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ORIGINAL RESEARCH ARTICLES

In search of an effective teaching approach for skill acquisition and retention: Teaching manual defibrillation to junior medical students

Á la recherche d'une approche pédagogique efficace pour l'acquisition et le maintien des compétences: Enseignement de la défibrillation manuelle à des jeunes étudiants en médecine

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Introduction: Although overloaded curricula, the increasing student to educator ratio, limited resources, insufficient curriculum alignment and the unpredictable clinical learning environment contribute to the decay of clinical skill competency, the problem of poor skill retention often lies in inadequate skill acquisition which is associated with the quality of the instruction. The aim of the study was to investigate the influence of three different instructional approaches on the acquisition and retention of skills in order to determine which method would be best suited for teaching in simulation in a resource-constrained environment.
Methods: A randomised controlled trial design was used to compare the efficacy of the traditional, Peyton's four-stage, and a modified five-step method. Regarding the latter, George and Doto's five-step method was altered to include peer teaching and feedback with a tutor in a supervisory role. Groups of first year students were taught 'manual defibrillation'. Subsequent to the teaching session as well as at two months later, students' skills were tested. Additional qualitative data regarding students' perceptions of the different teaching strategies they were exposed to were obtained by means of questionnaires.
Results: None of the three instructional approaches proved to be superior in acquisition or retention. Previous studies reported similar findings. The lack of differentiation between the three teaching methods might be attributed to the fact that all three methods included practice with feedback in one form or another. Numerous studies have identified these as critical components leading to effective learning in a simulation-based learning environment.
Conclusion: Considering that the three instructional approaches were similar in terms of skill acquisition and retention, incorporating peer teaching and feedback is a feasible strategy in a resource-limited environment.

Introduction: Malgré les programmes surchargés, l'augmentation du ratio nombre par éducateur d'élèves, les ressources limitées, l'alignement insuffisant des programmes d'études et l'environnement pédagogique clinique imprévisible contribuent à la dégradation de la maîtrise de la compétence clinique, le problème du faible maintien des compétences résidant souvent dans la mauvaise acquisition des compétences, problème lié à la qualité de l'enseignement. Le but de l'étude était d'enquêter sur l'influence de trois approches pédagogiques différentes concernant l'acquisition et le maintien de compétences de façon à déterminer quelle méthode serait la plus adaptée à un enseignement en simulation dans un environnement limité en ressources.
Méthodes: Une méthode d'essai contrôlé randomisé a été utilisée pour comparer l'efficacité de la méthode traditionnelle de Peyton à 4 étapes et une méthode modifiée à 5 étapes. En ce qui concerne cette dernière, la méthode George et Doto à 5 étapes a été modifiée pour inclure l'enseignement par les pairs et le retour d'information, le tuteur ayant un rôle de supervision. Les groupes d'étudiants de première année ont été formés à la « défibrillation manuelle ». Après la session de formation, ainsi que deux mois plus tard, les compétences des étudiants ont été testées. Des données qualitatives supplémentaires concernant la compréhension par les étudiants des différentes stratégies pédagogiques auxquelles ils ont été exposés ont été obtenues au moyen de questionnaires.
Résultats: Aucune des trois approches pédagogiques ne s'est avérée supérieure en termes d'acquisition ou de maintien. Des études précédentes ont fait état de résultats similaires. L'absence de différentiation entre les trois méthodes d'enseignement pourrait être attribuée au fait que les trois méthodes incluent, sous une forme ou une autre, une pratique avec retour d'information. De nombreuses études ont identifié ces deux éléments comme des composantes essentielles pour un apprentissage efficace dans un environnement pédagogique basé sur la simulation.
Conclusion: Etant donné que les trois approches pédagogiques étaient similaires en termes d'acquisition et de maintien des compétences, l'intégration de l'enseignement par les pairs et le retour d'information constituent une stratégie possible dans un environnement à ressources limitées.

African relevance

- None of the studied teaching approaches proved to be superior.
- When the student to lecturer ratio is high, peer feedback during teaching sessions is useful.
- A demonstration and feedback with practice are the most crucial components of clinical skills teaching and learning.

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Introduction

The teaching of practical skills remains a vital component of medical education. Simulation has become an important and effective tool in healthcare education due to limited and unpredictable clinical opportunities.[1–3] Increased student numbers and a greater emphasis on patient safety are amongst the many reasons.[2,3] Despite the global movement to augment clinical exposure with simulation training, the teaching and learning of clinical skills remains a challenge for most training institutions. Studies suggest that inadequate skill acquisition, which is associated with the quality of teaching, could be the main contributor of poor skill retention.[4,5] For this reason, there is a continual inquiry into the factors that influence both the acquisition and the retention of clinical skills.[6–9]

Procedural skills teaching has evolved over the last decades from the apprenticeship model (see one, do one, teach one) where learning is a result of social guidance,[10] through the traditional two-step approach, to more structured approaches such as Peyton's four-stage or George and Doto's five-step approach (Table 1).[5,7,11,12] However, the different approaches might not alter learning outcomes. There was no difference in either the acquisition or the retention of procedural skills when comparing the traditional method to Peyton's four-stage approach.[6,7,9] The studies were conducted for laryngeal mask insertion, gastric tube insertion and needle cricothyroidotomy using part task trainers, manikins and pig larynxes. This led the authors to conclude that the complexity of the procedural skill may influence the efficacy of the four-stage teaching approach and subsequently proposed that teaching more complex skills might favour the four-stage approach. The five-step method was used on inexperienced dental students and proved that they were able to perform the skill efficiently.[13]

Another aspect to learning is the effect of assessment (the testing effect). In addition to the extrinsic motivational effect of assessments, the intrinsic effect on students' learning is just as valuable.[14] Research has indicated that the use of tests resulted in improved retention of the studied material compared to students re-studying the material, regardless of feedback given to the students.[14] The testing effect was further illustrated by Kromann et al. in a study on medical students attending a cardio-pulmonary resuscitation (CPR) course; those that were tested immediately after the course had significantly better skill retention after two weeks.[15]

At Stellenbosch University's Faculty of Medicine and Health Sciences, students start attending simulated teaching sessions towards the end of their first year (of six) and continue to do so throughout the remainder of their studies as part of their clinical rotations. These sessions are, however, limited due to the already full curriculum and fairly high student to educator ratios. Most educators are also involved in clinical work and constantly struggle to find a balance between service delivery and the training of students. Consequently, there are few opportunities for students to practise skills under supervision and to receive individual feedback during the teaching sessions, both crucial elements of the learning process.[16] George and Doto's five-step teaching approach is used widely in the teaching of procedural skills, but has been modified for the American College of Surgeon's Advanced Trauma Life Support (ATLS) course.[17] The five-step approach was further modified to make it more appropriate to our setting (Table 1). The large groups of students and limited time per session lead to the idea of exchanging step four and step five of the five-step teaching approach; peer-teaching in step four was followed by a final step that summarised the process to ensure the procedure was done correctly. The thinking was that ending the session with a summary of how the procedure should be performed might compensate for any misunderstandings that could have happened due to the peer teaching and feedback part of the session.

Methods

Students were randomly divided to compare the efficacy of the different teaching approaches. Feedback from the students was collected using a self-designed non-validated questionnaire. The study was approved by the Stellenbosch University Health Research Ethics Committee (Ref: N12/02/005).

The study was conducted at the Faculty of Medicine and Health Sciences of Stellenbosch University (SU) in South Africa. The undergraduate medical programme follows a six year curriculum, with student numbers increasing to about 300 students in the first and second years. The Clinical Skills Centre (CSC) plays an integral role in the teaching and learning of clinical skills in the undergraduate medical curriculum. Small groups of students (instructor to student ratios of 1:20) attend practical teaching sessions in the CSC as they rotate through the various clinical disciplines. These practical sessions are supported by logbooks the students complete for various clinical areas, followed by a practical assessment at the end of the module.

All first year medical students of 2012 and 2013 were invited to participate. These students had not been exposed to clinical medicine and the assumption was that their prior knowledge and experience of the selected clinical skill was non-existent. Students were asked at the beginning of the study whether they had done the procedure before and all students responded negatively.

Informed written consent was obtained from participants. Participation was voluntary and students were free to decline participation or to withdraw from the study at any point without any consequences.

Students were randomly allocated to the three teaching approaches (the traditional two-step approach, Peyton's four-stage approach, or modified five-step approach) using a computerised random-number generator. Each teaching group was further divided into two: with or without an immediate post-teaching practical assessment. Those who were assessed straight after the teaching were told so at the beginning of the session. All groups were assessed after two months (Fig. 1). Students only received feedback after the two month assessment.

Manual defibrillation of a manikin with ventricular fibrillation was categorised by the researchers as a moderately complex skill and therefore identified as an appropriate skill for the purposes of this study. Students attended a 40 min teaching session in the CSC in groups of approximately 20 students with one defibrillator and one manikin that could be defibrillated for each of the groups. This was a real defibrillator used with full charge and the clinical skills educators were well aware of optimal safety precautions. These training sessions took place over a period of two days. Three different clinical skills educa-

Table 1 A comparison between the various teaching approaches.

Step	Traditional 2-step approach	Peyton's 4-stage approach	George and Doto's 5-step approach	Modified 5-step approach
1	The educator explains theory and demonstrates a procedure in simulation		The context in which the skill is used as well as the reason for performing the skill is described to serve as a motivation for the student to learn	The context in which the skill is used as well as the reason for performing the skill is described to serve as a motivation for the student to learn
2	The students practise with feedback from the educator	The educator performs the skill in real time without additional comments	The educator demonstrates the skill in real time without talking	The educator demonstrates the skill in real time without talking
3		The educator performs the skill a second time while explaining each individual step in detail	The educator repeats the demonstration but includes a detailed description of each step. Time is allowed for questions	The educator repeats the demonstration but includes a detailed description of each step. Time is allowed for questions
4		The educator performs the skill as the students describe the steps of the skill	Students describe how to do the skill step by step in order to commit the process to memory	The students practise in groups while giving peers feedback, with the educator assisting/correcting as needed
5		The student performs the skill with feedback from the educator as needed	The students perform the skill with the educator observing and providing feedback as needed	The steps of the skill are described together by the students (in the large group) in order to commit the process to memory

The study compared the modified five-step approach to the traditional two-step approach and Peyton's four-stage approach with regard to the acquisition and retention of a moderately complex clinical skill (manual defibrillation) in first year medical students. We attempted to investigate the effect of immediate assessment after the teaching session on skill retention as well.

tors taught the students each making use of another teaching approach throughout. In order to increase reliability, the educators received training on the specific teaching approach they had to use as well as a detailed lesson plan of what needed to be included in the session. Each student had the opportunity to perform defibrillation on the manikin at least once.

After the initial teaching sessions, participants were contacted via e-mail to participate in the two-months post-teaching practical assessment.

In order to ensure consistency, skill acquisition was tested by means of a standardised rating scale. The practical assessment was completed immediately after the teaching session. Students were randomised into immediate assessment or not, so that half of each group was tested immediately and the other half not. The assessors were clinical educators of the department but not involved with the specific teaching sessions, and were blinded to the specific teaching approach used. Four assessors were used and each student was tested by only one examiner.

Skill retention was assessed after two months using the same assessment procedure as that used for skill acquisition. Only two of the initial examiners could be used due to practical limitations, so two other clinical educators were asked to assist with the assessment. The assumption that the students would not be exposed to the taught skill during the two months was based on the fact that the curriculum does not have any first year medical students working in clinical areas, and that the students therefore would not have had the opportunity to see or practise the skill learned.

Students' perceptions regarding the relevant teaching approach were determined by a short questionnaire after their teaching session. The questionnaire used a 5-point Likert scale (Table 2). Data were entered into an electronic spread sheet (Microsoft Excel®, Microsoft Corporation, Redmond, WA). The entering of data was cross-checked.

The Centre for Statistical Consultation at Stellenbosch University assisted with the statistical analysis of the data. STATISTICA® version 9 (StatSoft Inc. 2009; www.statsoft.com) was used to analyse the data. The primary aim of the analysis was to compare the mean scores of each group. For this purpose, a two-way analysis of variance (ANOVA) was used with a 5% level of confidence to determine statistical significance. Data from students who attended the teaching session but failed to attend the two-month follow-up were included in the analysis regarding skill acquisition and students' perceptions.

Results

Three hundred and forty students were invited to take part in the study. Two hundred and ninety-four students were randomised (Traditional two-step $n = 86$; Peyton's four-stage $n = 105$, Modified five-step $n = 103$).

One hundred and seventy students completed the immediate post-teaching practical assessment. The mean score was 76.6% with the traditional two-step approach scoring the highest (80%, $n = 49$) and the Peyton's four-stage approach scoring the lowest (73%, $n = 62$) (Fig. 2). No significant difference between the three teaching approaches during the immediate post-teaching practical assessment was detected ($p = 0.37$). The traditional two-step approach was statistically better than

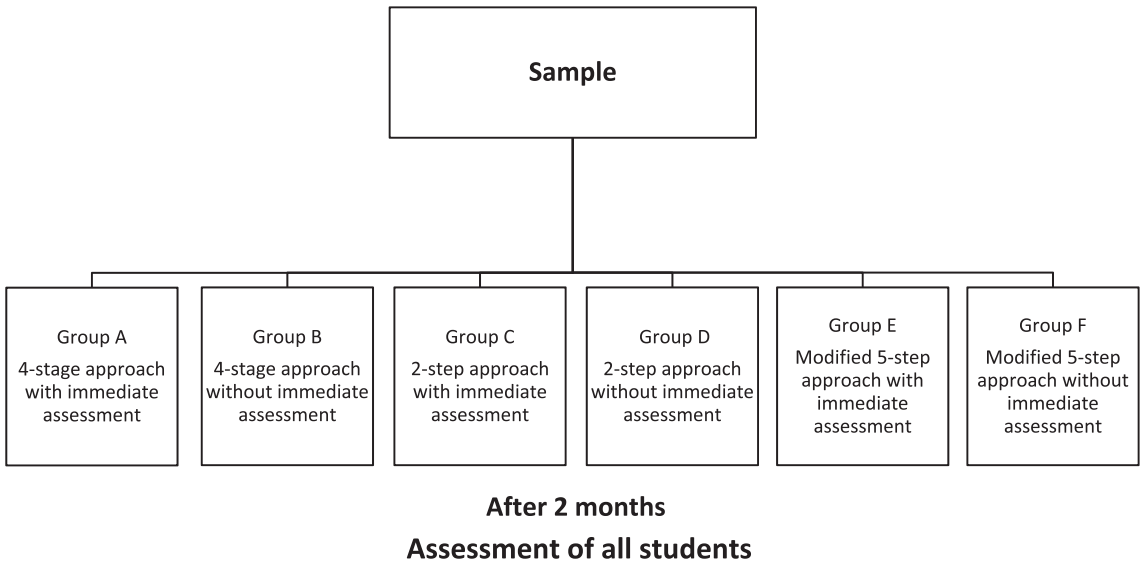

Figure 1 Study overview.

Table 2 Students' perception regarding knowledge acquisition and skill retention after the teaching session.

Statement	Overall	Traditional 2-step	Peyton's 4-stage	Modified 5-step
Would you say that the specific teaching method used enhanced your learning of the skill?	4.51	4.41	4.60	4.50
Did you get an adequate opportunity to practise the skill?	4.17	4.21	3.94	4.36
Did you receive adequate feedback from the educator while practising?	4.35	4.34	4.30	4.43
Would you say that you are now able to perform this skill with confidence on a manikin?	4.10	4.07	4.01	4.22
Would you say that you are now able to perform this skill with confidence on a patient?	3.26	3.27	3.11	3.40
Was the time scheduled for the practical teaching session adequate?	3.76	3.69	3.63	3.95

Scores presented as mean on a 5-point Likert scale (1—Strongly disagree to 5—Strongly agree).

the Peyton's four-stage method when comparing the groups individually ($p = 0.02$) (Traditional two-step vs Modified five-step $p = 0.33$; Peyton's four-stage vs Modified five-step $p = 0.09$).

The two month follow-up practical assessment was performed with only 104 students (Traditional two-step $n = 29$, Peyton's four-stage $n = 34$, Modified five-step $n = 41$). The mean score was 48% with the modified five-step approach minimally better than the rest (Fig. 2). No statistically significant difference was detected between the three teaching approaches ($p = 0.46$).

Immediate post-teaching assessment had no significant effect on skill retention rate ($p = 0.61$). The mean score with post-teaching assessment was 51.6% ($n = 57$), compared to a mean score of 44.5% without post-teaching assessment.

Most students had a positive learning experience, but students from the Peyton's four-stage group expressed the need for more practice (Table 2).

Students found "Demonstration with explanation" ($n = 210$, 29%) and "Practice session with educator feedback" ($n = 185$, 25%) the most useful part of the teaching sessions (Fig. 3).

Learning to "perform defibrillation" was evaluated by the majority of students as easy ($n = 164$) or moderately difficult ($n = 127$). Only five students rated it as being difficult.

The most pressing need expressed by students as a requirement to enhance their learning of the defibrillation skill was more practice time ($n = 53$), especially in Peyton's four-stage group with the other groups as follows: Peyton's four-stage group $n = 27$; Traditional two-step group $n = 16$; and the Modified five-step group $n = 10$. Other statements included a need for notes ($n = 27$), longer teaching session ($n = 19$), use of video material ($n = 19$), CPR training ($n = 15$), and ECG interpretation ($n = 11$).

Discussion

This study shows that none of the three teaching approaches are superior in either skill acquisition or retention; this is similar to previous studies.[6,7,9] It seems as if the most important component of clinical skill teaching and learning are the opportunity for feedback while practising the skill.[16] This notion is congruent with the theory of Bandura (scaffolding) and that learning occurs mainly due to modelling and feedback.[10] Greif et al. compared the traditional two-step method with three versions of Peyton's four-stage approach: the complete four-stage approach; without stage two (educator performing the skill in real time without additional comments) and without stage three (educator performs the skill a second time while explaining each individual step in detail).[7] There

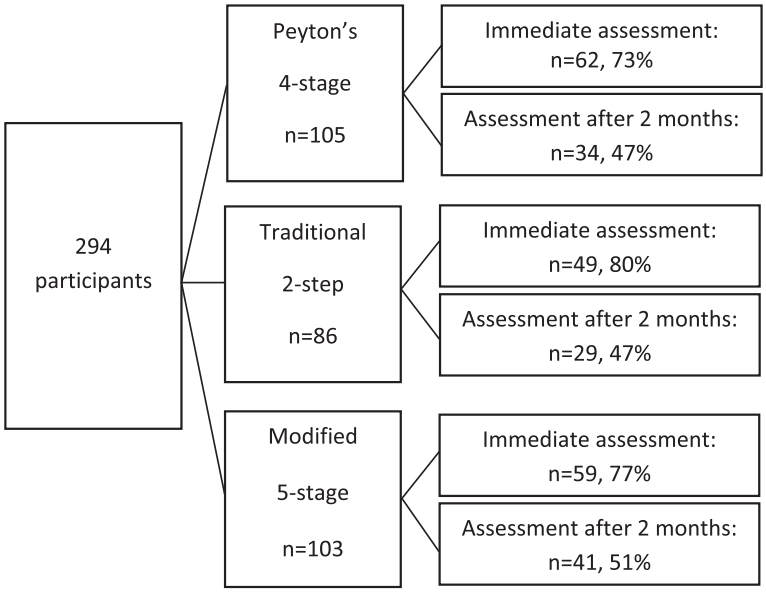

Figure 2 Explanation of the results per group.

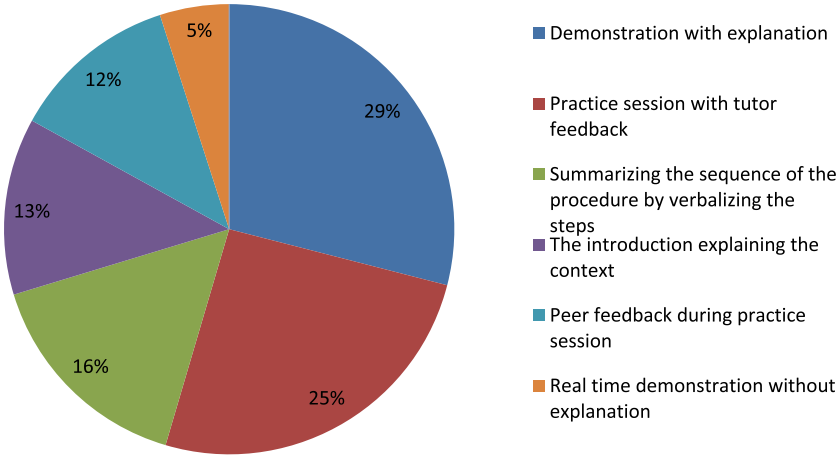

Figure 3 Aspects of the practical teaching session students found most helpful. Students were allowed to select more than one option.

was no significant difference between the different instructional approaches in terms of their influence on skill acquisition. In a study assessing the five-step approach in dental students, the proficiency in a specific skill was just as good as or even better than the traditional method.[13]

Ongoing practice of procedural skills is of vital importance. The decay in skill retention is bigger when there are limited opportunities to practise learned skills after a course.[18] Additional 'non-practice related' steps might be important to serve as motivation for learning by contextualising the procedure. Furthermore, it might enhance students' understanding of the procedure while also clarifying any misconstructions with regard to the procedure. Although these steps do not seem to be crucial in acquiring the isolated skill in a simulated environment, it might be important for learning critical thinking or theoretical knowledge. The feedback from the students (especially the Peyton's method group) also leaned towards a need for more time to practise. Although both Peyton's and the modified five-step method are lengthy teaching strategies, the four-stage approach contains three demonstrations of the procedure compared to only two in the modified five-step method. This resulted in less opportunity to practise due to the limited time frame, however, it was interesting to see that students' performance in the post-test did not differ significantly between the groups that had more time to practise. Therefore it seems that it was rather a matter of dissatisfaction with the learning experience than being disadvantaged in terms of quality of learning.

Numerous studies have identified feedback as the critical component leading to effective learning in a simulation-based learning environment.[1,14,16] In our modified five-step method, feedback was given mainly by peers under educator supervision as opposed to the other two approaches in which feedback was provided mainly by the educator. Most of the studies comparing similar instructional approaches have made use of an educator to student ratio of 1:1,[6,9] whereas in our study the ratio was 1:20. Under these circumstances, individualised educator feedback is virtually impossible and therefore not a consideration, hence the use of peer feedback in the session. Considering that the three instructional strategies seem to be

similar in terms of skill acquisition and retention, one can accept that incorporating peer learning techniques is a feasible strategy in our resource limited environment. The idea of making use of peer teaching can work well because peers are often in the position to explain difficult concepts to one another. Encouraging students to reflect on their learning experiences can advance their confidence.[19] One should be cautious and aware that when junior students give each other feedback they are all still at an early stage of their procedural learning cycle.

The so called "testing effect" was not apparent in this study. This is in contrast to the work published by Kromann et al. which indicated that assessment influences the retention of skills.[15] It is unclear why this is the case, but aspects like the difficulty level of the skills being taught as well as the time between the teaching session and the re-assessment might have played a role. Another difference in our study was that the students were re-assessed after two months, whereas the study by Kromann assessed the students two weeks after the initial teaching.[15]

Seeing that there does not seem to be a significant difference in the outcome of the various teaching approaches, clinical educators can reasonably use their time and resources as best they can. The fact that many of the teaching methods take quite a while to complete makes it understandable that in many busy teaching situations the two-stage technique is still preferred by some clinical educators. In our simulated teaching setting that is faced with resource constraints and high student to instructor ratios, we mainly make use of the modified five-step technique.

This study has several limitations that might have influenced the outcome. Firstly, the large attrition rate negatively affects the internal validity of the study and the results should be interpreted with caution. Secondly, participating volunteers might have been highly motivated individuals and the possibility exists that self-study could have occurred before the second assessment. This would result in overestimating the true effect of the teaching methods used. Thirdly, educators' specific teaching styles and amount of time allowed for students to practise, could have influenced the results in either direction. This effect was minimised by using standardised teaching techniques with the exact content outlined beforehand. Furthermore, by using a standardised marking sheet, assessment bias was also reduced.

Conclusion

This study revealed no statistically significant difference in either acquisition or retention of a moderately difficult skill. Demonstration and feedback with practice are crucial components for acquisition and retention of skill learning. The modified five-step approach includes a peer teaching and feedback component which is appropriate to overcome the obstacles of a resource constrained environment. Further research to benefit resource constrained environments should compare bigger groups (20 students) with smaller groups (5 students) when making use of the modified five-step approach in trying to determine how effective the learning is.

Conflict of interest

Dr. DJ van Hoving serves on the editorial board of the African Journal of Emergency Medicine. He was excluded from the peer review and editorial processes for this manuscript. Peer review was blinded to author identity. The authors declare no other conflict of interest.

Author contribution

All three authors were part of the initial design of the research. A.d.V. collected and analysed the data and D.J.v.H. was the statistical expert. A.d.V. and E.A. wrote the text of the manuscript and D.J.v.H. edited the final version. E.A. formatted it and submitted it.

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