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Methodological Standards in the Design and Reporting of Pilot and Feasibility Studies in Emergency Medicine Literature: Recommendations from a Systematic Review

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Abstract

Objective: Pilot and feasibility studies are intended to ensure that randomized controlled trials (RCTs) are feasible, economical, and rigorous, especially in a challenging research environment such as emergency medicine (EM). We aimed to evaluate the methodological quality in conducting and reporting randomized pilot and feasibility studies in the EM literature and propose recommendations to improve their quality.

Design: Methodological systematic review

Data sources and eligibility: We searched MEDLINE and Embase (2018-29 September 2023) for pilot or feasibility RCTs published as full texts in the five top-ranked and first-quartile EM journals according to Scimago.

Data extraction and analysis: We assessed their methodological features and reporting quality primarily based on the CONSORT extension.

Results: A total of 24 randomized trials identified as pilot (n=13), feasibility (n=3), or both (n=8) were included. At least one feasibility outcome was assessed in nine trials (feasibility trials), while 15 others only focused on treatment efficacy (efficacy trials). Only three (12.5%) studies progressed to the main trials. Among 12 feasibility trials, 55.6% reported their outcomes with uncertainty estimates, and 33.3% had clear progression criteria. Efficacy trials tended to make clinical implications on their results. Studies from the five top-ranked journals had better methodological and reporting quality than those from other first-quartile journals.

Conclusion: Main methodological concerns for pilot and feasibility studies in EM literature include misconceptions, misuses, and suboptimal design and reporting quality. These issues were more prominent in lower-ranked journals. Our findings highlight the need for resources and training for researchers, journal editors, and peer reviewers on the value, objectives, and appropriate conduct of pilot and feasibility studies. The conceptual framework and standardized methodological components should be emphasized. EM journals should reinforce the reporting standards and support their publication. These actions can lead to more methodologically rigorous pilot and feasibility studies in EM.

Registration: PROSPERO (CRD42023468437)

Keywords: pilot, pilot trial, feasibility, feasibility trial, emergency medicine

Strengths and limitations of this study

- This systematic review addresses a major methodological issue in the research community, which is the appropriate design, conduct, and reporting of pilot and feasibility studies, with a specific focus on Emergency Medicine literature.
- We propose recommendations based on the deficiencies identified in the review to improve the quality and robustness of studies of this design.
- Potential limitations include the search and inclusion criteria not being very sensitive, though it should not affect the overall results of the review.

Introduction

Pilot and feasibility studies (PFS) contribute significantly to the health research community by offering data necessary for the design and successful conduct of larger-scale studies, especially phase III randomized controlled trials (RCTs).(1) PFS can increase the chance of success of the main study and, most importantly, they can reduce the potential waste of time and resources.(2) In evaluating complex interventions, it is recommended that the feasibility and acceptability of interventions should be assessed and the trial design should be evaluated before making decisions about the study progression.(3) Many interventions evaluated in emergency medicine (EM) clearly meet the definition of complex intervention, with the complexity mainly arising from the interaction between the intervention's components and the clinical emergency context in which it is being implemented.(3) Consequently, PFS are essential for the success of full-scale definitive RCTs in a challenging environment such as EM. Despite their notable importance, academic research training has not paid enough attention to them.(2) Their methodological and reporting standards have not been widely implemented, and many misuses and misconceptions are still presented.(4)

Since a pilot and a feasibility study both aim at the same goal, they are often considered synonymous.(5) However, a conceptual framework developed by distinguished methodologists suggests that pilot studies are a subset of feasibility studies with similar objectives but with a specific design feature and similar methods to the definitive trial; they thus agree that the two terms should not be considered mutually exclusive.(5–7) PFS performed prior to a full-scale RCT can be randomized or non-randomized.(6)

In many other clinical areas, reviews have shown that the methodological standards and reporting quality of published PFS were still suboptimal, with each research field having different issues and obstacles.(8–13) No reviews, however, have been performed to assess such

standards on published studies in EM. Therefore, this systematic review aimed to evaluate the methodological and reporting standards of randomized PFS conducted in adults, in an emergency department (ED) setting and published in top-ranked EM journals. The ultimate objective was to propose recommendations based on the deficiencies identified in our review to improve the quality of PFS.

Methods

Trial identification

The report of this study followed the PRISMA (preferred reporting items for systematic reviews and meta-analyses) 2020 reporting guidelines.(14) The protocol was registered in PROSPERO (CRD42023468437) prior to commencing abstract screening. Published literature in first-quartile EM journals based on Scimago (15) with one or both of the words 'pilot' and 'feasibility' in the title or abstract was identified by searching MEDLINE (2018–2023 September 29) and Embase (2018–2023 September 29) via Ovid. We started our search beginning in 2018 to allow for time to implement the conceptual framework for PFS and the corresponding Consolidated Standards of Reporting Trials (CONSORT) extension in 2016.(2,16) Based on the five top-ranked EM-based journals according to Scimago(15), Resuscitation, Academic Emergency Medicine (ACEM), Scandinavian Journal of Trauma, Resuscitation, and Emergency Medicine (SJTREM), Annals of Emergency Medicine (AnnalsEM), and Western Journal of Emergency Medicine (WJEM) were included as search terms. We also included studies published in other EM journals within the first quartile (Q1) to be compared to the five top-ranked journals. We limited retrieval to those published between 2018-2023 September 29, written in English, and enrolled patients from the ED. The search strategy and results are presented in Appendix. Duplicates were removed using Covidence and manual deduplication.

Only primary randomized PFS involving adult patients in the ED were included, and those that were not original articles or conference abstracts without retrievable full texts were excluded. For this review, we did not delineate between pilot and feasibility studies despite the consensus definition, and we employed a more restricted definition focusing on only external pilot studies performed prior to full-scale RCTs.(5,6,17) In searching for the corresponding definitive trials, we performed a literature search of the included PFS' titles, key terms, citations, and authors' names in the same databases and clinicaltrials.gov.

Study screening and data collection processes

Two reviewers (O.R and J.P.L) independently and in duplicate screened abstracts and full texts, with discordances resolved by a third reviewer (M.E.). They also independently and in duplicate extracted trial characteristics, and their methodological and reporting aspects. Discordances at this stage were adjudicated by a senior reviewer (A.W.). We used Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia) for all the review processes.

Trial characteristics

We recorded general and specific trial characteristics related to PFS. The study type was categorized based on the authors' definition (pilot, feasibility, or both). Feasibility outcomes were categorized according to Thabane et al.(2) into the four following domains;

Process: the feasibility of the study protocol; appropriateness of the inclusion and exclusion criteria, recruitment and consent rate; retention, adherence, and follow-up rate; randomization procedure and blinding; acceptability and feasibility of the intervention; selection of the primary outcome; preparation and appropriateness of the interventions and instruments used for outcome measurements.

Resources: the capacity of study centers and researchers, i.e., willingness and capacity, length of time to obtain consent, apply study intervention, and collect study data, and the required training and number of researchers.

Management: potential human and data management problems.

Scientific: information to guide the sample size for the main trial; treatment safety and dose-response.

Methodological and reporting standards

We evaluated the methodological quality of the included trials using a list of components adapted from Arain et al.(5) and Shanyinde et al.(18) and developed using the CONSORT extension(16) as a guide (Table 1). We defined the authors' conclusion about the feasibility of future definitive trials into three categories: proceed without changes, proceed with modifications, and not proceed.

Data analysis

We analyzed all data using descriptive statistics. We categorized included trials into two groups: those from the five top-ranked journals and those from the other Q1 journals. Furthermore, we defined trials that only assessed efficacy outcomes as efficacy trials and those with at least one feasibility outcome as feasibility trials. Some of the characteristics and methodological components were compared descriptively between these two categorizations.

Results

Search results

Of the 1745 citations retrieved, 1281 articles remained after the removal of duplicates. We assessed 345 full texts and included 24 pilot and feasibility RCTs in the final analysis.(19–42) The majority of studies excluded at the title and abstract screening stage were published as

conference abstracts (n=86). We also further excluded 81 adult trials in non-Q1 EM journals and 34 pediatric trials, as they were not the focus of this review. Details of study screening and reasons for exclusion are presented in Figure 1.

Trial characteristics

The summary of included trials' characteristics with methodological and reporting standards is presented in Table 2. Their individual characteristics are elaborated in Supplementary Table 1. Among 24 included trials, 13 were from the five top-ranked journals (Resuscitation (n=1), ACEM (n=9), SJTREM (n=1), AnnalsEM (n=1), and WJEM (n=1)), and 11 were from other Q1 journals (American Journal of Emergency Medicine (n=7), Emergency Medicine Australasia (n=2), Internal and Emergency Medicine (n=1), and International Journal of Emergency Medicine (n=1)). The majority were single-centered (87.5%), published after 2019 (70.8%), and from the United States (50.0%). Most defined their studies as 'pilot' (54.2%), especially those from other Q1 journals. The overall sample sizes ranged from 22 to 272. Counselling/education program and drug/intravenous fluid are the most common types of intervention assessed (both 29.2%), especially among top-ranked journals. More trials from top-ranked journals reported blinding in their trials and registered their trials as pilot/feasibility than those from other Q1 journals (61.5% versus 18.2% and 76.9% versus 27.3%, respectively).

Methodological and reporting standards

Most trials calculated their sample size based on efficacy outcomes (41.7%) or did not calculate or mention sample size calculation at all (37.5%). Of all included trials, 15 (62.5%) were efficacy trials with only hypothesis testing of efficacy outcomes, and 9 (37.5%) were feasibility trials with at least one feasibility outcome. Most of these feasibility trials were from top-ranked journals. Only two trials (8.3%) reported having endorsed the CONSORT extension

statement, and three (12.5%) progressed to the main study, all of which were from the five top-ranked journals.

Among the 9 feasibility trials, 5 (55.6%) reported the results appropriately with uncertainty estimates, and 3 (33.3%) had clear progression criteria with justification and appropriately made conclusions based on their criteria. Almost all these trials were from top-ranked EM journals. Four studies (44.4%) suggested that future trials should proceed without changes, while the other 4 (44.4%) recommended proceeding with some protocol modifications (on recruitment, eligibility criteria, engagement and delivery methods of intervention, and outcome assessment), and 1 (11.1%) did not recommend proceeding because their aim was not to inform future trials. The most common primary feasibility outcome category was 'process' (66.7%). The full list of feasibility outcomes evaluated can be found in Table 3. Overall, only the process and scientific domains were evaluated.

A total of 20 trials (83.3%) performed hypothesis testing on efficacy outcomes; 5 were feasibility, and 15 were pure efficacy trials (Table 4). Efficacy trials tended to support the intervention even though the results were not significant. There were relatively equal number and proportion of trials that made clinical implications to support the intervention among those from the five top-ranked and other Q1 journals.

Discussion

PFS play a pivotal role in successfully completing phase III RCTs, as they provide necessary information to evaluate the adequacy of the planned methods and procedures to avoid the potential futility of conducting large, expensive, yet unfeasible RCTs.(43) The key concepts of PFS have been well-established and disseminated, with guidelines for reporting and suggestions to improve their scientific rigour.(16,43) Although there is a growing number of published PFS

in the literature, many reviews in multiple clinical areas have identified weaknesses in their conduct and reporting.(8–13) We found concordant results in EM literature in this review, with mostly suboptimal methodological and reporting quality, even among Q1 EM journals.

Major issues for PFS in EM literature

Publication bias

This review identified only 24 pilot/feasibility RCTs in Q1 EM journals during the past five years. This number is much lower than that of other clinical areas(9,10,12,44), which could have been because our inclusion was not sensitive enough, or there were merely fewer clinical trials in EM. In either case, we might face the same challenges in other clinical areas; that is, many of these PFS never get published.(2,5,17) In fact, many conference abstracts were excluded at the screening stage, with only less than half (44.2%) going on to have their full texts published. One possible reason behind this is that most PFS are poorly designed with no clear feasibility objectives with an emphasis on statistical significance.(2) Another possible reason was that EM journals do not support the publication of such trials. Most of the included trials were from two out of nine journals, and more PFS were published from the 5 top-ranked (13 articles) compared to other Q1 journals (11 articles from 20 journals). More importantly, we found the methodological and reporting quality of PFS published in the five top-ranked journals were more robust than those from other Q1 journals in many aspects, highlighting the need to emphasize rigorous methods and quality in reporting among lower-ranked EM journals to improve the quality of the overall EM literature.

***Recommendation*:** EM trialists should understand the rigorous design and conduct of PFS. They should also follow established guidelines for PFS reporting, such as the CONSORT extension statement, to improve the overall quality of published articles. Moreover, they should

acknowledge that they, as researchers, have both ethical and scientific obligations to publish their studies. EM journals should also recognize the importance of these studies and encourage their publications. To guide authors, journals should implement clear PFS-specific instructions as they do with other study designs. In this way, both the quality and quantity of well-designed, well-executed, and well-reported PFS can be enhanced among the whole EM research community.

Hypothesis testing of treatment efficacy

The most common misuse of pilot trials is to perform hypothesis testing for treatment efficacy and conclude whether an intervention is effective or not.(4) This analysis is inappropriate, especially when no formal power calculations were carried out; such statistical analyses are thus most likely underpowered.(2,17,45) Moreover, with such small sample sizes, there are likely baseline imbalances and confidence intervals (CIs) of the estimates are usually wide and likely to include minimal clinically important difference (MCID) despite statistical significance.(17) In our review, the majority (83.3%) of all included trials performed statistical comparisons of treatment effects. Furthermore, all efficacy trials made clinical implications on their efficacy results, with some even promoting the use of the intervention when statistical or clinical significance was not met. These efficacy results may lead to misleading interpretations, especially when no formal power calculation was performed. Additionally, a relatively equal proportion of trials from both top-ranked and lower-ranked Q1 journals made clinical implications on intervention efficacy hypothesis testing, suggesting that this issue probably extends throughout the EM literature.

Recommendation: PFS should only report group estimates or effect estimates with CIs. These treatment effect estimates should only be used for hypothesis generation or sample size

estimation for the main trial. Hypothesis testing using inferential statistics should not be performed, or their results should be reported with caution. They should be interpreted based on MCID rather than p-values from underpowered analyses.(46) Also, the authors should not make strong implications, such as superiority or no effects, especially in the conclusion. 'Potential efficacy' may be declared when the CI around the treatment effect estimate covers the pre-defined MCID.(8) Moreover, the authors should clearly state that these analyses were exploratory in nature and mandate future confirmatory trials.

Assessment of safety and tolerability

PFS, with often small sample sizes, cannot provide definitive information on the safety and tolerability of the intervention, especially when none is demonstrated.(4) They may be able to help detect serious adverse events should they arise, but the rate always needs to be reported with CIs.(4) In this review, 13 studies (54.2%) reported safety outcomes, but less than half stated the relevant limitations. Some concluded their safety profile as 'no difference in adverse effects', which is misleading.

Recommendation: Adverse effects should be monitored in PFS, the same as any RCTs. However, authors should explicitly declare that the trial is underpowered to detect between-group differences or any rare adverse effects. On the contrary, if the CI around the harm effect estimate lies beyond the upper limit for safety, the authors should only report 'potential harm' instead of addressing certainty in their results.(8)

Trial registration and reporting

Pilot trials, specifically randomized PFS, should follow the same guidelines and requirements as full-scale RCTs, including trial registration, to minimize publication bias.(8) In this review, however, not all published pilot trials provided trial registration information. This was surprising

as these unregistered RCTs were published in Q1 EM journals, in which strict CONSORT standards should have been implemented. Furthermore, some trials were not registered as 'pilot' or 'feasibility' studies. Moreover, only a few reported having complied with the CONSORT extension for PFS, even though the extension was published almost two years before our search start date. One clear consequence is that feasibility outcomes were not reported and interpreted appropriately. As mentioned in the previous topic, results should be reported with uncertainty estimates, and this uncertainty should be reflected in the final report. The reporting of the results have implications on the design of future trials and the generalizability of the feasibility results to other settings.(16,43) In this review, only about 50% of feasibility trials reported uncertainty estimates of their feasibility outcomes. Furthermore, even a smaller number of trials reported having clear progression criteria. Appropriate and transparent use of progression criteria could offer clarity in delivering unbiased decisions on whether to proceed to a definitive trial or identify feasibility issues that can be modified. However, we found trials that concluded to proceed without changes (n=3) and proceed with changes (n=2) that did not have predefined progression criteria, so it was unclear how authors made those decisions and if there was any bias associated with their conclusions.

***Recommendation*:** Randomized PFS should be registered and indicate that they are pilot or feasibility in nature. The design should also be clearly described in publications, ideally in the title, for greater transparency.(44) The CONSORT extension checklist should be implemented in the journals' editorial guidelines for submission specifically for PFS. This would reinforce the authors to adhere to these criteria and set the appropriate standards for PFS published in EM literature. As stated in the CONSORT extension, PFS should have feasibility objectives always accompanied by uncertainty estimates and clear *a priori* progression criteria with conclusions

made accordingly. The progression criteria should involve all, not just one, important trial components assessed, with decisions made considering both point estimates and uncertainty estimates of feasibility outcomes.

Sample size calculation

Generally, a justification for the sample size chosen is required for PFS. Some may employ a confidence interval approach for feasibility outcomes.(2,47,48) Several simulation studies recommended different rules-of-thumb based on varying precisions of effect sizes of the expected outcomes.(49,50) Although effect sizes and uncertainty estimates derived from PFS can be used to guide sample size calculation of the main trial(2), implications on these estimates should be made with extreme caution due to their considerable variability.(2,3,17,45) In this review, not all trials justified how they defined their sample size and many made strong implications on their efficacy estimates.

Recommendation: A pilot study should have a clear justification for the sample size chosen. If preliminary estimates from PFS are used to calculate the sample size for the main trial, MCID should be considered, and the sample size estimation method that takes into account the uncertainty of the effect estimates should be endorsed.(2,4,45,46)

Misconceptions about pilot studies

Many researchers generally identify their studies as 'pilot' when they have limited resources available.(2,7) Some considered designating their trials as 'pilot' would increase their chance of being funded or successfully publish their studies.(5,11) Others redefined their trials *a posteriori* because the journal demanded so to caution readers of the uncertainty in the results.(51) In EM literature, similar issues exist. We retrieved more pilot than feasibility trials, similar to previous reviews.(5,10,18) Most trials named 'pilot' by the authors were stand-alone efficacy trials. In

contrast, most feasibility trials appropriately employed feasibility objectives, suggesting little misuse of this particular term. Overall, these findings imply that EM researchers, and perhaps journals, might have a misconception of the definition of pilot RCTs. It seems that most consider a pilot RCT as a smaller and underpowered version of the definitive trial or the first trial evaluating that particular research question.

In addition, the primary objective of conducting PFS should be to inform the design and ensure the feasibility of the full-scale RCTs. Nevertheless, despite most included trials stating that future definitive trials were feasible or should be performed, only 3 (12.5%) led to full-scale trials (1 published and 2 ongoing). One of the possible reasons explaining the small proportion of progressing trials was that this review was conducted shortly after the included PFS were published; therefore, it may be unlikely that the authors could initiate or complete the definitive trials. Also, despite multiple measures adopted to search for subsequent full-scale trials, we could have still missed some unidentified definitive trials since we did not contact the trial authors. Future comprehensive reviews of published definitive trials should be performed to evaluate their quality and assess whether appropriate PFS were carried out beforehand and how they influenced the design of the definitive trials. Nonetheless, a similar low rate of progression to definitive trials was also seen in reviews of other clinical fields.(5,9,44,52) Other issues reported by authors of pilot studies were the lack of funding, recruitment inadequacies, personnel change-over, and that the pilot trials had sufficiently answered the research questions.(9,52) The authors could also have refrained from publishing the pilot trials but instead added the pilot sample into the main trial to save time and cost, a situation easily detected and potentially preventable by public trial registration. Similar issues may also be presented in EM, although authors' survey should be performed to better understand the problem.

***Recommendation*:** Misconceptions about the true definition and objectives of PFS, especially a 'pilot' study, should be addressed to the EM research community. The primary objective of PFS should be to inform the main trial. Trialists should not believe in efficacy outcomes from PFS and should be encouraged to proceed to definitive trials to confirm the results, unless feasibility issues don't allow.

Underrecognized trial aspects

It is interesting and surprising to observe that the resources and management domains of feasibility objectives were not evaluated in any of the included trials, unlike in other clinical areas(10,53), even though several included PFS involved complex procedures and interventions, where resources and management may be an issue for successful full-scale trials.

Another crucial trial aspect that might not have been emphasized enough is the process of informed consent and how researchers disclose the nature of PFS to potential participants.(2,45) These ethical issues are challenging in EM, where obtaining informed consent often occurs in a time-dependent and busy environment that usually involves patients with emergency conditions. In this review, we found that some trials employed deferred consent, and no trials explicitly stated the nature of their study accordingly in their informed consent forms.

Recommendation: We encourage EM trialists to further evaluate all relevant feasibility domains, especially in resource-demanding trials and where data management may be a concern, such as those involving life-saving procedures. EM trialists should understand and abide by the highest ethical standards when performing PFS, as with any other research study. Informed consent should be obtained whenever possible, and the process should be transparent with clear definitions of the study's nature, rationale, objectives, and criteria for success.(2) A deferred or implied consent should be considered only in conditions that, without such a procedure,

recruitment might not be possible and RCTs can't be performed; it should not be implemented to expedite trial duration and process. PFS in EM research involving emergency or life-threatening conditions may be required to prove if such a scenario is applicable.

Limitations

This systematic review, though robust in its methods, has limitations. First, we searched for articles with the term 'pilot' or 'feasibility' only in the title or abstract since we wanted to focus on those explicitly addressed as such. Moreover, we only included Q1 EM journals and only added the five top-ranked journal names in the search term among over 100 EM-related journals.(15) Also, we excluded pediatric trials and those not conducted in the ED as we aimed to focus specifically on ED adult trials. Therefore, our search results might not have been representative of Q1 journals or the whole EM literature. Secondly, the full methodological and reporting quality was not performed. We could have employed other tools, such as the Cochrane Risk of Bias 2.0 tool and the full CONSORT extension checklist, but they were not the main objectives of this review, and we preferred to focus on specific essential elements. Nonetheless, a more comprehensive review might provide a better picture of the trials' overall quality and reporting completeness.

Conclusion

PFS play an important role in health research in providing information for the planning and justification of full-scale RCTs. We found the methodological and reporting quality of randomized PFS published in high-ranking EM journals was below standard, as many still primarily focused on clinical efficacy with low-quality reporting of objectives and PFS-specific outcomes. Therefore, our review highlights the need for resources and training for researchers, journal editors, peer reviewers, and research ethics boards on the value, objectives, and

appropriate conduct of PFS. The conceptual framework and standardized methodological components should be widely disseminated and emphasized. Also, EM journals should acknowledge the importance of pilot and feasibility work, reinforce the reporting standards, and support the publication of these studies. These actions can lead to more methodologically rigorous PFS that will inform feasible, successful, and rigorous future definitive RCTs in the EM literature.

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Competing interests statement.

All authors declare no competing interests.

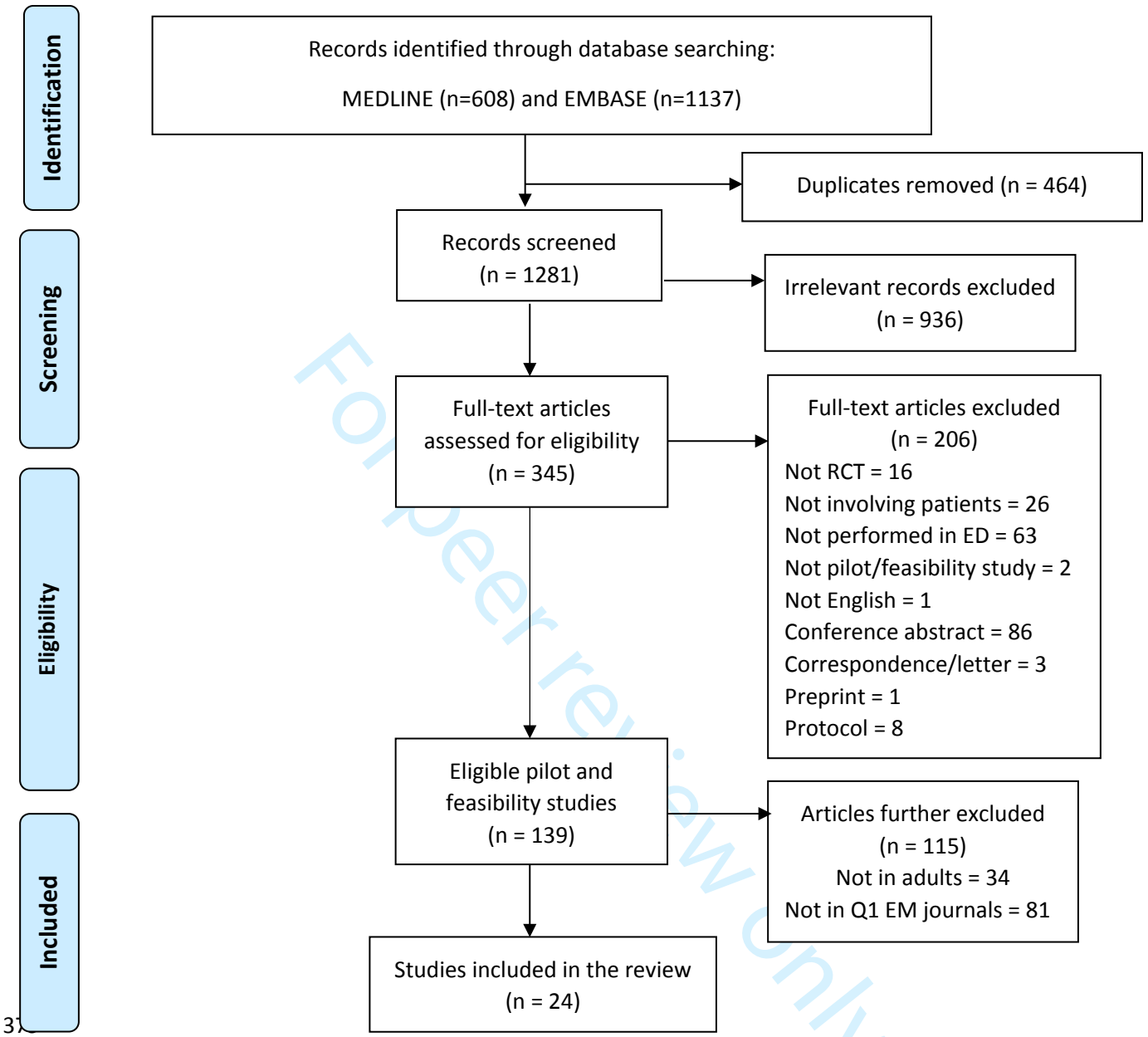

Figure 1. The PRISMA flow chart of study selection and inclusion
Abbreviation: RCT, randomized controlled trial; ED, Emergency Department; Q1 EM, first-quartile Emergency Medicine

Table 1. Reporting and methodological standards for pilot and feasibility studies

Section	Major CONSORT checklist for reporting	Methodological standards specific to a pilot study
Title and abstract	Identification as and summary of a pilot/feasibility design	
Background and objectives	Reasons for conducting a pilot study, rationale for future definitive trial, specific objectives of a pilot study	- Provide rationale for conducting a pilot study - State specific feasibility objectives of a pilot study
Methods; trial design	Description of pilot study design	
Methods; randomization, blinding	Type of randomization, sequence generation, allocation concealment methods, implementation and blinding	
Methods; participants	Eligibility criteria, settings and locations, how participants were identified and consented	
Methods; interventions	Details of interventions for each group	
Methods; outcomes	Measurements to address pilot study objectives, criteria used to judge whether or how to proceed with future definitive trial	- State appropriate progression criteria to judge feasibility and/or decide whether to proceed to a definitive trial
Methods; sample size	Rationale for sample size	- Appropriately state the rationale for the pilot study sample size
Methods; Analysis	Methods used to address pilot study objectives	- Feasibility objectives appropriately analyzed with descriptive statistics - Inferential statistics of efficacy outcomes should not be performed - Analyses should be explicitly stated that they were to inform future trials
Results; Participants	Participants' flow, duration of recruitment, baseline data, numbers analyzed for each objective	
Results; outcomes	Report results with uncertainty estimates by randomized group	- Report feasibility outcomes descriptively with uncertainty estimates
Results; harms	All important intended and unintended harms	
Discussion; limitations	Addressing sources of potential bias and remaining uncertainty about feasibility	- Discuss potential biases and uncertainty of feasibility outcomes - If estimates of efficacy outcomes or inferential statistics performed, explicitly declare their uncertainty
Discussion; generalizability	Generalizability of pilot study methods and findings to future definitive trial and other studies	- Discuss generalizability of feasibility outcomes that impact future trials
Discussion; interpretation	Interpretation consistent with pilot study objectives and findings, Implications for progression to future definitive trial, including any proposed amendments	- Discuss implications for progression to future definitive trial - If inferential statistics performed, clinical implications should not be made or emphasized

Notes;- "pilot study" refers to pilot/feasibility study/trial and applies to both randomized and non-randomized studies

Table 2. Trial characteristics and methodological and reporting standards

Trial characteristics	Total N=24	Five top-ranked journals N=13	Other Q1 journals N=11
Year of publication, n(%)			
2018	3 (12.5)	1 (7.7)	2 (18.2)
2019	4 (16.7)	1 (7.7)	3 (27.3)
2020	10 (41.7)	6 (46.2)	4 (36.4)
2021	4 (16.7)	3 (23.1)	1 (9.1)
2022	3 (12.5)	2 (15.4)	1 (9.1)
Study setting[a], n(%)			
United States of America	12 (50.0)	7 (53.8)	5 (45.5)
Europe	8 (33.3)	5 (38.5)	3 (27.3)
Australia	2 (8.3)	0 (0)	2 (18.2)
Asia	2 (8.3)	1 (7.7)	1 (9.1)
Africa	1 (4.2)	1 (7.7)	0 (0)
Number of study center, median [min, max]	1 [1, 33]	1 [1, 33]	1 [1, 1]
Study type defined by the authors, n(%)			
Pilot	13 (54.2)	5 (38.5)	8 (72.7)
Feasibility	3 (12.5)	3 (23.1)	0 (0)
Both pilot and feasibility	8 (33.3)	5 (38.5)	3 (27.3)
Type of intervention, n(%)			
Drug or fluid	7 (29.2)	4 (30.8)	3 (27.3)
Device for treatment	2 (8.3)	1 (7.7)	1 (9.1)
Device for procedure	5 (20.8)	2 (15.4)	3 (27.3)
Treatment process	3 (12.5)	1 (7.7)	2 (18.2)
Counseling/education/monitoring program	7 (29.2)	5 (38.5)	2 (18.2)
Number of arms, median [min, max]	2 [2, 3]	2 [2, 3]	2 [2, 3]
Any blinding presented, n(%)	10 (41.7)	8 (61.5)	2 (18.2)
Sample size, median [min, max]	68 [22, 272]	55 [29, 255]	83 [22, 272]
Funding, n(%)			
None	9 (37.5)	4 (30.8)	5 (45.5)
From industrial sources	2 (8.3)	2 (15.4)	0 (0)
From non-industrial sources	13 (54.2)	7 (53.8)	6 (54.5)
Trial registration, n(%)			
None	7 (29.2)	1 (7.7)	6 (54.5)
Registered as pilot/feasibility study	13 (54.2)	10 (76.9)	3 (27.3)
Registered but not as pilot/feasibility study	4 (16.7)	2 (15.4)	2 (18.2)
Sample size calculation			
Calculated based on feasibility outcome	3 (12.5)	2 (15.4)	1 (9.1)
Calculated based on efficacy outcome	10 (41.7)	4 (30.8)	6 (54.5)
Targeted based on expected availability	1 (4.2)	1 (7.7)	0 (0)
Not calculated, based on rule-of-thumb	1 (4.2)	1 (7.7)	0 (0)
Not calculated or not mentioned	9 (37.5)	5 (38.5)	4 (36.4)
Ethical requirement[a]			
Informed consent required	18 (75.0)	10 (76.9)	8 (72.7)
Consent not required or deferred	4 (16.7)	3 (23.1)	1 (9.1)
Not mentioned	3 (12.5)	1 (7.7)	2 (18.2)
Primary trial objectives			
Efficacy trial with only efficacy outcome(s)	15 (62.5)	6 (46.2)	9 (81.8)
Feasibility trial with feasibility objective(s)	9 (37.5)	7 (53.8)	2 (18.2)
CONSORT extension for pilot trials cited and endorsed	2 (8.3)	2 (15.4)	0 (0)
Progression to the main trial	3 (12.5)	3 (23.1)	0 (0)

[a]one study had two settings or consent types. Abbreviation: Q1, first-quartile

Table 3. Methodological and reporting standards of feasibility trials

Standards	N=9, n(%)
Report feasibility objectives with uncertainty estimates	5 (55.6)
Clear progression criteria with thresholds justified	3 (33.3)
Conclusion for future trial	
Proceed, no changes required	4 (44.4)
Proceed with modifications	4 (44.4)
Not	1 (11.1)
Primary outcome category	
Process – inclusion criteria, recruitment, consent rate	2 (22.2)
Process – retention, compliance, adherence, follow-up rate	1 (11.1)
Process – acceptability and feasibility of intervention	3 (33.3)
Scientific – preliminary estimates for main trial sample calculation	1 (11.1)
Scientific – clinical outcomes	2 (22.2)
Study components assessed	
Process – inclusion criteria, recruitment, consent rate	4 (44.4)
Process – acceptability and feasibility of intervention	8 (88.9)
Process – retention, compliance, adherence, follow-up rate	5 (55.6)
Process – blinding	1 (11.1)
Process – outcome measurements, data collection	2 (22.2)
Scientific – preliminary estimates for main trial sample calculation	3 (33.3)
Scientific – clinical outcomes	8 (88.9)
Scientific – surrogate outcomes	1 (11.1)
Scientific – safety, adverse events	4 (44.4)

Table 4. Methodological and reporting standards of pilot and feasibility trials with hypothesis testing of efficacy outcomes

Standards	By study type		By published journal	
	Feasibility trials n = 5	Efficacy trials n = 15	Five top-ranked n=9	Other Q1 n=11
Primary outcome results				
No significant between-group difference	2 (40.0)	8 (53.3)	4 (44.4)	6 (54.5)
Intervention significantly better than control/standard care	3 (60.0)	7 (46.7)	5 (55.6)	5 (45.5)
Clinical implication statement				
None	1 (20.0)	0 (0)	1 (11.1)	0 (0)
Support intervention	3 (60.0)	13 (86.7)	8 (88.9)	8 (72.7)
State “no difference” or “no effect”	1 (20.0)	2 (13.3)	0 (0)	3 (27.3)

Abbreviation: Q1, first-quartile

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Appendix. Search strategy and results

Database(s): **Embase** 1974 to 2023 September 29
Search Strategy:

#	Searches	Results
1	(pilot or feasibility or vanguard).ti,ab.	605491
2	emergency medicine.mp. or exp emergency medicine/	63176
3	emergency department.mp. or exp emergency ward/	267200
4	emergency patient.mp. or exp emergency patient/	5168
5	exp emergency/ or emergency.mp.	690957
6	2 or 3 or 4 or 5	690961
7	exp "randomized controlled trial (topic)"/ or exp randomized controlled trial/ or randomized.mp.	1426097
8	"controlled clinical trial (topic)"/ or controlled clinical trial/	484023
9	(randomized or randomised).ab.	1070672
10	7 or 8 or 9	1676521
11	resuscitation.jn.	12355
12	"annals of emergency medicine".jn.	20441
13	academic emergency medicine.jn.	17112
14	"scandinavian journal of trauma resuscitation and emergency medicine".jn.	1512
15	"western journal of emergency medicine".jn.	3159
16	11 or 12 or 13 or 14 or 15	54579
17	6 or 16	708159
18	1 and 10 and 17	2456
19	limit 18 to (human and english language and yr="2018 -Current")	1137

Database(s): **OVID Medline** Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE(R) Daily and Ovid MEDLINE(R) 1946 to Present

Search Strategy:

#	Searches	Results
1	(pilot or feasibility or vanguard).ti,ab.	423204
2	exp emergency medicine/ or exp pediatric emergency medicine/	15678
3	emergency department.mp. or exp Emergency Service, Hospital/	165558
4	emergency room.mp.	22921
5	emergency.mp. or exp Emergencies/	420395
6	2 or 3 or 4 or 5	429408
7	exp Randomized Controlled Trial/	602377
8	(randomized controlled trial or controlled clinical trial).pt. or randomized.ab. or randomised.ab.	1077849
9	trial.ti,ab.	771533
10	7 or 8 or 9	1422442
11	resuscitation.jn.	9421
12	"annals of emergency medicine".jn.	14298
13	academic emergency medicine.jn.	6581
14	"scandinavian journal of trauma resuscitation & emergency medicine".jn.	1511
15	"western journal of emergency medicine".jn.	2511
16	11 or 12 or 13 or 14 or 15	34322
17	6 or 16	444291
18	1 and 10 and 17	1758
19	limit 18 to (english language and humans and yr="2018 -Current")	608

Supplementary Table 1. Characteristics of included trials

Author, year	Journal	Study setting	Study type by authors	Sample size	Condition	Type of intervention	Arms	Primary outcome	Other outcomes	Conflict of interest
Jones, 2018	Annals EM	USA, single center	Pilot and feasibility	50	Migraine headache	Drug (IV fluid bolus vs slow rate)	2	Preliminary estimate for main trial sample calculation	Rate of protocol completion, effectiveness of blinding, clinical efficacy, safety	Non-industrial funding
Fox, 2018	AJEM	USA, single center	Pilot and feasibility	30	Lower back pain	Treatment process (battlefield acupuncture)	2	Clinical efficacy	Safety	None declared
Bruguera, 2018	ACEM	USA, single center	Feasibility	200	At-risk drinkers	Counseling/education program (specialized brief intervention)	2	Clinical efficacy	-	Non-industrial funding
Meurer, 2019	ACEM	USA, single center	Pilot and feasibility	55	Discharged with elevated BP	Counseling/education program (mobile health BP intervention)	2	Compliance/adherence	Recruitment rate, feasibility of intervention, clinical efficacy, surrogate outcome, safety	Non-industrial funding
Cochrane, 2019	AJEM	USA, single center	Pilot	70	Difficult IV placement	Device procedure (US-guided IV with or without guidewire)	2	Clinical efficacy	-	Non-industrial funding
Merritt, 2019	AJEM	USA, single center	Pilot	272	Discharged with PC follow-up	Counseling/education program (PC follow-up appointment website)	3	Clinical efficacy	-	Non-industrial funding
Kim, 2019	AJEM	Korea, single center	Pilot	22	Carbon monoxide intoxication	Treatment device (HFNC vs conventional oxygen bag)	2	Surrogate outcome	-	Non-industrial funding
LaBarbara, 2020	ACEM	USA, 2 centers	Pilot and feasibility	64	Post-motor-vehicle-crash	Counseling/education program (PTSD coach application)	2	Recruitment and retention rate	Acceptability of intervention, clinical efficacy	Non-industrial funding
Probst, 2020	ACEM	USA, single center	Pilot and feasibility	51	Syncope	Counseling/education program (shared decision-making tool)	2	Recruitment rate	Follow-up rate, outcome measurement and selection, acceptability of intervention, preliminary estimate for main trial sample calculation, clinical efficacy	Non-industrial funding
Mitra, 2020	EMA	Australia, single center	Pilot	30	Migraine	Drug (propofol vs standard care)	2	Feasibility and acceptability of intervention	preliminary estimate for main trial sample calculation, clinical efficacy, safety	Non-industrial funding

Lin, 2020	AJEM	USA, single center	Pilot	93	Combative agitation	Drug (ketamine vs standard care)	2	Clinical efficacy	Safety	None declared
Doyle, 2020	EMA	Australia, single center	Pilot	80	Discharged from emergency department	Counseling/education program (mobile discharged instruction)	2	Clinical efficacy	-	Non-industrial funding
Villa,2020	IntEM	Europe, single center	Pilot and feasibility	100	Dermatological emergency	Device assessment (telemedicine)	2	Safety	Clinical efficacy	None declared
Peacock, 2020	ACEM	USA and EU, 33 centers	Pilot	70	Hyperkalemia	Drug (sodium zirconium cyclosilicate vs standard care)	2	Surrogate outcome	Clinical efficacy, safety	Industrial funding
Dean, 2020	ACEM	USA, single center	Pilot	30	Cannabinoid hyperemesis	Drug (topical capsaicin vs placebo)	2	Clinical efficacy	Safety	Non-industrial funding
Ruangsomboon, 2021	ACEM	Thailand, single center	Pilot	37	Acute severe asthma	Treatment device (HFNC vs standard oxygen therapy)	2	Preliminary estimate for main trial sample calculation	Clinical efficacy, safety	None declared
Rafique, 2019	ACEM	USA, single center	Pilot	43	Hyperkalemia	Drug (patiromer vs standard care)	2	Surrogate outcome	Clinical efficacy, safety	Industrial funding
Hyuha, 2021	IJEM	Tanzania, single center	Feasibility	255	Trauma patients screened for HIV	Counseling/education program (text messaging to promote care)	2	Clinical efficacy	Feasibility of intervention	Non-industrial funding
Sabbadini, 2021	WJEM	USA, single center	Pilot and feasibility	29	Trauma	Device assessment (ultrasound protocols)	2	Clinical efficacy	Feasibility of intervention	None declared
Lesnik, 2021	AJEM	Slovenia, single center	Pilot	100	Patients requiring peripheral IV	Device procedure (tissue vs standard adhesives for securing IV catheters)	2	Clinical efficacy	Safety	None declared
Fuest, 2021	Resuscitation	Germany, single center	Pilot	30	Cardiac arrest	Treatment process (different ventilator modes)	3	Surrogate outcome	Clinical efficacy	None declared
Katzenschlager, 2022	SJTREM	Germany, single center	Feasibility	66	Trauma	Device assessment (hyperspectral imaging)	2	Feasibility of intervention	-	None declared

Jessen, 2022	ACEM	Denmark, 3 centers	Pilot and feasibility	124	Sepsis	Drug (restrictive fluid vs standard care)	2	Feasibility of intervention	Recruitment rate, adherence rate, outcome measurement, clinical efficacy, safety	Non-industrial funding
Bakker, 2022	AJEM	Netherland, single center	Pilot	83	Acute pain from chest trauma	Treatment process (Kinesiotaping)	2	Clinical efficacy	-	None declared

Abbreviations; AnnalsEM, Annals of emergency Medicine; AJEM, American Journal of Emergency Medicine; ACEM, Academic Emergency Medicine; EMA, Emergency Medicine Australasia; IntEM, Internal and Emergency Medicine; IJEM, International Journal of Emergency Medicine; WJEM, Western Journal of Emergency Medicine; SJTREM, Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine; USA, United States of America; EU, Europe; BP, blood pressure; IV, intravenous; PC, primary care; PTSD, post-traumatic stress disorder; HFNC, high-flow nasal cannula; US, ultrasound

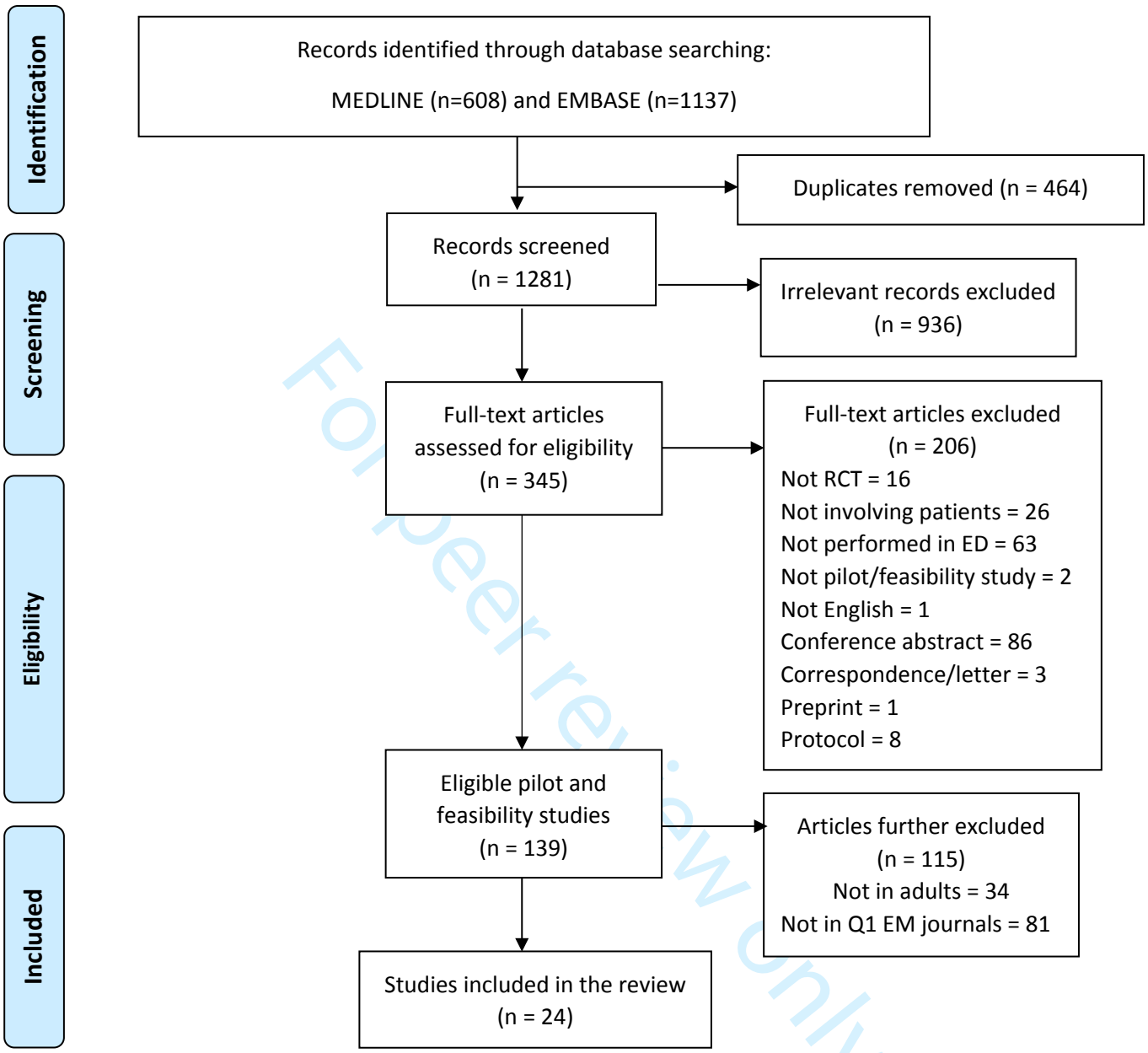

Figure 1. The PRISMA flow chart of study selection and inclusion
Abbreviation: RCT, randomized controlled trial; ED, Emergency Department; Q1 EM, first-quartile Emergency Medicine

BMJ Open

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Methodological Standards in the Design and Reporting of Pilot and Feasibility Studies in Emergency Medicine Literature: a Systematic Review

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Methodological Standards in the Design and Reporting of Pilot and Feasibility Studies in Emergency Medicine Literature: a Systematic Review

Abstract

Objective: Pilot and feasibility studies are intended to ensure that subsequent randomized controlled trials (RCTs) are feasible, economical, and rigorous, especially in a challenging research environment such as emergency medicine (EM). We aimed to evaluate the methodological quality in conducting and reporting randomized pilot and feasibility studies in the EM literature and propose recommendations to improve their quality.

Design: Methodological systematic review

Data sources and eligibility: We searched MEDLINE and Embase (2018-29 September 2023) for pilot or feasibility RCTs published as full texts in the five top-ranked and other first-quartile EM journals according to Scimago.

Data extraction and analysis: We assessed their methodological features and reporting quality primarily based on the CONSORT extension.

Results: A total of 24 randomized trials identified as pilot (n=13), feasibility (n=3), or both (n=8) were included. At least one feasibility outcome was assessed in nine trials (feasibility trials), while 15 others only focused on treatment efficacy (efficacy trials). Only three (12.5%) studies progressed to the main trials. Among 12 feasibility trials, 55.6% reported their outcomes with uncertainty estimates, and 33.3% had clear progression criteria. Efficacy trials tended to draw clinical implications on their results. Studies from the five top-ranked journals had better methodological and reporting quality than those from other first-quartile journals.

Conclusion: Main methodological concerns for pilot and feasibility studies in first-quartile EM literature include misconceptions, misuses, and suboptimal design and reporting quality. These issues were more prominent in lower-ranked first-quartile journals. Our findings highlight the need for resources and training for researchers, journal editors, and peer reviewers on the value, objectives, and appropriate conduct of pilot and feasibility studies. The conceptual framework and standardized methodological components should be emphasized. EM journals should reinforce the reporting standards and support their publication. These actions can lead to more methodologically rigorous pilot and feasibility studies in EM.

Registration: PROSPERO (CRD42023468437)

Keywords: pilot, pilot trial, feasibility, feasibility trial, emergency medicine

Strengths and limitations of this study

- Robust systematic review methods are performed to addresses a major methodological issue.
- Comprehensive aspects of the design, conduct, and reporting of pilot and feasibility studies are assessed and evaluated.
- The search and inclusion criteria are not very sensitive, though it should not affect the overall results of the review.

Introduction

Pilot and feasibility studies (PFSs) contribute significantly to the health research community by offering data necessary for the design and successful conduct of larger-scale studies, especially phase III randomized controlled trials (RCTs).[1] PFSs can increase the chance of success of the main study and, most importantly, they can reduce the potential waste of time and resources.[2] In evaluating complex interventions, it is recommended that the feasibility and acceptability of interventions should be assessed and the trial design should be evaluated before making decisions about the study progression.[3] Many interventions evaluated in emergency medicine (EM) clearly meet the definition of complex intervention, with the complexity mainly arising from the interaction between the intervention's components and the clinical emergency context in which it is being implemented.[3] Consequently, PFSs are essential for the success of full-scale definitive RCTs in a challenging environment such as EM. Despite their notable importance, academic research training has not paid enough attention to them.[2] Their methodological and reporting standards have not been widely implemented, and many misuses and misconceptions are still presented.[4]

Since a pilot and a feasibility study both aim at the same goal, they are often considered synonymous.[5] However, a conceptual framework developed by distinguished methodologists suggests that pilot studies are a subset of feasibility studies with similar objectives but with a specific design feature and similar methods to the definitive trial; they thus agree that the two terms should not be considered mutually exclusive.[5–7] PFSs performed prior to a full-scale RCT can be randomized or non-randomized, though a pilot study whose design matches that of the full trial would normally be randomized.[6]

In many other clinical areas, reviews have shown that the methodological standards and reporting quality of published PFSs were still suboptimal, with each research field having

different issues and obstacles.[8–13] No reviews, however, have been performed to assess such standards on published studies in EM. Therefore, this systematic review aimed to evaluate the methodological and reporting standards of randomized PFSs conducted in adults, in an emergency department (ED) setting and published in top-ranked EM journals. The ultimate objective was to propose recommendations based on the deficiencies identified in our review to improve the quality of PFSs.

Methods

Trial identification

The report of this study followed the PRISMA (preferred reporting items for systematic reviews and meta-analyses) 2020 reporting guidelines.[14] The protocol was registered in PROSPERO (CRD42023468437) prior to commencing abstract screening. Published literature in first-quartile EM journals based on Scimago [15] with one or both of the words 'pilot' and 'feasibility' in the title or abstract was identified by searching MEDLINE (2018–2023 September 29) and Embase (2018–2023 September 29) via Ovid. We started our search beginning in 2018 to allow for time to implement the conceptual framework for PFSs and the corresponding Consolidated Standards of Reporting Trials (CONSORT) extension in 2016.[2,16] Based on the five top-ranked EM-based journals according to Scimago[15], *Resuscitation*, *Academic Emergency Medicine (ACEM)*, *Scandinavian Journal of Trauma, Resuscitation, and Emergency Medicine (SJTREM)*, *Annals of Emergency Medicine (AnnalsEM)*, and *Western Journal of Emergency Medicine (WJEM)* were included as search terms. We also included studies published in other EM journals within the first quartile (Q1) to be compared to the five top-ranked journals. We limited retrieval to those published between 2018-2023 September 29, written in English, and enrolled patients from the ED. The search strategy and results are presented in Appendix.

Duplicates were removed using Covidence and manual deduplication. Only randomized PFSs involving adult patients in the ED were included, and those that were not original articles or that were conference abstracts without retrievable full texts were excluded. For this review, we did not delineate between pilot and feasibility studies despite the consensus definition, and we employed a more restricted definition focusing on only external pilot studies performed prior to full-scale RCTs.[5,6,17] In searching for the corresponding definitive trials, we performed a literature search of the included PFSs' titles, key terms, citations, and authors' names in the same databases and clinicaltrials.gov.

Study screening and data collection processes

Two reviewers (O.R and J.P.L) independently and in duplicate screened abstracts and full texts, with discordances resolved by a third reviewer (M.E.). They also independently and in duplicate extracted trial characteristics, and their methodological and reporting aspects. Discordances at this stage were adjudicated by a senior reviewer (A.W.). We used Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia) for all the review processes.

Trial characteristics

We recorded general and specific trial characteristics related to PFSs. The study type was categorized based on the authors' definition (pilot, feasibility, or both). Feasibility outcomes were categorized according to Thabane et al.[2] into the four following domains;

Process: the feasibility of the study protocol; appropriateness of the inclusion and exclusion criteria, recruitment and consent rate; retention, adherence, and follow-up rate; randomization procedure and blinding; acceptability and feasibility of the intervention; selection of the primary

outcome; preparation and appropriateness of the interventions and instruments used for outcome measurements.

Resources: the capacity of study centers and researchers, i.e., willingness and capacity, length of time to obtain consent, apply study intervention, and collect study data, and the required training and number of researchers.

Management: potential human and data management problems.

Scientific: information to guide the sample size for the main trial; treatment safety and dose-response.

Methodological and reporting standards

We evaluated the methodological quality of the included trials using a list of components adapted from Arain et al.[5] and Shanyinde et al.[18] and developed using the CONSORT extension[16] as a guide (Table 1). We defined the authors' conclusion about the feasibility of future definitive trials into three categories: proceed without changes, proceed with modifications, and not proceed.

Data analysis

We analyzed all data using descriptive statistics. We categorized included trials into two groups: those from the five top-ranked journals and those from the other Q1 journals excluding the top five, in order to compare their standards. Furthermore, we defined trials that only assessed efficacy outcomes as efficacy trials and those with at least one feasibility outcome as feasibility trials. Some of the characteristics and methodological components were compared descriptively between these two categorizations.

Patient and Public Involvement

None

Results

Search results

Of the 1745 citations retrieved, 1281 articles remained after the removal of duplicates. We assessed 345 full texts and included 24 pilot and feasibility RCTs in the final analysis.[19–42] The majority of studies excluded at the title and abstract screening stage were published as conference abstracts (n=86). We also further excluded 81 adult trials in non-Q1 EM journals and 34 pediatric trials, as they were not the focus of this review. Details of study screening and reasons for exclusion are presented in Figure 1.

Trial characteristics

The summary of included trials' characteristics with methodological and reporting standards is presented in Table 2. Their individual characteristics are elaborated in Supplementary Table 1. Among 24 included trials, 13 were from the five top-ranked journals (*Resuscitation* (n=1), *ACEM* (n=9), *SJTREM* (n=1), *AnnalsEM* (n=1), and *WJEM* (n=1)), and 11 were from other Q1 journals (*American Journal of Emergency Medicine* (n=7), *Emergency Medicine Australasia* (n=2), *Internal and Emergency Medicine* (n=1), and *International Journal of Emergency Medicine* (n=1)). The majority were single-centered (87.5%), published after 2019 (70.8%), and from the United States (50.0%). Most defined their studies as 'pilot' (54.2%), especially those from other Q1 journals. The overall sample sizes ranged from 22 to 272. Counselling/education program and drug/intravenous fluid were the most common types of intervention assessed (both 29.2%), especially among top-ranked journals. More trials from top-ranked journals reported blinding in their trials and registered their trials as pilot/feasibility than those from other Q1 journals (61.5% versus 18.2% and 76.9% versus 27.3%, respectively).

Methodological and reporting standards

Most trials calculated their sample size based on efficacy outcomes (41.7%) or did not calculate or mention sample size calculation at all (37.5%). Of all included trials, 15 (62.5%) were efficacy trials that included no feasibility components other than hypothesis testing of efficacy outcomes, and 9 (37.5%) were feasibility trials assessing at least one feasibility outcome. Most of these feasibility trials were from top-ranked journals. Only two trials (8.3%) reported having endorsed the CONSORT extension statement, and three (12.5%) progressed to the main study, all of which were from the five top-ranked journals.

Among the 9 feasibility trials, 5 (55.6%) reported the results appropriately with uncertainty estimates (such as confidence intervals (CIs)), and 3 (33.3%) had clear progression criteria with justification and appropriately made conclusions based on their criteria. Almost all these trials were from top-ranked EM journals. Four studies (44.4%) suggested that future trials should proceed without changes, while the other 4 (44.4%) recommended proceeding with some protocol modifications (on recruitment, eligibility criteria, engagement and delivery methods of intervention, and outcome assessment), and 1 (11.1%) did not recommend proceeding because their aim was not to inform future trials. The most common primary feasibility outcome category was 'process' (66.7%). The full list of feasibility outcomes evaluated can be found in Table 3. Overall, only the process and scientific domains were evaluated.

A total of 20 trials (83.3%) performed hypothesis testing on efficacy outcomes; 5 were feasibility, and 15 were pure efficacy trials (Table 4). The authors of efficacy trials tended to support the intervention even though the results were not significant. There were relatively equal number and proportion of trials that drew clinical implications to support the intervention among those from the five top-ranked and other Q1 journals.

Discussion

PFSs play a pivotal role in successfully completing phase III RCTs, as they provide necessary information to evaluate the adequacy of the planned methods and procedures to avoid the potential futility of conducting large, expensive, yet unfeasible RCTs.[43] The key concepts of PFSs have been well-established and disseminated, with guidelines for reporting and suggestions to improve their scientific rigour.[16,43] Although there is a growing number of published PFSs in the literature, many reviews in multiple clinical areas have identified weaknesses in their conduct and reporting.[8–13] We found concordant results in EM literature in this review, with mostly suboptimal methodological and reporting quality, even among Q1 EM journals.

Major issues for PFSs in EM literature

Publication bias

This review identified only 24 pilot/feasibility RCTs in Q1 EM journals during the past five years. This number is much lower than that of other clinical areas[9,10,12,44], which could have been because our inclusion was not sensitive enough, or there were merely fewer clinical trials in EM. In either case, we might face the same challenges in other clinical areas; that is, many of these PFSs never get published.[2,5,17] In fact, many conference abstracts were excluded at the screening stage, with only less than half (44.2%) going on to have their full texts published. One possible reason behind this is that most PFSs are poorly designed with no clear feasibility objectives with an emphasis on statistical significance.[2] Another possible reason was that EM journals do not support the publication of such trials. Most of the included trials were from two out of nine journals, and more PFSs were published from the 5 top-ranked (13 articles) compared to other Q1 journals (11 articles from 20 journals). More importantly, we found the

methodological and reporting quality of PFSs published in the five top-ranked journals was more robust than that of studies from other Q1 journals in many respects, highlighting the need to emphasize rigorous methods and quality in reporting among lower-ranked EM journals to improve the quality of the overall EM literature.

***Recommendation*:** EM trialists should understand the rigorous design and conduct of PFSs. They should also follow established guidelines for PFSs reporting, such as the CONSORT extension statement, to improve the overall quality of published articles. Moreover, they should acknowledge that they, as researchers, have both ethical and scientific obligations to publish their studies. EM journals should also recognize the importance of these studies and encourage their publication. To guide authors, journals should implement clear PFS-specific instructions as they do with other study designs. In this way, both the quality and quantity of well-designed, well-executed, and well-reported PFSs can be enhanced among the whole EM research community.

Hypothesis testing of treatment efficacy

The most common misuse of pilot trials is to perform hypothesis testing for treatment efficacy and conclude whether an intervention is effective or not.[4] This analysis is inappropriate, especially when no formal power calculations were carried out; such statistical analyses are thus most likely underpowered.[2,17,45] In our review, the majority (83.3%) of all included trials performed statistical comparisons of treatment effects. Furthermore, all efficacy trials drew clinical implications on their efficacy results, with some even promoting the use of the intervention when statistical or clinical significance was not met. These efficacy results may lead to misleading interpretations, especially when no formal power calculation was performed. Additionally, a relatively equal proportion of trials from both top-ranked and lower-ranked Q1

journals drew clinical implications on intervention efficacy hypothesis testing, suggesting that this issue probably extends throughout the EM literature.

Recommendation: PFSs should only report group estimates or effect estimates with CIs. Hypothesis testing using inferential statistics should not be performed, and these results should not be interpreted based on p-values from underpowered analyses.[46] Researchers may use the variance around the effect estimates to inform the sample size of the main trial. Data should be presented or shared in sufficient detail that would allow future systematic reviews and meta-analysis to extract. Also, the authors should not draw strong implications, such as superiority or no effects, especially in the conclusion. 'Potential efficacy' may be declared when the CI around the treatment effect estimate covers the pre-defined MCID.[8] Moreover, the authors should clearly state that these analyses were exploratory in nature and mandate future confirmatory trials.

Assessment of safety and tolerability

PFSs, with often small sample sizes, cannot provide definitive information on the safety and tolerability of the intervention, especially when none is demonstrated.[4] They may be able to help detect serious adverse events should they arise, but the rate always needs to be reported with CIs.[4] In this review, 13 studies (54.2%) reported safety outcomes, but less than half stated the relevant limitations. Some concluded their safety profile as 'no difference in adverse effects', which is misleading.

Recommendation: Adverse effects should be monitored in PFSs, the same as any RCTs. However, authors should explicitly declare that the trial is underpowered to detect between-group differences or any rare adverse effects. On the contrary, if the CI around the harm effect estimate lies beyond the upper limit for safety, the authors should only report 'potential harm'

instead of addressing certainty in their results, as any estimate from an underpowered study can be unreliable.[8]

Trial registration and reporting

Pilot trials, specifically randomized PFSs, should follow the same guidelines and requirements as full-scale RCTs, including trial registration, to minimize publication bias.[8] In this review, however, not all published pilot trials provided trial registration information. This was surprising as these unregistered RCTs were published in Q1 EM journals, in which strict CONSORT standards should have been implemented. Furthermore, some trials were not registered as 'pilot' or 'feasibility' studies. Moreover, only a few reported having complied with the CONSORT extension for PFSs, even though the extension was published almost two years before our search start date. One clear consequence is that feasibility outcomes were not reported and interpreted appropriately. As mentioned in the previous topic, results should be reported with uncertainty estimates, and this uncertainty should be reflected in the final report. The reporting of the results has implications for the design of future trials and the generalizability of the feasibility results to other settings.[16,43] In this review, only about 50% of feasibility trials reported uncertainty estimates of their feasibility outcomes. Furthermore, even a smaller number of trials reported having clear progression criteria. Appropriate and transparent use of progression criteria could offer clarity in delivering unbiased decisions on whether to proceed to a definitive trial or identify feasibility issues that can be modified. However, we found trials that concluded to proceed without changes (n=3) and proceed with changes (n=2) that did not have predefined progression criteria, so it was unclear how the authors made those decisions and if there was any bias associated with their conclusions.

***Recommendation*:** Randomized PFSs should be registered and indicate that they are pilot or feasibility in nature. The design should also be clearly described in publications, ideally in the title, for greater transparency.[44] The CONSORT extension checklist should be implemented in the journals' editorial guidelines for submission specifically for PFSs. This would reinforce the authors to adhere to these criteria and set the appropriate standards for PFSs published in EM literature. As stated in the CONSORT extension, PFSs should have feasibility objectives always accompanied by uncertainty estimates and clear *a priori* progression criteria with conclusions made accordingly. The progression criteria should involve all, not just one, important trial components assessed, with decisions made considering both point estimates and uncertainty estimates of feasibility outcomes.

Sample size calculation

Generally, a justification for the sample size chosen is required for PFSs. Some may employ a confidence interval approach for feasibility outcomes.[2,47,48] Several simulation studies recommended different rules-of-thumb based on varying precisions of effect sizes of the expected outcomes.[49,50] A formula has also been proposed for sample size estimation of PFSs aiming to detect problems in a trial, such as inclusion/exclusion criteria.[51] Although effect sizes and uncertainty estimates derived from PFSs can be used to guide sample size calculation of the main trial[2], implications on these estimates should be made with extreme caution due to their considerable variability.[2,3,17,45] Also, PFSs are usually too small to estimate parameters required for the definitive trial if its design is a clustered RCT.[52] In this review, not all trials justified how they defined their sample size and many drew strong implications on their efficacy estimates.

Recommendation: A pilot study should have a clear justification for the sample size chosen. If preliminary estimates from PFSs are used to calculate the sample size for the main trial, MCID should be considered, and the sample size estimation method that takes into account the uncertainty of the effect estimates should be endorsed.[2,4,45,46,53]

Misconceptions about pilot studies

Many researchers generally identify their studies as 'pilot' when they have limited resources available.[2,7] Some considered designating their trials as 'pilot' would increase their chance of being funded or successfully publish their studies.[5,11] Others redefined their trials *a posteriori* because the journal demanded so to caution readers of the uncertainty in the results.[54] In EM literature, similar issues exist. We retrieved more pilot than feasibility trials, similar to previous reviews.[5,10,18] Most trials named 'pilot' by the authors were stand-alone efficacy trials. In contrast, most feasibility trials appropriately employed feasibility objectives, suggesting little misuse of this particular term. Overall, these findings imply that EM researchers, and perhaps journals, might have a misconception of the definition of pilot RCTs. It seems that most consider a pilot RCT as a smaller and underpowered version of the definitive trial or the first trial evaluating that particular research question.

In addition, the primary objective of conducting PFSs should be to inform the design and ensure the feasibility of the full-scale RCTs. Nevertheless, despite most included trials stating that future definitive trials were feasible or should be performed, only 3 (12.5%) led to full-scale trials (1 published and 2 ongoing). One of the possible reasons explaining the small proportion of progressing trials was that this review was conducted shortly after the included PFSs were published; therefore, it may be unlikely that the authors could have initiated or completed the definitive trials by this time. Also, despite multiple measures adopted to search for subsequent

full-scale trials, we could have still missed some unidentified definitive trials since we did not contact the trial authors. Future comprehensive reviews of published definitive trials should be performed to evaluate their quality and assess whether appropriate PFSs were carried out beforehand and how they influenced the design of the definitive trials. Nonetheless, a similar low rate of progression to definitive trials was also seen in reviews of other clinical fields.[5,9,44,55] Other issues reported by authors of pilot studies were the lack of funding, recruitment inadequacies, personnel change-over, and that the pilot trials had sufficiently answered the research questions.[9,55] The authors could also have refrained from publishing the pilot trials but instead added the pilot sample into the main trial to save time and cost, a situation easily detected and potentially preventable by public trial registration. Similar issues may also be presented in EM, although authors' survey should be performed to better understand the problem.

***Recommendation*:** Misconceptions about the true definition and objectives of PFSs, especially a 'pilot' study, should be addressed to the EM research community. The primary objective of PFSs should be to inform the main trial. Trialists should not believe in efficacy outcomes from PFSs and should be encouraged to proceed to definitive trials to confirm the results, unless feasibility issues don't allow.

Underrecognized trial aspects

It is interesting and surprising to observe that the resources and management domains of feasibility objectives were not evaluated in any of the included trials, unlike in other clinical areas[10,56], even though several included PFSs involved complex procedures and interventions, where resources and management may be an issue for successful full-scale trials.

Another crucial trial aspect that might not have been emphasized enough is the process of informed consent and how researchers disclose the nature of PFSs to potential participants.[2,45] These ethical issues are challenging in EM, where obtaining informed consent often occurs in a time-dependent and busy environment that usually involves patients with emergency conditions. In this review, we found that some trials employed deferred consent, and no trials explicitly stated the nature of their study accordingly in their informed consent forms.

Recommendation: We encourage EM trialists to further evaluate all relevant feasibility domains, especially in resource-demanding trials and where data management may be a concern, such as those involving life-saving procedures. EM trialists should understand and abide by the highest ethical standards when performing PFSs, as with any other research study. Informed consent should be obtained whenever possible, and the process should be transparent with clear definitions of the study's nature, rationale, objectives, and criteria for success.[2] The consent process should make it clear that the study being proposed is not one looking at treatment efficacy, in order to correct possible false expectations from those being asked to participate.[57] A deferred or implied consent should be considered only in conditions that, without such a procedure, recruitment might not be possible and RCTs can't be performed; it should not be implemented to expedite trial duration and process. PFSs in EM research involving emergency or life-threatening conditions may be required to prove if such a scenario is applicable.

Limitations

This systematic review, though robust in its methods, has limitations. First, we searched for articles with the term 'pilot' or 'feasibility' only in the title or abstract since we wanted to focus on those explicitly addressed as such. Second, we only included Q1 EM journals and only added the five top-ranked journal names in the search term among over 100 EM-related journals.[15]

Third, we excluded pediatric trials and those not conducted in the ED as we aimed to focus specifically on ED adult trials, and pediatric trials and pediatric EM literature may have other distinct aspects not considered nor included in this review. Therefore, our search results might not have been representative of Q1 journals or the whole EM literature. Moreover, the full methodological and reporting quality was not performed. We could have employed other tools, such as the Cochrane Risk of Bias 2.0 tool and the full CONSORT extension checklist, but they were not the main objectives of this review and might not be relevant to all PFSs. Also, we preferred to focus on specific essential elements. Nonetheless, a more comprehensive review might provide a better picture of the trials' overall quality and reporting completeness.

Conclusion

PFSs play an important role in health research in providing information for the planning and justification of full-scale RCTs. We found the methodological and reporting quality of randomized PFSs published in high-ranking first-quartile EM journals was below standard, as many still primarily focused on clinical efficacy with low-quality reporting of objectives and PFS-specific outcomes. Therefore, our review highlights the need for resources and training for researchers, journal editors, peer reviewers, and research ethics boards on the value, objectives, and appropriate conduct of PFSs. The conceptual framework and standardized methodological components should be widely disseminated and emphasized. Also, EM journals should acknowledge the importance of pilot and feasibility work, reinforce the reporting standards, and support the publication of these studies. These actions can lead to more methodologically rigorous PFSs that will inform feasible, successful, and rigorous future definitive RCTs in the EM literature.

Contributorship statement

OR, ME, AW conceived and designed the study. OR, JPL, ME, AW collected, managed, and analyzed the data. OR drafted the article. AW supervised the conduct of the study and provided critical insights for the review.

Competing interests

All authors declare no competing interests.

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Data sharing statement

No additional data available.

Figure legends

Figure 1. The PRISMA flow chart of study selection and inclusion
Abbreviation: RCT, randomized controlled trial; ED, Emergency Department; Q1 EM, first-quartile Emergency Medicine

Table 1. Reporting and methodological standards for pilot and feasibility studies

Section	Major CONSORT checklist for reporting	Methodological standards specific to a pilot study
Title and abstract	Identification as and summary of a pilot/feasibility design	
Background and objectives	Reasons for conducting a pilot study, rationale for future definitive trial, specific objectives of a pilot study	- Provide rationale for conducting a pilot study - State specific feasibility objectives of a pilot study
Methods; trial design	Description of pilot study design	
Methods; randomization, blinding	Type of randomization, sequence generation, allocation concealment methods, implementation and blinding	
Methods; participants	Eligibility criteria, settings and locations, how participants were identified and consented	
Methods; interventions	Details of interventions for each group	
Methods; outcomes	Measurements to address pilot study objectives, criteria used to judge whether or how to proceed with future definitive trial	- State appropriate progression criteria to judge feasibility and/or decide whether to proceed to a definitive trial
Methods; sample size	Rationale for sample size	- Appropriately state the rationale for the pilot study sample size
Methods; Analysis	Methods used to address pilot study objectives	- Feasibility objectives appropriately analyzed with descriptive statistics - Inferential statistics of efficacy outcomes should not be performed - Analyses should be explicitly stated that they were to inform future trials
Results; Participants	Participants' flow, duration of recruitment, baseline data, numbers analyzed for each objective	
Results; outcomes	Report results with uncertainty estimates by randomized group	- Report feasibility outcomes descriptively with uncertainty estimates
Results; harms	All important intended and unintended harms	
Discussion; limitations	Addressing sources of potential bias and remaining uncertainty about feasibility	- Discuss potential biases and uncertainty of feasibility outcomes - If estimates of efficacy outcomes or inferential statistics performed, explicitly declare their uncertainty
Discussion; generalizability	Generalizability of pilot study methods and findings to future definitive trial and other studies	- Discuss generalizability of feasibility outcomes that impact future trials
Discussion; interpretation	Interpretation consistent with pilot study objectives and findings, Implications for progression to future definitive trial, including any proposed amendments	- Discuss implications for progression to future definitive trial - If inferential statistics performed, clinical implications should not be made or emphasized

Notes;- "pilot study" refers to pilot/feasibility study/trial and applies to both randomized and non-randomized studies

Table 2. Trial characteristics and methodological and reporting standards

Trial characteristics	Total N=24	Five top-ranked journals N=13	Other Q1 journals N=11
Year of publication, n(%)			
2018	3 (12.5)	1 (7.7)	2 (18.2)
2019	4 (16.7)	1 (7.7)	3 (27.3)
2020	10 (41.7)	6 (46.2)	4 (36.4)
2021	4 (16.7)	3 (23.1)	1 (9.1)
2022	3 (12.5)	2 (15.4)	1 (9.1)
Study setting[a], n(%)			
United States of America	12 (50.0)	7 (53.8)	5 (45.5)
Europe	8 (33.3)	5 (38.5)	3 (27.3)
Australia	2 (8.3)	0 (0)	2 (18.2)
Asia	2 (8.3)	1 (7.7)	1 (9.1)
Africa	1 (4.2)	1 (7.7)	0 (0)
Number of study center, median [min, max]	1 [1, 33]	1 [1, 33]	1 [1, 1]
Study type defined by the authors, n(%)			
Pilot	13 (54.2)	5 (38.5)	8 (72.7)
Feasibility	3 (12.5)	3 (23.1)	0 (0)
Both pilot and feasibility	8 (33.3)	5 (38.5)	3 (27.3)
Type of intervention, n(%)			
Drug or fluid	7 (29.2)	4 (30.8)	3 (27.3)
Device for treatment	2 (8.3)	1 (7.7)	1 (9.1)
Device for procedure	5 (20.8)	2 (15.4)	3 (27.3)
Treatment process	3 (12.5)	1 (7.7)	2 (18.2)
Counseling/education/monitoring program	7 (29.2)	5 (38.5)	2 (18.2)
Number of arms, median [min, max]	2 [2, 3]	2 [2, 3]	2 [2, 3]
Any blinding presented, n(%)	10 (41.7)	8 (61.5)	2 (18.2)
Sample size, median [min, max]	68 [22, 272]	55 [29, 255]	83 [22, 272]
Funding, n(%)			
None	9 (37.5)	4 (30.8)	5 (45.5)
From industrial sources	2 (8.3)	2 (15.4)	0 (0)
From non-industrial sources	13 (54.2)	7 (53.8)	6 (54.5)
Trial registration, n(%)			
None	7 (29.2)	1 (7.7)	6 (54.5)
Registered as pilot/feasibility study	13 (54.2)	10 (76.9)	3 (27.3)
Registered but not as pilot/feasibility study	4 (16.7)	2 (15.4)	2 (18.2)
Sample size calculation			
Calculated based on feasibility outcome	3 (12.5)	2 (15.4)	1 (9.1)
Calculated based on efficacy outcome	10 (41.7)	4 (30.8)	6 (54.5)
Targeted based on expected availability	1 (4.2)	1 (7.7)	0 (0)
Not calculated, based on rule-of-thumb	1 (4.2)	1 (7.7)	0 (0)
Not calculated or not mentioned	9 (37.5)	5 (38.5)	4 (36.4)
Ethical requirement[a]			
Informed consent required	18 (75.0)	10 (76.9)	8 (72.7)
Consent not required or deferred	4 (16.7)	3 (23.1)	1 (9.1)
Not mentioned	3 (12.5)	1 (7.7)	2 (18.2)
Primary trial objectives			
Efficacy trial with only efficacy outcome(s)	15 (62.5)	6 (46.2)	9 (81.8)
Feasibility trial with feasibility objective(s)	9 (37.5)	7 (53.8)	2 (18.2)
CONSORT extension for pilot trials cited and endorsed	2 (8.3)	2 (15.4)	0 (0)
Progression to the main trial	3 (12.5)	3 (23.1)	0 (0)

[a]one study had two settings or consent types. Abbreviation: Q1, first-quartile

Table 3. Methodological and reporting standards of feasibility trials

Standards	N=9, n(%)
Report feasibility objectives with uncertainty estimates	5 (55.6)
Clear progression criteria with thresholds justified	3 (33.3)
Conclusion for future trial	
Proceed, no changes required	4 (44.4)
Proceed with modifications	4 (44.4)
Not	1 (11.1)
Primary outcome category	
Process – inclusion criteria, recruitment, consent rate	2 (22.2)
Process – retention, compliance, adherence, follow-up rate	1 (11.1)
Process – acceptability and feasibility of intervention	3 (33.3)
Scientific – preliminary estimates for main trial sample calculation	1 (11.1)
Scientific – clinical outcomes	2 (22.2)
Study components assessed	
Process – inclusion criteria, recruitment, consent rate	4 (44.4)
Process – acceptability and feasibility of intervention	8 (88.9)
Process – retention, compliance, adherence, follow-up rate	5 (55.6)
Process – blinding	1 (11.1)
Process – outcome measurements, data collection	2 (22.2)
Scientific – preliminary estimates for main trial sample calculation	3 (33.3)
Scientific – clinical outcomes	8 (88.9)
Scientific – surrogate outcomes	1 (11.1)
Scientific – safety, adverse events	4 (44.4)

Table 4. Methodological and reporting standards of pilot and feasibility trials with hypothesis testing of efficacy outcomes

Standards	By study type		By published journal	
	Feasibility trials n = 5	Efficacy trials n = 15	Five top-ranked n=9	Other Q1 n=11
Primary outcome results				
No significant between-group difference	2 (40.0)	8 (53.3)	4 (44.4)	6 (54.5)
Intervention significantly better than control/standard care	3 (60.0)	7 (46.7)	5 (55.6)	5 (45.5)
Clinical implication statement				
None	1 (20.0)	0 (0)	1 (11.1)	0 (0)
Support intervention	3 (60.0)	13 (86.7)	8 (88.9)	8 (72.7)
State “no difference” or “no effect”	1 (20.0)	2 (13.3)	0 (0)	3 (27.3)

Abbreviation: Q1, first-quartile

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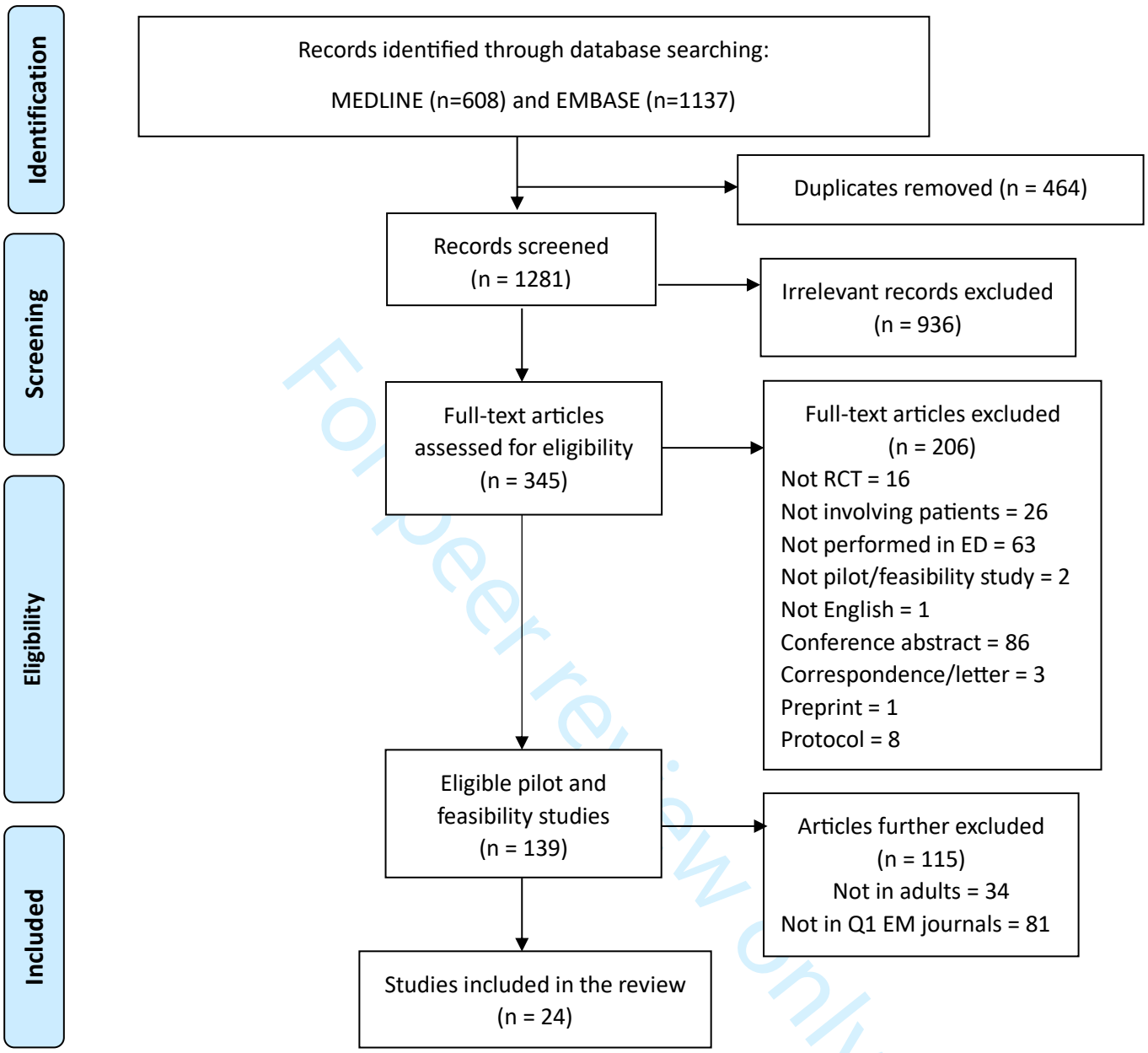

Figure 1. The PRISMA flow chart of study selection and inclusion
Abbreviation: RCT, randomized controlled trial; ED, Emergency Department; Q1 EM, first-quartile Emergency Medicine

Appendix. Search strategy and results

Database(s): **Embase** 1974 to 2023 September 29
Search Strategy:

#	Searches	Results
1	(pilot or feasibility or vanguard).ti,ab.	605491
2	emergency medicine.mp. or exp emergency medicine/	63176
3	emergency department.mp. or exp emergency ward/	267200
4	emergency patient.mp. or exp emergency patient/	5168
5	exp emergency/ or emergency.mp.	690957
6	2 or 3 or 4 or 5	690961
7	exp "randomized controlled trial (topic)"/ or exp randomized controlled trial/ or randomized.mp.	1426097
8	"controlled clinical trial (topic)"/ or controlled clinical trial/	484023
9	(randomized or randomised).ab.	1070672
10	7 or 8 or 9	1676521
11	resuscitation.jn.	12355
12	"annals of emergency medicine".jn.	20441
13	academic emergency medicine.jn.	17112
14	"scandinavian journal of trauma resuscitation and emergency medicine".jn.	1512
15	"western journal of emergency medicine".jn.	3159
16	11 or 12 or 13 or 14 or 15	54579
17	6 or 16	708159
18	1 and 10 and 17	2456
19	limit 18 to (human and english language and yr="2018 -Current")	1137

Database(s): **OVID Medline** Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE(R) Daily and Ovid MEDLINE(R) 1946 to Present

Search Strategy:

#	Searches	Results
1	(pilot or feasibility or vanguard).ti,ab.	423204
2	exp emergency medicine/ or exp pediatric emergency medicine/	15678
3	emergency department.mp. or exp Emergency Service, Hospital/	165558
4	emergency room.mp.	22921
5	emergency.mp. or exp Emergencies/	420395
6	2 or 3 or 4 or 5	429408
7	exp Randomized Controlled Trial/	602377
8	(randomized controlled trial or controlled clinical trial).pt. or randomized.ab. or randomised.ab.	1077849
9	trial.ti,ab.	771533
10	7 or 8 or 9	1422442
11	resuscitation.jn.	9421
12	"annals of emergency medicine".jn.	14298
13	academic emergency medicine.jn.	6581
14	"scandinavian journal of trauma resuscitation & emergency medicine".jn.	1511
15	"western journal of emergency medicine".jn.	2511
16	11 or 12 or 13 or 14 or 15	34322
17	6 or 16	444291
18	1 and 10 and 17	1758
19	limit 18 to (english language and humans and yr="2018 -Current")	608

Supplementary Table 1. Characteristics of included trials

Author, year	Journal	Study setting	Study type by authors	Sample size	Condition	Type of intervention	Arms	Primary outcome	Other outcomes	Conflict of interest
Jones, 2018	Annals EM	USA, single center	Pilot and feasibility	50	Migraine headache	Drug (IV fluid bolus vs slow rate)	2	Preliminary estimate for main trial sample calculation	Rate of protocol completion, effectiveness of blinding, clinical efficacy, safety	Non-industrial funding
Fox, 2018	AJEM	USA, single center	Pilot and feasibility	30	Lower back pain	Treatment process (battlefield acupuncture)	2	Clinical efficacy	Safety	None declared
Bruguera, 2018	ACEM	USA, single center	Feasibility	200	At-risk drinkers	Counseling/education program (specialized brief intervention)	2	Clinical efficacy	-	Non-industrial funding
Meurer, 2019	ACEM	USA, single center	Pilot and feasibility	55	Discharged with elevated BP	Counseling/education program (mobile health BP intervention)	2	Compliance/adherence	Recruitment rate, feasibility of intervention, clinical efficacy, surrogate outcome, safety	Non-industrial funding
Cochrane, 2019	AJEM	USA, single center	Pilot	70	Difficult IV placement	Device procedure (US-guided IV with or without guidewire)	2	Clinical efficacy	-	Non-industrial funding
Merritt, 2019	AJEM	USA, single center	Pilot	272	Discharged with PC follow-up	Counseling/education program (PC follow-up appointment website)	3	Clinical efficacy	-	Non-industrial funding
Kim, 2019	AJEM	Korea, single center	Pilot	22	Carbon monoxide intoxication	Treatment device (HFNC vs conventional oxygen bag)	2	Surrogate outcome	-	Non-industrial funding
LaBarbara, 2020	ACEM	USA, 2 centers	Pilot and feasibility	64	Post-motor-vehicle-crash	Counseling/education program (PTSD coach application)	2	Recruitment and retention rate	Acceptability of intervention, clinical efficacy	Non-industrial funding
Probst, 2020	ACEM	USA, single center	Pilot and feasibility	51	Syncope	Counseling/education program (shared decision-making tool)	2	Recruitment rate	Follow-up rate, outcome measurement and selection, acceptability of intervention, preliminary estimate for main trial sample calculation, clinical efficacy	Non-industrial funding
Mitra, 2020	EMA	Australia, single center	Pilot	30	Migraine	Drug (propofol vs standard care)	2	Feasibility and acceptability of intervention	preliminary estimate for main trial sample calculation, clinical efficacy, safety	Non-industrial funding

Lin, 2020	AJEM	USA, single center	Pilot	93	Combative agitation	Drug (ketamine vs standard care)	2	Clinical efficacy	Safety	None declared
Doyle, 2020	EMA	Australia, single center	Pilot	80	Discharged from emergency department	Counseling/education program (mobile discharged instruction)	2	Clinical efficacy	-	Non-industrial funding
Villa,2020	IntEM	Europe, single center	Pilot and feasibility	100	Dermatological emergency	Device assessment (telemedicine)	2	Safety	Clinical efficacy	None declared
Peacock, 2020	ACEM	USA and EU, 33 centers	Pilot	70	Hyperkalemia	Drug (sodium zirconium cyclosilicate vs standard care)	2	Surrogate outcome	Clinical efficacy, safety	Industrial funding
Dean, 2020	ACEM	USA, single center	Pilot	30	Cannabinoid hyperemesis	Drug (topical capsaicin vs placebo)	2	Clinical efficacy	Safety	Non-industrial funding
Ruangsomboon, 2021	ACEM	Thailand, single center	Pilot	37	Acute severe asthma	Treatment device (HFNC vs standard oxygen therapy)	2	Preliminary estimate for main trial sample calculation	Clinical efficacy, safety	None declared
Rafique, 2019	ACEM	USA, single center	Pilot	43	Hyperkalemia	Drug (patiromer vs standard care)	2	Surrogate outcome	Clinical efficacy, safety	Industrial funding
Hyuha, 2021	IJEM	Tanzania, single center	Feasibility	255	Trauma patients screened for HIV	Counseling/education program (text messaging to promote care)	2	Clinical efficacy	Feasibility of intervention	Non-industrial funding
Sabbadini, 2021	WJEM	USA, single center	Pilot and feasibility	29	Trauma	Device assessment (ultrasound protocols)	2	Clinical efficacy	Feasibility of intervention	None declared
Lesnik, 2021	AJEM	Slovenia, single center	Pilot	100	Patients requiring peripheral IV	Device procedure (tissue vs standard adhesives for securing IV catheters)	2	Clinical efficacy	Safety	None declared
Fuest, 2021	Resuscitation	Germany, single center	Pilot	30	Cardiac arrest	Treatment process (different ventilator modes)	3	Surrogate outcome	Clinical efficacy	None declared
Katzenschlager, 2022	SJTREM	Germany, single center	Feasibility	66	Trauma	Device assessment (hyperspectral imaging)	2	Feasibility of intervention	-	None declared

Jessen, 2022	ACEM	Denmark, 3 centers	Pilot and feasibility	124	Sepsis	Drug (restrictive fluid vs standard care)	2	Feasibility of intervention	Recruitment rate, adherence rate, outcome measurement, clinical efficacy, safety	Non-industrial funding
Bakker, 2022	AJEM	Netherland, single center	Pilot	83	Acute pain from chest trauma	Treatment process (Kinesiotaping)	2	Clinical efficacy	-	None declared

Abbreviations; AnnalsEM, Annals of emergency Medicine; AJEM, American Journal of Emergency Medicine; ACEM, Academic Emergency Medicine; EMA, Emergency Medicine Australasia; IntEM, Internal and Emergency Medicine; IJEM, International Journal of Emergency Medicine; WJEM, Western Journal of Emergency Medicine; SJTREM, Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine; USA, United States of America; EU, Europe; BP, blood pressure; IV, intravenous; PC, primary care; PTSD, post-traumatic stress disorder; HFNC, high-flow nasal cannula; US, ultrasound