BMJ Open

Feasibility of quality indicators on prehospital advanced airway management in a physician-staffed emergency medical service: survey-based assessment of the provider point of view

Alexandre Kottmann ,[1,2,3,4,5,6] Mathieu Pasquier,[1,3] Pierre-Nicolas Carron,[1,3] Ludovic Maudet,[1,7] Jean-Daniel Rouvé,[7] L Suppan,[8] David Caillet-Bois,[1] Thomas Riva,[4,9] Roland Albrecht,[2,9] Andreas Krüger,[5,10,11] Stephen Johan Mikal Sollid[5,6]

To cite: Kottmann A, Pasquier M, Carron P-N, *et al*. Feasibility of quality indicators on prehospital advanced airway management in a physician-staffed emergency medical service: survey-based assessment of the provider point of view. *BMJ Open* 2024;**14**:e081951. doi:10.1136/bmjopen-2023-081951

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (https://doi.org/10.1136/bmjopen-2023-081951).

Received 10 November 2023
Accepted 20 February 2024

For numbered affiliations see end of article.

Correspondence to
Dr Alexandre Kottmann; alexandre.kottmann@chuv.ch

ABSTRACT

Objective We aimed to determine the feasibility of quality indicators (QIs) for prehospital advanced airway management (PAAM) from a provider point of view.

Design The study is a survey based feasibility assessment following field testing of QIs for PAAM.

Setting The study was performed in two physician staffed emergency medical services in Switzerland.

Participants 42 of the 44 emergency physicians who completed at least one case report form (CRF) dedicated to the collection of the QIs on PAAM between 1 January 2019 and 31 December 2021 participated in the study.

Intervention The data required to calculate the 17 QIs was systematically collected through a dedicated electronic CRF.

Primary and secondary outcome measures Primary outcomes were provider-related feasibility criteria: relevance and acceptance of the QIs, as well as reliability of the data collection. Secondary outcomes were effort to collect specific data and to complete the CRF.

Results Over the study period, 470 CRFs were completed, with a median of 11 per physician (IQR 4–17; range 1–48). The median time to complete the CRF was 7 min (IQR 3–16) and was considered reasonable by 95% of the physicians. Overall, 75% of the physicians assessed the set of QIs to be relevant, and 74% accepted that the set of QIs assessed the quality of PAAM. The reliability of data collection was rated as good or excellent for each of the 17 QIs, with the lowest rated for the following 3 QIs: duration of preoxygenation, duration of laryngoscopy and occurrence of desaturation during laryngoscopy.

Conclusions Collection of QIs on PAAM appears feasible. Electronic medical records and technological solutions facilitating automatic collection of vital parameters and timing during the procedure could improve the reliability of data collection for some QIs. Studies in other services are needed to determine the external validity of our results.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The heterogeneity of the characteristics of the physicians who participated to the study is representative of the prehospital emergency physician population practising in Switzerland.
⇒ The process of monitoring prehospital advanced airway management and its documentation in the case report forms (CRFs) on a daily basis allowed to optimise a high completeness of the data.
⇒ A small part of the physicians answered the questionnaire of the survey up to 2 years after completing their last CRF as some of them just complete a 6-month fellowship in the service.
⇒ Despite using questions used in previous feasibility studies, proposing the questionnaire in two languages and data retrieval and software having been the same for all the physicians, there was a high range in certain answers.
⇒ The study was conducted in two physician-staffed emergency medical services and external validity can be seen as limited.

INTRODUCTION

Prehospital advanced airway management (PAAM) is a critical care intervention consisting of successive complex tasks that can be delivered to a high standard in the prehospital setting.[1 2] However, despite a straightforward rationale for carrying out PAAM, its benefit in improving outcomes remains disputed.[3] Studies that use standard research methods have struggled to reliably evaluate this complex intervention, mainly because of not sufficiently taking into account the considerable heterogeneity in patients and clinical scenarios, as well as the diversity

QI No.	QI name	Short definition
QI 1	Overall intubation clinical practice	Overall number of successful intubations performed by the provider in the hospital and pre-hospital setting prior to the recorded attempt†.
QI 2	Prehospital intubation periodic exposure	Number of successful intubations performed by the provider in the pre-hospital setting during the 12 months prior to the recorded attempt†
QI 3	Intubation periodic exposure	Number of successful intubations performed by the provider in the hospital and pre-hospital setting during the 12 months prior to the recorded attempt†.
QI 4	Intubation attempts†	Total number of intubation attempts for the given patient.
QI 5	Capnography for tube position confirmation	Rate of (quantitative) continuous waveform end-tidal CO2 monitoring and documentation; for tracheal tube placement confirmation, immediately after advanced/definitive airway insertion.
QI 6	Preoxygenation method	Rate of patients where preoxygenation was performed with a Bag-Valve-Mask (BVM) or an automated ventilator, with PEEP.
QI 7	Preoxygenation duration	Duration of the preoxygenation phase, using a Bag-Valve-Mask or an automated ventilator with PEEP.
QI 8	RSI for intubation	Rate of rapid sequence intubation, including an anaesthetic drug (induction) and a NMBA (paralysis), for intubation of patients with vital signs.
QI 9	Laryngoscopy duration‡	Duration of the "no oxygenation time" during laryngoscopy†.
QI 10	Intubation Indication threshold	Rate of intubation of trauma patients with GCS<9 compared to all trauma patients with GCS<9
QI 11	EtCO2 monitoring during transport	Rate of intubated patients with continuous EtCO2 (capnometry) monitoring during transport to hospital compared to all intubated patients.
QI 12	Automated ventilation during transport	Rate of patients ventilated with an automated ventilator during transport to hospital (after insertion of advanced airway device) compared to all patients with an inserted advanced airway device and ventilated during transport to hospital.
QI 13	First attempt success	Rate of successful tracheal intubation at first attempt compared to all patients who had at least one intubation attempt† ‡.
QI 14	Overall intubation success	Rate of successful tracheal intubation, compared to all patients who had at least one intubation attempt† ‡.
QI 15	Desaturation during laryngoscopy‡	Rate of patient with SpO2 drop below 90% or ≥10% from baseline during intubation/laryngoscopy‡‡.
QI 16	Complications¥	Rate of complications observed during the intervention and clearly associated with the pre-hospital airway management compared to all patients who underwent at least on intubation attempt‡.
QI 17	Normoventilation at hospital delivery	Rate of patients with an inserted advanced airway device in place that are normoventilated at handover in hospital: $EtCO_2$= 30-45mmHg (4-6kPa)/PaO_2=35-50mmHg (4.67-6.67kPa), compared to all ventilated patients with an inserted advanced airway device in place (patient still ventilated by the prehospital ventilator or BVM). For TBI patients: $EtCO_2$= 35-40mmHg (4.67-5.33kPa), PaO_2=30-35mmHg (4-4.67kPa) according to the Brain Trauma Foundation.

Figure 1 Quality indicators for prehospital advanced airway management.[9] †Intubation attempt: an attempt is each time the laryngoscope blade passed the front teeth. Correction of the tube's depth is not defined as a new attempt. ‡Laryngoscopy duration: defined as the time between the moment the preoxygenation mask is removed from the face of the patient and the moment the tube position is confirmed in the trachea (preferably with capnography). §Intubation success: a success is defined by a tube confirmed in the trachea (preferably by at least two different techniques, one of them ideally being quantitative $EtCO_2$ measure immediately after insertion). ¶Services with blood gas analysis possibility should use $PaCO_2$. ¥Complications contain the items of the updated Utstein-style airway template.[29] Immediately recognised/corrected oesophageal intubation; not immediately recognised/corrected oesophageal intubation; endotracheal tube misplaced in left or right main stem bronchus; incorrect positioning or difficult ventilation with supraglottic airway device; dental trauma; aspiration or vomiting during airway management (and not present before); cardiac arrest during airway management; complications during surgical or percutaneous airway management (eg, bleeding or pneumothorax); new hypoxia during airway management; new bradycardia during airway management; new hypotension during airway management. The three latter ones are defined as follows: hypoxia: adults and children: SpO_2 < 90%. Hypotension: infants <1 year: systolic blood pressure (SBP) <70 mm Hg (systolic, children 1–10 years: SBP <70 + (2 × age), children >10 years: SBP <90 mm Hg, adults: SBP <90 mm Hg or decrease >10% from baseline value. Bradycardia: newborn to 3 years: <100 beats per minute, 3–9 years: <80 beats per minute, 10–16 years: <60 beats per minute, adults: <50 beats per minute.[29]

of providers and techniques, all of which may influence outcomes.[4–6] Complex interventions like PAAM might be better evaluated by using specific quality improvement methodology that measures dedicated, well-defined indicators.[6 7] The collection and monitoring of quality indicators (QIs) in prehospital critical care is rare and has not yet been described for a specific topic such as advanced airway management.[8]

To contribute to progress on this issue, an international group of experts in 2018 developed a set of 17 QIs divided into the 3 categories described by Donabedian (structure, process, outcome) and covering all steps of PAAM (figure 1).[9] In 2019, we introduced the collection of data required to calculate these QIs in two physician-staffed emergency medical services (PEMS) based in Lausanne, Switzerland. In this study, we aimed to assess the feasibility of the 17 QIs for PAAM from a provider point of view by using a survey among the prehospital emergency physicians of these two services.

METHOD

Study setting

Physicians of the prehospital sector of the Emergency Department of Lausanne University Hospital are staffing two PEMS units: the Lausanne Ground Emergency Medical Service (GEMS) and the local helicopter of the Helicopter Emergency Medical Service (HEMS) Rega-Swiss Air Ambulance. Both PEMS units are systematically staffed with a physician and a paramedic. They are available 24/7 and respond annually to about 1500 and 900 missions, respectively.[10] Whereas the GEMS mainly responds to primary missions (on scene; >95%), the HEMS also performs a significant share of secondary missions (interhospital; ca. 50%).[11]

The level of airway management training and clinical experience of the physicians ranges from emergency medicine residents to senior attending specialists in emergency medicine and/or anaesthesiology with several years of experience. Physicians working on the HEMS have at least 1 year of clinical experience in anaesthesiology, as well as 6 months in intensive care medicine.

In both services, PAAM is performed exclusively by the physicians. Of about 150 intubations performed during primary missions annually, one-third are related to the HEMS and two-thirds to the GEMS. Standard PAAM includes rapid sequence intubation for patients with vital signs, systematic use of a C-MAC PM (KARL STORZ SE & Co. KG, Tuttlingen, Germany) videolaryngoscope for intubation and mandatory use of continuous waveform capnography after intubation. All videolaryngoscopies are recorded, stored and reviewed by a senior consultant of the ED.

Since 1 January 2019, the two PEMS have collected the data required to calculate the 17 QIs for PAAM through a dedicated case report form (CRF) by using Research Electronic Data Capture tools (REDCap Consortium,

Table 1 Questionnaire for the assessment of the feasibility of QIs for PAAM from a provider point of view

For each QI	
Relevance	
Do you consider this QI suitable to meaningfully describe/measure the quality of care in this specific aspect of prehospital advanced airway management?	Yes/no/I don't know
Acceptance	
Would you accept that an aspect of the quality of prehospital advanced airway management would be measured and rated using this indicator?	Yes/no/I don't know
Reliability of data collection	
How do you estimate the reliability of data collection for this QI?	Excellent/good/fair/poor/very poor
Promoting and hindering factors	
Are there additional promoting factors for retrieving data required for this QI? And if so, what promoting factors?	Free text
Are there additional hindering factors for retrieving data required for this QI? And if so, what hindering factors?	Free text
Only for QI 1, 2, 3, 15, 17	
Effort	
How much time would you approximately need to obtain the required data to calculate this QI?	Time (minutes)
Under your given day-to-day practice routine, is this effort reasonable to you?	Yes/no/I don't know
General questions about the REDCap CRF	
Effort	
How much time would you approximately need to complete a REDCap CRF airway management for a simple procedure (success at first attempt)	Time (minutes)
Under your given day-to-day practice routine, is this effort reasonable to you?	Yes/no/I don't know

CRF, case report form; PAAM, prehospital advanced airway management; QI, quality indicator.

Vanderbilt University, Nashville, Tennessee, USA).[12] The CRF was completed by the physician immediately after every mission in which PAAM had been attempted.

Outcomes

The main goal of the study was to assess the feasibility of each of the 17 QIs for PAAM from the provider's point of view. Feasibility was assessed by the provider through evaluation of each of the following criteria, which represent the primary outcomes: relevance, acceptance and reliability of data collection. The definitions of the criteria and the questions used for their assessment are presented in the questionnaire in table 1. Relevance and acceptance were assessed with a 'yes or no' approach and the correlation between them was evaluated.[13] Reliability of data collection was assessed by using a five-point Likert scale, corresponding to positive (excellent and good), fair and negative (poor and very poor) ratings. Further, participants could report promoting and hindering factors for retrieving data for each QI.[14]

Secondary outcomes were assessment of the effort required to collect specific data needed to calculate five QIs (QI 1, 2, 3, 15 and 17) not included in the CRF, as well as of the completion of the dedicated CRF on REDCap. To assess the effort, we asked participants to estimate the time needed to complete the task and to judge whether this time was reasonable or not.

Cross-sectional survey

A questionnaire was developed with the LimeSurvey online survey tool (LimeSurvey GmbH, Hamburg, Germany). We tested and adapted it from the feedback of three emergency physicians who did not participate in the survey later on. For better understanding, we made the questionnaire available to the participants in both French and English. The translation was validated by an English native speaker who was independent of the study group.

All physicians who worked for the two PEMS and who had completed at least one REDCap CRF between 1 January 2019 and 31 December 2021 were informed of the upcoming survey and their email addresses were checked.[12] They were invited to participate in the survey by sending them a personal link. Participation was voluntary. The survey started on 11 April 2022. A weekly reminder was emailed until the survey was closed after 30 days.

Statistical analysis

Categorical variables were described as frequency and relative percentages. Continuous variables were described

as mean and SD if normally distributed and as median and IQR if not normally distributed. The statistical correlation between two continuous variables was measured by Pearson's correlation coefficient.

The statistical analyses were performed by using STATA statistics software V.14.2 (StataCorp LLC).

RESULTS

Study sample

Forty-two (95%) of the 44 physicians who worked in the PEMS during the study period completed the questionnaire. Fifty-nine per cent (n=26) of the participants were male.

Over the study period, 470 CRFs were completed and the median number of completed CRFs per physician was 11 (IQR 4–17; range 1–48). The median time to complete the CRF was 7 min (IQR 3–16; range 1–25) and this was deemed reasonable by 95% (n=40) of the participants.

Assessment of the QIs

The relevance, acceptance and reliability of data collection of each of the 17 QIs are presented in figure 2. On average, 75% of the physicians assessed the set of QIs to be relevant and thus meaningful in describing or measuring the quality of PAAM, and 74% accepted that the set of QIs assessed the quality of PAAM. A positive correlation was found between relevance and acceptance (Pearson's r=0.87).

Sixty-five per cent of the physicians estimated the collection of the data required for the set of QIs to be reliable. Free-text comments on promoting and hindering factors for retrieving the data required to calculate the different QIs are summarised in online supplemental file 1.

The time required to collect QI 1, 2, 3, 15 and 17 is presented in table 2. Overall, the time required to collect these QIs was assessed as reasonable given the day-to-day practice routine and constraints.

DISCUSSION

The results of this study suggest that the collection of QIs to measure the quality of PAAM is feasible in PEMS. The providers found the QIs to be relevant, acceptable and the collection of data required to calculate the QIs reliable. The completion of a dedicated CRF was deemed feasible and the effort to complete it was considered acceptable within the available resource and time constraints.

Feasibility criteria

Feasibility is key in continuous quality improvement to enhance acceptance of upcoming feedback based on the measurement of the QIs.[15–18] Although the meaning of feasibility seems intuitive and many criteria have been described in the past, there is no internationally validated set of criteria.[17 19 20] We based our study on the feasibility criteria previously published in two studies on the feasibility of QIs in an ambulatory setting, which has many similarities to prehospital critical care.[14 17] We focused on three provider-related feasibility criteria: relevance, acceptance and reliability of data collection.[14] We did not assess non-provider-related feasibility criteria such as applicability, availability of data and technical feasibility of data collection. Indeed, PAAM is an important procedure performed regularly by the physicians in both PEMS and data were collected directly in a REDCap CRF specifically developed for this purpose.

Relevance and acceptance

The average relevance and acceptance of the set of QIs (75% and 74%, respectively) are comparable to the highest values described by Ewald *et al* (76% and 73%, respectively) for a subgroup of QIs and are higher than the values described by de Cruppé *et al* (61% and 58%, respectively).[14 17]

A high relevance might be related to the scientific evidence and strength of an indicator and reflects the quality of the QI development process, especially if assessed by a different group than the one that developed the QI.[15 16] On the other hand, acceptance might be influenced both by the reliability of data collection and by the overall acceptance of healthcare being assessed through indicators. Further, acceptance is not only influenced by relevance, but it also highly correlates with it, as described in the past.[14]

The two QI assessed as most relevant to describe the quality of PAAM were the duration of the laryngoscopy (QI 9, 92.9%) and the overall intubation clinical practice (QI 1, 85.7%). Both describe the pure technical skill of intubation and also figure among the top three of the most accepted QIs (88.1% and 83.3%, respectively), together with the number of intubation attempts (QI 4, 83.3%). These findings support the fact that technical skill seems to be key in determining the quality of PAAM.[3 21]

Monitoring capnometry during transport was the QI with the highest acceptance (QI 11, 90.8%). Normoventilation is aimed for in most ventilated patients and is associated with decreased mortality when applied in the early management of traumatic brain injury.[22 23]

Capnometry monitoring during transport enables targeted optimisation of ventilation en route the hospital.[21 24]

The intubation indication threshold (QI 10, 50%), automated ventilation during transport (QI 12, 54.8%) and preoxygenation duration (QI 7, 59.5%) obtained both lowest acceptance and relevance. Unlike the best-rated QI, they describe elements of PAAM that are not directly related to the technical act of intubation and their impact on outcome QIs might seem less intuitive.

Reliability of data collection

The average reliability of data collection required for the QIs (65%) is similar to the value described by de Cruppé *et al* (69%) and higher than the 50% described by Ewald *et al*.[14 17] This can be explained by the high proportion of

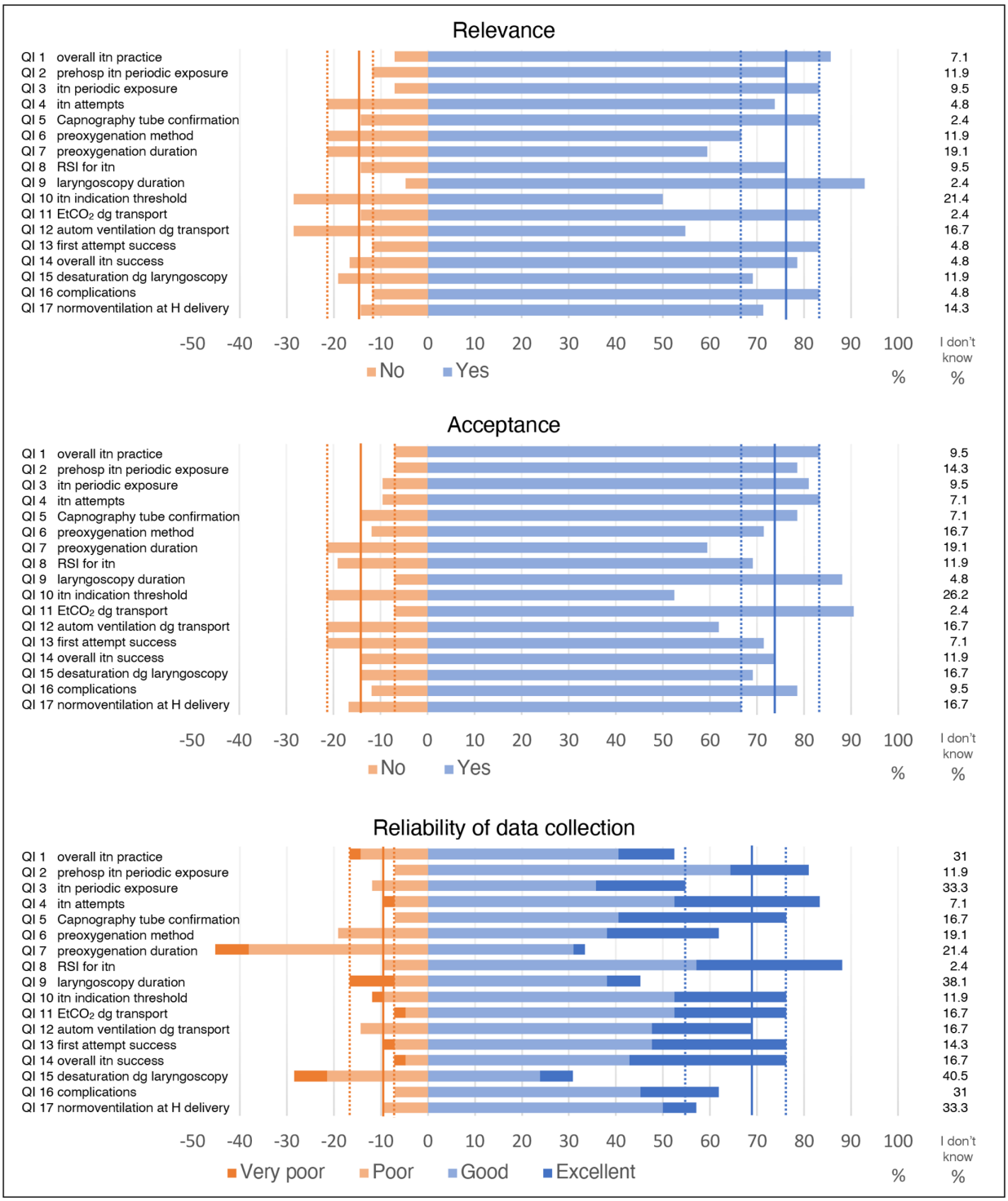

Figure 2 Provider-related feasibility criteria.

electronic medical records (EMR) in both de Cruppé's study and our study.[14]

The lowest reliability of data collection was observed for the QI in which data had to be recorded by the physician himself and required his attention during PAAM (duration of preoxygenation: QI 7, duration of laryngoscopy: QI 9, desaturation during laryngoscopy: QI 15), and for those dependent on data collected by another service/organisation (overall intubation clinical practice: QI 1, periodic overall intubation exposure: QI 3). The latter two QIs were also those requiring the longest time to retrieve the data.

Reliability of data collection is often a limiting factor in quality measurement initiatives due to the availability and retrievability of the data required to calculate the QI.[14 17–19 25] Retrievability of the data is dependent on the format of the data.[14] The increasing use of EMR will increase availability and retrievability of the data, and thus

Table 2 Estimation of the time and reasonability of the effort to retrieve the data to calculate QI 1, 2, 3, 15 and 17 by the physicians (n=42) of the two PEMS

QI no.	Estimated time to retrieve the data required to calculate each QI*			Reasonability of the effort to retrieve the data required to calculate each QI		
	≤60 min n (%) median (IQR)	>60 min n (%)	I don't know n (%)	Reasonable n (%)	Not reasonable n (%)	I don't know n (%)
QI 1	20 (47) 10 (3–45)	13 (31)	9 (21)	25 (60)	11 (26)	6 (14)
QI 2	28 (67) 12.5 (3–30)	6 (14)	8 (19)	33 (79)	4 (10)	5 (12)
QI 3	23 (55) 15 (5–60)	11 (26)	8 (19)	23 (55)	11 (26)	8 (19)
QI 15	22 (52) 5 (2–15)	6 (14)	14 (33)	22 (52)	13 (31)	7 (17)
QI 17	27 (64) 5 (2–60)	5 (12)	10 (24)	22 (52)	13 (31)	7 (17)

For times ≤60 min, physicians were invited to estimate the time with a precision of 1 min. If they estimated that the time was >60 min, no further precision was required.
PEMS, physician-staffed emergency medical services; QI, quality indicator.

also improve its reliability. Further, the collection of QIs should be a prospective effort, QIs first being defined and then the required data being collected. The availability of the data should not restrict or influence the decision to collect an indicator or not.[19]

Beyond this, and as mentioned in the free-text comments, reliability of data collection could be further improved by the automatic export of data (eg, vital parameters) from medical devices (eg, monitor) to the EMR, video recording of the procedure, or a dedicated person present on scene and looking for specific data points.[26] Moreover, most of the datapoints have been shown to be reliably collectable in specific projects in the past.[2 27] However, the collection of the data must remain feasible in the long term and within the given resource and time constraints. In our study, the effort to complete a dedicated CRF for the collection of the QIs for PAAM was considered reasonable by almost all the physicians who participated to the survey (95%), a much higher result than that reported by de Cruppé *et al* (unacceptable for 67%) and Ewald *et al* (acceptable for 35%).[14 17] The regular involvement of the service's physicians in scientific projects might in part explain these outstanding results. Further, the topic addressed in our study was specific and the time to complete it was much lower. For monitoring of larger QI sets, technical solutions should be found to allow for automated data collection and/or direct collection in the EMR, the data being part of the standard data set documented for every HEMS mission.[14 17]

Finally, a culture of transparency and learning both from excellence and mistakes in a service is paramount for continuous quality improvement. Automated data collection is possible for certain indicators such as vital signs, but human documentation will remain necessary for other indicators such as complications and success, where a reporting bias is always possible.

Improvement of the QI set

Feasibility field testing allows improvement of a set of QI. Its content validity can be increased by improving the average relevance of the set of QIs either by removing or modifying the least relevant QIs.[28] On the other hand, it enables the identification of QIs where reliability of data collection is low and in need of improvement.

AAM being a relatively rare intervention in our PEMS and in order to have a representative sample and a valuable assessment before potentially adapting the QIs and the REDCap CRFs, a 3-year field test to reach 470 CRFs seemed to be adequate and comparable to a previous study on QIs in prehospital critical care in which the data from 450 missions were collected during its pilot phase.[7 20] However, the length of the study period may represent a limitation, as some physicians answered the questionnaire 2 years after completing their last CRF. Nevertheless, the study also included 30% of senior physicians who participated over the 3-year period.

Another limitation might be related to the questionnaire. Despite using existing questions from previous feasibility studies and proposing the questionnaire in two languages, there was a high range in certain answers, although data were retrieved from the EMR by using the same procedure and software (especially for QI 15 and QI 17). This might be due to ambiguities in the questions or misunderstanding of the participants.

One of the strengths of the study is the high participation rate (95% of all physicians who worked in the PEMS during the study period) and the heterogeneity of the physicians' characteristics, which is representative of the prehospital emergency physician population practising in Switzerland. However, the study was conducted in two PEMS and external validity can be seen as limited. Nevertheless, our results show that monitoring of QI for PAAM, a specific but critical and highly relevant procedure of

prehospital emergency medicine, is feasible with simple means. This should inspire other PEMS to follow the path which will contribute to increase the external validity of our results and improve quality of PAAM.

In conclusion, a set of 17 QIs on PAAM obtained high acceptance and relevance when assessed by emergency physicians of two PEMS. The collection of the data required to calculate the QIs through a dedicated CRF is reliable, and the effort to complete the CRF was considered reasonable for the size of the set. In order to maximise the reliability of data collection, data should be collected prospectively and electronically. Wherever possible, data should be collected automatically and/or directly in the EMR.

Author affiliations
[1]Emergency Department, Department of Interdisciplinary Centres, Lausanne University Hospital, Lausanne, Vaud, Switzerland
[2]Medicine, REGA, Zurich, Switzerland
[3]Faculty of Biology and Medicine, University of Lausanne, Lausanne, Vaud, Switzerland
[4]Department of Anaesthesiology and Pain Medicine, Inselspital University Hospital Bern, Bern, Switzerland
[5]Department of Research and Development, Norwegian Air Ambulance Foundation, Drøbak, Norway
[6]Faculty of Health Sciences, University of Stavanger, Stavanger, Norway
[7]Anaesthesiology, Department of Interdisciplinary Centres, Lausanne University Hospital, Lausanne, Vaud, Switzerland
[8]Division of Emergency Medicine, Department of Anaesthesiology, Clinical Pharmacology, Intensive Care and Emergency Medicine, Geneva University Hospitals, Geneve, Switzerland
[9]Faculty of Medicine, University of Bern, Bern, Switzerland
[10]Department of Emergency Medicine and Prehospital Services, St. Olavs University Hospital, Trondheim, Norway
[11]Institute of Circulation and Medical Imaging, Norwegian University of Science and Technology, Trondheim, Norway

Twitter Alexandre Kottmann @alexkottmann

Acknowledgements The authors sincerely thank Dr. A.S. Feiner for English proofreading of the survey questionnaire.

Contributors All authors participated substantially to the project. Conceptualisation: AKottmann, MP, P-NC, SJMS and AKrüger. Development of the CRF: AKottmann, MP, LM and J-DR. Study design: AKottmann and MP. Ethics approval coordination: AKottmann. Development of the survey: AKottmann, DC-B and MP. Data analysis: AKottmann. Writing of the manuscript: AKottmann, MP, P-NC, LM, LS and SJMS. Review of the manuscript: TR, J-DR, RA and AKrüger. Guarantor: AKottmann. All authors have read and agreed to the published version of the manuscript.

Funding The Norwegian Air Ambulance Foundation covered the open access publication fees.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval The project was considered a quality assurance study and was therefore exempted from a formal agreement by the local ethic committee (Human Research Ethics Committee of the Canton of Vaud, Switzerland: CER-VD Req-2021-01289). Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request.

ORCID iD
Alexandre Kottmann http://orcid.org/0000-0002-1991-6110

REFERENCES

1 Schmidt AR, Ulrich L, Seifert B, *et al*. Ease and difficulty of prehospital airway management in 425 paediatric patients treated by a helicopter emergency medical service: a retrospective analysis. *Scand J Trauma Resusc Emerg Med* 2016;24:22.
2 Gellerfors M, Fevang E, Bäckman A, *et al*. Pre-hospital advanced airway management by anaesthetist and nurse anaesthetist critical care teams: a prospective observational study of 2028 pre-hospital tracheal Intubations. *Br J Anaesth* 2018;120:1103–9.
3 Lecky F, Bryden D, Little R, *et al*. Emergency intubation for acutely ill and injured patients. *Cochrane Database Syst Rev* 2008;2008:CD001429.
4 Davis DP, Idris AH, Sise MJ, *et al*. Early ventilation and outcome in patients with moderate to severe traumatic brain injury. *Crit Care Med* 2006;34:1202–8.
5 Wang HE, Davis DP, O'Connor RE, *et al*. Drug-assisted intubation in the prehospital setting (resource document to NAEMSP position statement). *Prehosp Emerg Care* 2006;10:261–71.
6 Shepperd S, Lewin S, Straus S, *et al*. Can we systematically review studies that evaluate complex interventions *PLoS Med* 2009;6:e1000086.
7 Rubin HR, Pronovost P, Diette GB. From a process of care to a measure: the development and testing of a quality indicator. *Int J Qual Health Care* 2001;13:489–96.
8 Haugland H, Uleberg O, Klepstad P, *et al*. Quality measurement in physician-staffed emergency medical services: a systematic literature review. *Int J Qual Health Care* 2019;31:2–10.
9 Kottmann A, Krüger AJ, Sunde GA, *et al*. Establishing quality indicators for pre-hospital advanced airway management: a modified nominal group technique consensus process. *Br J Anaesth* 2022;128:e143–50.
10 Lausanne Vd: rapport D'Activité 2021 Du service de protection et de Sauvetage de la Vielle de Lausanne. 2021.
11 Giacalone S, Kottmann A, Darioli V, *et al*. Clinical characteristics and haemodynamic state of patients undergoing interhospital transfer for postpartum haemorrhage: a study of a single-centre helicopter emergency medical service. *Eur J Obstet Gynecol Reprod Biol* 2022;268:48–55.
12 Harris PA, Taylor R, Thielke R, *et al*. Research electronic data capture (Redcap)--a metadata-driven methodology and workflow process for providing translational research Informatics support. *J Biomed Inform* 2009;42:377–81.
13 Schober P, Vetter TR. Correlation analysis in medical research. *Anesth Analg* 2020;130:332.
14 de Cruppé W, Kleudgen S, Diel F, *et al*. Feasibility of 48 quality indicators in ambulatory care in Germany: a cross-sectional observational study. *Z Evid Fortbild Qual Gesundhwes* 2015;109:682–94.
15 Beyer M, Chenot R, Erler A, *et al*. Using quality indicators to measure the quality of general practice care in Germany. *Z Evid Fortbild Qual Gesundhwes* 2011;105:13–20.
16 Stroup CA. *Developing and using quality indicators for emergency medical services evaluation and improvement*. 2017.
17 Ewald DA, Huss G, Kraska RA, *et al*. Feasibility testing of the core set of quality indicators for Paediatric primary care in Europe, COSI-PPC-EU. *Eur J Pediatr* 2019;178:707–19.
18 Wollersheim H, Hermens R, Hulscher M, *et al*. Clinical indicators: development and applications. *Neth J Med* 2007;65:15–22.

19 Emond YE, Stienen JJ, Wollersheim HC, *et al*. Development and measurement of perioperative patient safety indicators. *Br J Anaesth* 2015;114:963–72.
20 Haugland H, Olkinuora A, Rognås L, *et al*. Testing quality indicators and proposing benchmarks for physician-staffed emergency medical services: a prospective Nordic multicentre study. *BMJ Open* 2019;9:e030626.
21 Davis DP. The need for standardized data reporting for prehospital airway management. *Crit Care* 2011;15:133.
22 Spaite DW, Bobrow BJ, Keim SM, *et al*. Association of statewide implementation of the prehospital traumatic brain injury treatment guidelines with patient survival following traumatic brain injury. *JAMA Surg* 2019;154:e191152.
23 Nolan JP, Sandroni C, Böttiger BW, *et al*. European resuscitation Council and European society of intensive care medicine guidelines 2021: post-resuscitation care. *Resuscitation* 2021;161:220–69.
24 Howard MB, McCollum N, Alberto EC, *et al*. Association of ventilation during initial trauma resuscitation for traumatic brain injury and post-traumatic outcomes: a systematic review. *Prehosp Disaster Med* 2021;36:460–5.
25 Marshall MN, Roland M, Campbell SM, *et al*. *Measuring general practice. A demonstration project to develop and test A set of primary care clinical quality indicators*. London: The Nuffield Trust, 2003.
26 DeStefano S, Pellinen J, Sillau S, *et al*. Standardization of seizure response times and data collection in an epilepsy monitoring unit. *Epilepsy Res* 2022;180:106869.
27 Helm M, Kremers G, Lampl L, *et al*. Incidence of transient hypoxia during pre-hospital rapid sequence intubation by anaesthesiologists. *Acta Anaesthesiol Scand* 2013;57:199–205.
28 Schang L, Blotenberg I, Boywitt D. What makes a good quality indicator set? A systematic review of criteria. *Int J Qual Health Care* 2021;33:mzab107.
29 Sunde GA, Kottmann A, Heltne JK, *et al*. Standardised data reporting from pre-hospital advanced airway management - a nominal group technique update of the Utstein-style airway template. *Scand J Trauma Resusc Emerg Med* 2018;26:46.