospital Emergency Care, 25:4, 504-511, DOI: 10.1080/10903127.2020.1794435

To link to this article: https://doi.org/10.1080/10903127.2020.1794435

Development of a Binary End-of-Event Outcome Indicator for the NEMSIS Public Release Research Dataset

Melissa L. Miller, MD, Erin W. Lincoln, MD, Lawrence H. Brown, PhD

Abstract

Introduction: Emergency department and hospital discharge status are available for less than 2% of events recorded in the National EMS Information System (NEMSIS) Public Release Research dataset. The purpose of this project was to develop a binary ("dead" vs. "alive") end-of-event outcome indicator for the NEMSIS dataset. **Methods**: The data dictionary for the Version 3 NEMSIS dataset was evaluated to identify elements and codes providing information about a patient's end-of-event status—defined as the point at which EMS providers stopped providing care for an encountered patient, whether at the scene of the event or the transport destination. Those element and code combinations were then used to test the criteria using the NEMSIS-2017 dataset. After revising the criteria based on the NEMSIS-2017 results, the final criteria were then applied to the 2018 NEMSIS dataset. To assess representativeness, the characteristics of events with a determinable outcome were compared to those of the entire dataset. To assess accuracy, the end-of-event indicator was compared with the final reported outcome for patients with a known emergency department disposition. **Results**: Eighteen NEMSIS element and code combinations suggest a patient was likely "dead" at the end of EMS care, and 15 combinations suggest a patient was likely "alive" at the end of EMS care. A binary end-of-event outcome indicator could be determined for 13,045,887 (98.6%) of the 13,229,079 NEMSIS-2018 9-1-1 initiated ground EMS responses in which patient contact was established, and for 132,728 (89.1%) of the 148,963 events with documented cardiac arrest. The characteristics of the events with determinable end-of-event outcomes did not differ from those of the full dataset. Among patients with a known outcome, 99.6% of those with an "alive" end-of-event indicator were in fact alive at the time of emergency department disposition. **Conclusion**: A binary end-of-event outcome indicator can be determined for 98.6% of 9-1-1 initiated ground EMS scene responses and 89.1% of cardiac arrests included in the NEMSIS dataset. The events with a determinable outcome appear representative of the larger dataset and the end-of-event indicators are generally consistent with reported emergency department outcomes. **Key words:** National EMS Information System (NEMSIS); treatment outcomes; emergency medical services

PREHOSPITAL EMERGENCY CARE 2021;25:504–511

Received May 26, 2020 from Division of Emergency Medicine, Department of Surgery and Perioperative Care, Dell Medical School, University of Texas, Austin, Texas (MLM, EWL, LHB). Revision received June 22, 2020; accepted July 6, 2020.

No potential conflict of interest was reported by the author(s).

LHB conceived the study; MLM, EWL and LHB designed the study and developed the methodology; LHB executed the analysis; MLM, EWL and LHB reviewed and interpreted the results; LHB drafted the manuscript and MLM, EWL and LHB all made critical contributions to the revision of the final manuscript.

Presented at the National Association of EMS Physicians Annual Meeting, San Diego, CA, January 2020.

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Supplemental data for this article is available on the publisher's website.

This article was originally published with errors, which have now been corrected in the online version. Please see Correction (http://dx.doi.org/10.1080/10903127.2020.1866345).

doi:10.1080/10903127.2020.1794435

Introduction

The National EMS Information System (NEMSIS) issues a "Public Release Research Dataset" every year (1). The NEMSIS dataset enables retrospective analyses based on data from a broad sample of U.S. EMS systems. While prospective randomized trials are considered the "gold standard" for studies of therapeutic interventions, retrospective analyses remain important in all of health care. Particularly in the age of "big data," they can establish important associations more efficiently than prospective studies—most notably for rare events. They can also provide preliminary data that lead to subsequent prospective studies. Finally, they are often more appropriate than prospective studies for evaluating outcomes associated with potentially harmful exposures (2–4).

Distal outcome measures such as neurologic status at hospital discharge, 30-day readmission or one-year all-cause mortality are not included in or linkable to the NEMSIS dataset. Emergency department and hospital discharge status are reported, but only for a small portion of NEMSIS records—less than 2% in the 2017 and 2018 NEMSIS datasets.

There is also no single NEMSIS element that identifies patient "end-of-event" status—that is, patient status at the point EMS providers stop providing care.

The purpose of this project was to develop a binary end-of-event outcome indicator for the Version 3 iterations of the NEMSIS Public Release Research Dataset, to assess how well the cases with a determinable end-of-event indicator represent the total dataset, and—where possible—to assess agreement between the end-of-event indicator and the reported emergency department disposition.

Methods

Development of the Binary End-of-Event Outcome Indicator

The Version 3 NEMSIS Public Release Research Dataset data dictionary (5) was evaluated to identify elements and codes potentially providing information about a patient's end-of-event status. End-of-event was defined as the point at which the EMS providers stopped providing care for an encountered patient, whether at the scene of the event or at the transport destination. Patient status was defined as "presumptively alive" or "presumptively dead," with presumptively dead including pulseless patients undergoing continued resuscitation.

The three authors independently evaluated NEMSIS *Scene*, *Situation*, *Disposition* and *Arrest* elements to identify specific codes that suggest a patient was likely dead at the end of the event, and specific codes that suggest a patient was likely alive at the end of the event. Only elements and codes that all three authors agreed were indicative of a patient's end-of-event status were used to create the initial end-of-event indicator.

These original criteria were then applied to the NEMSIS-2017 database to generate both presumptively alive and presumptively dead indicators (separately) for the included events. This process was limited to events that represent 9-1-1 initiated responses to an emergency scene by a ground transport EMS unit that resulted in patient contact.

Resolving Missing and Conflicting End-of-Event Indicators

Using the original criteria, approximately 7% of NEMSIS-2017 events had no end-of-event indicator, and 0.4% had conflicting end-of-event indicators. For example, *Patient Disposition* coded as "Patient treated, transported by private vehicle" would intuitively suggest the patient was alive at the end of EMS contact. However, that code could coexist with a *Final Patient Acuity* coded as "Dead without resuscitation efforts" and *Type of Destination* coded as "Morgue/Mortuary"—more likely suggesting that a deceased patient was transported by a private mortuary service. For events with missing or conflicting end-of-event indicators, we generated and manually explored frequency tables and cross tabulations of the various NEMSIS *Scene*, *Situation*, *Disposition* and *Arrest* elements in order to identify combinations of codes that might resolve the end-of-event status.

Generating and Testing the Final End-of-Event Indicators

After identifying additional element and code combinations that resolved the majority of events with missing or conflicting end-of-event indicators, the final criteria were then applied de-novo to the NEMSIS-2018 research dataset. Again, this analysis was limited to events representing 9-1-1 initiated scene responses by a ground transport EMS unit that resulted in patient contact.

Assessing Representativeness of Events with a Determinable End-of-Event Indicator

Some events continued to have no clear dead or alive indicator, or conflicting dead and alive indicators. To assess whether the subset of events with determinable, non-conflicting end-of-event indicators were representative of the full dataset, we compared their patient and event characteristics to those of all ground 9-1-1 initiated scene responses with patient contact included in the NEMSIS-2018 dataset. Given the extreme size of the NEMSIS dataset, we focused on practical similarities between cases with and without end-of-event indicators, rather than statistical differences.

Assessing Agreement between End-of-Event Indicators and Emergency Department Disposition

We also assessed agreement between the derived end-of-event indicator and the known emergency department outcome for the subsample of included events with a documented, final emergency department disposition. Events with an emergency department disposition coded as admitted (code 09) or discharged or transferred (codes 01 – 09; 21; 43-70) were considered to represent patients who were alive; events with an emergency department disposition coded as deceased/expired (code 20) were

TABLE 1. Criteria for binary end-of-event outcome indicator = "presumptively dead"

Criterion	NEMSIS Element and Code
MCI triage classification: black / deceased	escene_08 = 2708009
Initial patient acuity: dead without resuscitation efforts (black)	esituation_13 = 2813007
Patient dead at scene, no resuscitation attempted (with transport)	edisposition_12 = 4212013
Patient dead at scene, no resuscitation attempted (without transport)	edisposition_12 = 4212015
Patient dead at scene, resuscitation attempted (without transport)	edisposition_12 = 4212019
Final patient acuity: dead without resuscitation efforts (black)	edisposition_19 = 4219007
Type of destination: morgue/mortuary	edisposition_21 = 4221009
Resuscitation not attempted due to perceived futility	earrest_03 = 3003007
Resuscitation not attempted due to DNR	earrest_03 = 3003009
Resuscitation without ROSC	earrest_12 = 3012001
Non-perfusing rhythm present at ED arrival (agonal)	earrest_17 = 9901001
Non-perfusing rhythm present at ED arrival (asystole)	earrest_17 = 9901003
Non-perfusing rhythm present at ED arrival (PEA)	earrest_17 = 9901035
Non-perfusing rhythm present at ED arrival (AED Shockable Rhythm)	earrest_17 = 9901065
Non-perfusing rhythm present at ED arrival (VF)	earrest_17 = 9901067
Non-perfusing rhythm present at ED arrival (pulseless VT)	earrest_17 = 9901071
Resuscitation discontinued due to DNR	earrest_16 = 3016001
Resuscitation discontinued due to obvious signs of death	earrest_16 = 3016005
End of cardiac arrest status: expired in field	earrest_18 = 3018003

considered to represent patients who had died. Events with no emergency department disposition but with a hospital disposition of admitted, transferred or discharged alive were also presumed to represent patients who were alive at the time of emergency department disposition. We evaluated agreement between the end-of-event indicator and the final emergency department outcome using Kappa.

Data Management

All of the data manipulations and calculations were performed in Stata Version 16.0 (StataCorp, College Station, TX). The Stata commands for creating the binary end-of-event outcome indicator are included in Appendix A (supplemental material), and are also available from the authors as an annotated Stata ".do file."

Ethics Approval

The Office of Research Support and Compliance at the University of Texas affirmed that this study did not constitute human subjects research.

RESULTS

All three authors originally agreed that 18 unique NEMSIS element and code combinations suggest a patient was likely dead at the end of EMS care (Table 1), and 13 NEMSIS element and code combinations suggest a patient was likely alive at the end of EMS care (Table 2). For example, *Cardiac Rhythm on Arrival at Destination* coded as "Asystole" suggests a patient was presumptively dead at the end of EMS care, regardless of whether resuscitation was ongoing at the destination. *Patient [Field] Disposition* coded as "Patient treated, released (AMA)" suggests the patient was alive at the end of EMS care. A physiologically viable systolic blood pressure—which we defined as 60 to 280 mmHg—recorded within three minutes before or one minute after arrival at the receiving destination was also interpreted as suggesting a transported patient was presumptively alive at the end of EMS care.

NEMSIS-2017 contains information on 7,907,829 events, of which 4,728,800 (59.8%) represent 9-1-1 initiated scene responses by a ground transport EMS unit that resulted in patient contact. Using the original consensus criteria, 326,963 (6.9%) of these events had neither a dead nor an alive end-of-event indicator, and 20,093 (0.4%) produced conflicting end-of-event outcome indicators. A non-conflicting end-of-event outcome indicator could be determined for 4,381,744 (92.7%) of the events, including 48,351 (87.5%) of the 55,247 cases with documented cardiac arrest (i.e., *Cardiac Arrest* element coded as "Yes, prior to EMS arrival" or "Yes, after EMS arrival"). Among the events with a determinable end-of-event outcome indicator, 98.9% of patients were presumptively alive and 1.1% of patients were presumptively dead at the end of EMS care.

Resolution of Missing and Conflicting End-of-Event Indicators

After manual analysis of the events with missing or conflicting end-of-event indicators, three useful

Table 2. Criteria for binary end-of-event outcome indicator = "presumptively alive"

Criterion	NEMSIS Element and Code
No dead criteria met AND cardiac arrest documented as "No"	earrest_01 = 3001001
Resuscitation discontinued due to ROSC	earrest_16 = 3016011
Perfusing rhythm with pulse at ED arrival (VT with pulse)	earrest_17 = 9901069
End of cardiac arrest status: ROSC in field	earrest_18 = 3018007
Patient evaluated, no treatment/transport required	edisposition_12 = 4212021
Patient refused evaluation/care (without transport)	edisposition_12 = 4212025
Patient treated, released (AMA)	edisposition_12 = 4212027
Patient treated, released (per protocol)	edisposition_12 = 4212029
Patient treated, transported by law enforcement	edisposition_12 = 4212035
Patient treated, transported by private vehicle	edisposition_12 = 4212037
Final patient acuity: emergent (yellow)	edisposition_19 = 4219003
Final patient acuity: lower acuity (green)	edisposition_19 = 4219005
Viable Systolic Blood Pressure (60-280 mmHg) at destination arrival	evitals_06 > 60 & < 280; [etimes_11] – [evitals_01] < 3 & > −1
No dead criteria met, patient treated, transported by this unit, AND …	edisposition_12 = 4212033
no indication of cardiac arrest before EMS arrival	earrest_01 ≠ 3001003
no indication of cardiac arrest after EMS arrival	earrest_01 ≠ 3001005
no indication of defibrillation under "resuscitation attempted"	earrest_03 ≠ 3003001
no indication of ventilation under "resuscitation attempted"	earrest_03 ≠ 3003003
no indication of compressions under "resuscitation attempted"	earrest_03 ≠ 3003005
no indication of defibrillation under "procedures"	eprocedure_03 ≠ 426220008; 450661000124102
no indication of CPR under "procedures"	eprocedure_03 ≠ 429283006; 89666000
No dead criteria met AND organized final cardiac rhythm:	
atrial fibrillation; atrial flutter; first degree block;	earrest_17 = 9901007; 9901009; 9901011
left bundle branch block; right bundle branch block; sinus arrhythmia	9901021; 9901041; 9901043
normal sinus rhythm; sinus tachycardia; supraventricular tachycardia	9901047; 9901049; 9901059

Shaded criteria were added after review of the initial consensus criteria applied to the NEMSIS-2017 dataset.

clarifying element and coding combinations emerged. These are highlighted in Table 2 and described below:

First, 14,395 (71.6%) of the events with conflicting dead and alive indicators were events with codes suggesting the patient was found dead and that no resuscitative efforts were attempted (e.g., *Initial Patient Acuity* = "Dead without resuscitation efforts"), but with the *Cardiac Arrest* element coded as "No." This likely represents a documentation practice of casting cardiac arrest as synonymous with resuscitation attempted. Thus, we revised the criteria so that events with *Cardiac Arrest* coded as "No" were only assigned a presumptively alive indicator if they also did not meet any of the presumptively dead indicator criteria.

Second, 257,241 (78.8%) of the events with a missing end-of-event indicator were events with the field disposition coded as "Patient treated, transported by this unit." Thus, we revised the criteria to apply a presumptively alive indicator to events with no indication of cardiac arrest, no other dead indicator criteria, and a field disposition of "Patient treated, transported by this unit."

Finally, 407 (26.3%) of 1,548 cardiac arrest events with a missing end-of-event indicator reported an organized cardiac rhythm—that was not also documented as pulseless electrical activity—upon arrival at the transport destination. Thus, we revised the criteria so that events in which the patient had a non-PEA organized rhythm upon arrival at the transport destination, and that also did not meet any other presumptively dead indicator criteria, were assigned a presumptively alive indicator. As in our original process, only cardiac rhythms that all three authors agreed likely represented perfusing rhythms were included in this criterion.

Applying the Final Criteria to the NEMSIS-2018 Dataset

The NEMSIS-2018 Dataset contains 22,532,890 events, of which 13,229,079 (58.7%) represent 9-1-1 initiated responses by a ground transport EMS unit that resulted in patient contact. Using the final criteria, 165,572 (1.3%) of these events had neither a dead nor an alive end-of-event indicator, and 17,620 (0.1%) produced conflicting end-of-event outcome indicators. A non-conflicting end-of-event outcome indicator could be determined for 13,045,887 (98.6%) of the events, including 132,728 (89.1%) of the 148,963 cases with documented cardiac arrest.

Among the events with a determinable end-of-event outcome indicator, 98.6% of patients were presumptively alive and 1.4% of patients were presumptively dead at the end of the EMS encounter. For all cardiac arrest events with a determinable end-of-event outcome, 18.2% of patients were

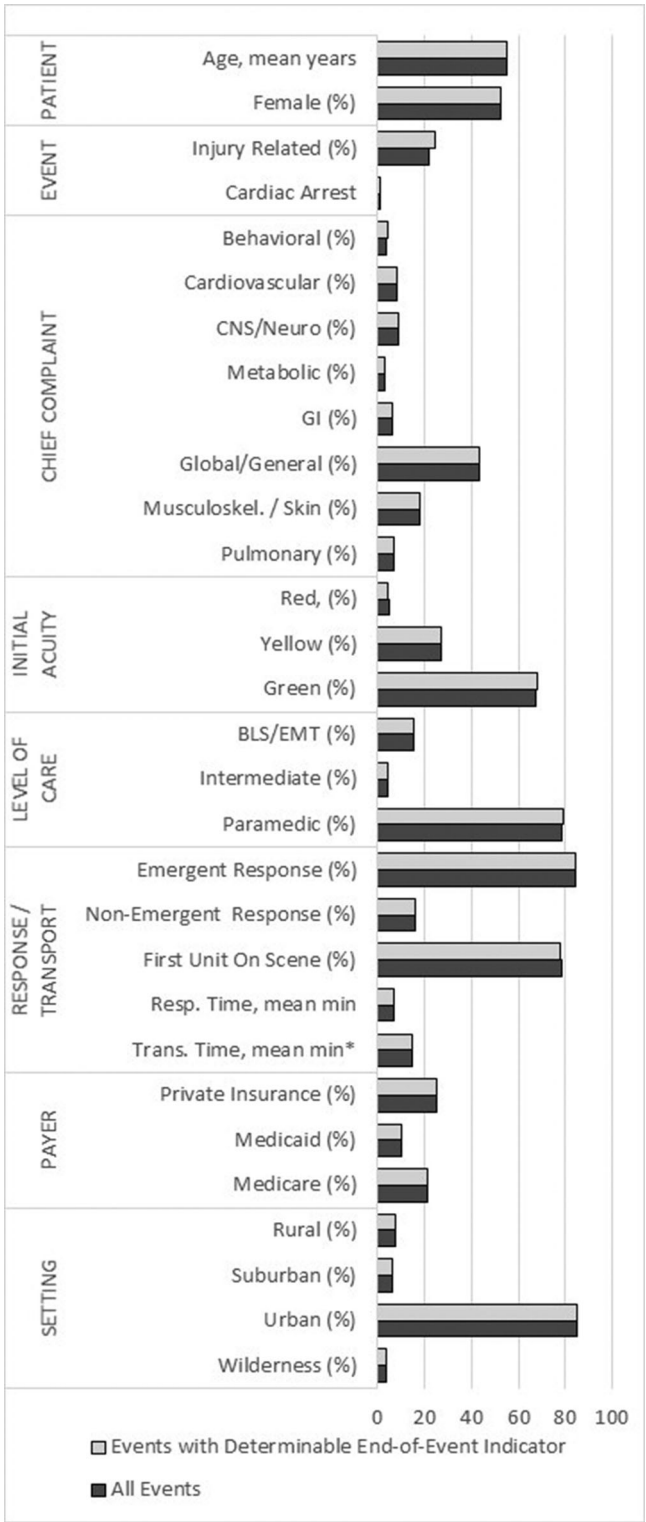

FIGURE 1. Comparison of events with a determinable end-of-event indicator to all NEMSIS ground 9-1-1 initiated scene responses with patient contact.

presumptively alive and 81.8% were presumptively dead. For the 90,668 cardiac arrest events in which resuscitation was attempted, 22,100 (24.4%) were

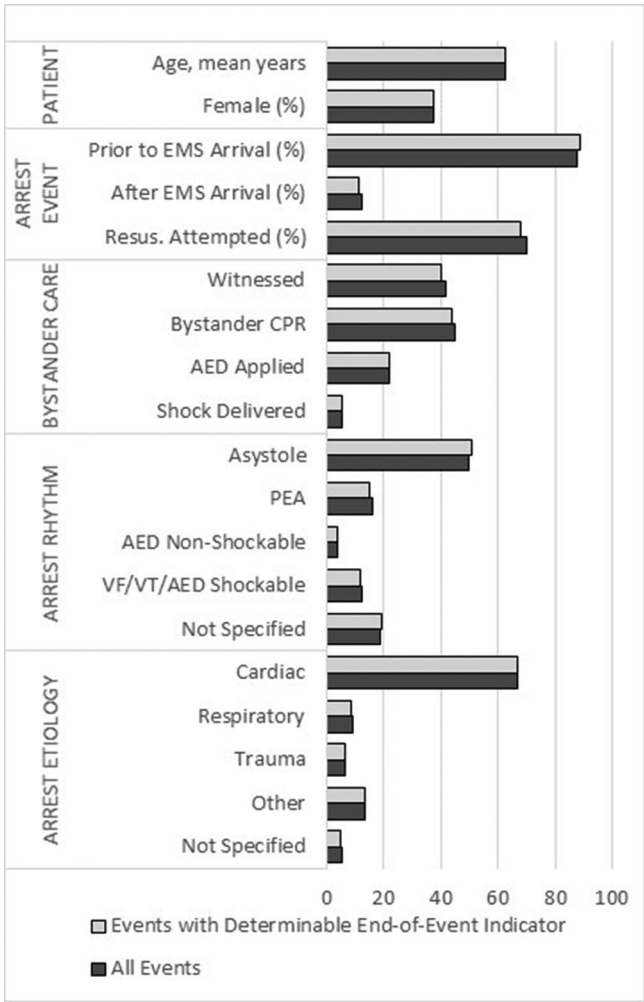

FIGURE 2. Figure 1: Comparison of cardiac arrest events with a determinable end-of-event indicator to all NEMSIS ground 9-1-1 initiated scene responses with patient contact documented as cardiac arrest.

presumptively alive and 68,568 (75.6%) were presumptively dead at the end of EMS care.

Representativeness of Events with a Determinable End-of-Event Indicator

Figure 1 compares the event and patient characteristics for all 9-1-1 initiated scene responses by a ground transport unit in the NEMSIS-2018 dataset with the characteristics of the events with a determinable end-of-event indicator. Detailed tabular comparisons are shown in Appendixes B-F (supplemental material). The events with determinable end-of-event outcomes appear nearly perfectly representative of the full dataset. Figure 2 compares the event and patient characteristics among cardiac arrest events. Although cardiac arrest events overall were less likely to have a determinable end-of-event indicator, the cardiac

Table 3. Agreement between the end-of-event indicator and the ultimate emergency department disposition among patients with definitive disposition data available

	Emergency Department Disposition		
End-of-Event Indicator	"Discharged" or "Admitted"	"Deceased/Expired"	Kappa
(All Cases, N = 35,296)			
Presumptively Alive	34,248	143	0.83
Presumptively Dead	152	753	
(Cardiac Arrests, N = 1,090)			
Presumptively Alive	237	38	0.63
Presumptively Dead	121	694	

arrest events with an end-of-event indicator were similar to those in the overall NEMSIS dataset.

Agreement between End-of-Event Indicators and Emergency Department Disposition

Definitive emergency department outcomes were available for 35,296 of the NEMSIS-2018 events with a non-conflicting end-of-event indicator. Nearly all (99.6%) of the patients in this subsample classified as presumptively alive at the end of EMS care had an emergency department disposition of admitted, discharged or transferred; 83.2% of the patients classified as presumptively dead at the end of EMS care had an emergency department disposition of deceased/expired. Agreement between the end-of-event indicator and the reported emergency department outcome was nearly perfect, with overall agreement of 99.2% and a Kappa of 0.83 (Table 3).

Emergency department outcomes were available for 1,090 of the cardiac arrest events with a non-conflicting end-of-event indicator. Most (86.2%) of the patients in this subsample classified as presumptively alive at the end of EMS care had an emergency department disposition of admitted, discharged or transferred; 85.2% of the cardiac arrest patients classified as presumptively dead at the end of EMS care had an emergency department disposition of deceased/expired. Agreement between the end-of-event indicator and the reported emergency department outcome among cardiac arrest events was substantial, with overall agreement of 85.4% and a Kappa of 0.65 (Table 3).

Discussion

We created a discrete, binary end-of-event outcome indicator for 98.6% of the NEMSIS-2018 9-1-1 initiated ground EMS responses in which patient contact was established, and for 89.1% of the cases with documented cardiac arrest. The events with a determinable end-of-event outcome indicator appear representative of the full NEMSIS-2018 dataset.

Beyond the face validity of the end-of-event indicator criteria, we also found some evidence of their accuracy. Although the emergency department represents a different phase of care, and one would not expect EMS outcomes and emergency department outcomes to exactly match, there was reasonable concordance between the derived end-of-event indicators and reported emergency department outcomes. Among events with reported emergency department disposition data, less than 1% of patients presumptively alive at the end of EMS care were categorized as deceased or expired at emergency department disposition. That is consistent with the reported mortality rate for emergency department patients nationally (6). Similarly, 83% of the patients presumptively dead at the end of EMS care that had an emergency department disposition documented were in fact categorized as deceased or expired at emergency department disposition. It is not unrealistic to estimate that approximately 15% of patients delivered to the emergency department in cardiac arrest are subsequently resuscitated and survive to hospital admission (7–10). Although it is impossible to confirm using the NEMSIS data, if we presume that 100% of the non-transported presumptively dead patients were in fact dead at the end of EMS care, the predictive value of the presumptively dead indicator criteria would be greatly increased.

Creating a standardized end-of-event outcome indicator has several potential benefits. First, as demonstrated through this process, intuitive single-variable indicators of outcome such as non-transport of encountered patients or the absence of documented cardiac arrest can be misleading. Second, while not as informative as distal outcome measures, the end-of-event outcome indicator can be determined for most patients encountered during 9-1-1 initiated scene response, while a definitive emergency department disposition is recorded for less than 2% of the events included in the NEMSIS

database. Finally, although individual research teams can develop study-specific outcome measures for their analyses, use of a standardized indicator of end-of-event status would allow for more meaningful comparisons of findings across different NEMSIS-based studies (11). Although this process was developed and evaluated using the NEMSIS-2017 and NEMSIS-2018 datasets, the data commands for creating the outcome indicator should remain valid for future years using Version 3 data elements. With little effort, the process could be replicated in prior versions of the NEMSIS research data set, as well as in other non-NEMSIS EMS datasets.

LIMITATIONS

The end-of-event outcome criteria are based on the perspectives of the three authors—two emergency physicians and one EMS research scientist. We only included criteria that all three authors independently identified as likely indicating a patient's end-of-event status; we made no attempt to resolve disagreements by discussion. Other element and code combinations could also provide an indication of patient end-of-event status. While these end-of-event indicator criteria have good face validity and we found some evidence of their accuracy, the true outcome for the majority of NEMSIS events remains unknown. Evaluating these criteria in a sample of EMS events with reliable emergency department disposition data gathered through health information exchanges would help establish their validity.

The events with determinable outcomes appear representative of the entire set of ground 9-1-1 initiated scene responses that result in patient contact, but end-of-event outcomes could not be determined for some of the NEMSIS events—including 10.9% of cardiac arrest events. The majority (77%) of the cardiac arrest events without a determinable outcome had conflicting dead and alive indicators. There is no way to know which indicators are correct, and which are data entry errors. The remaining cardiac arrest events without a clear outcome had an emergency department status documented that did not clearly indicate the end-event-status. For example, "ongoing resuscitation in the emergency department" could mean ongoing compressions and ventilations in a patient still in cardiac arrest, or it could mean ongoing ventilation and vasopressor support for a patient who achieved return of spontaneous circulation. We chose not to make assumptions about these outcomes, but future researchers might opt to interpret these endpoints differently.

Finally, the end-of-event indicator determinations depend on the documentation practices of the responding EMS systems and the attending EMS professionals, with many missing and sometimes contradictory entries. The NEMSIS dataset also does not delineate chart entries recorded in real time, versus those recorded after the conclusion of the event. This highlights the need for careful data entry by EMS clinicians and attentive data cleaning by data coordinators, but it is a commonly reported limitation of NEMSIS-based studies (12–14).

CONCLUSION

We have developed a process for assigning a binary end-of-event outcome indicator to events included in Version 3 NEMSIS public release research datasets. An end-of-event indicator can be determined for 98.6% of 9-1-1 initiated ground EMS responses and for 89.1% of cases with documented cardiac arrest included in the 2018 NEMSIS dataset. The events with a determinable end-of-event outcome appear representative of the larger dataset and—for events with known dispositions—the end-of-event indicators are generally consistent with reported emergency department outcomes.

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