AUSTRALASIAN JOURNAL OF
PARAMEDICINE

PARAMEDICS AUSTRALASIA

Research

National study of emergency medical services core competencies: a confirmatory factor analysis

Talal AlShammari MSc(CritCare), PhD Candidate and Lecturer[1]; Paul A Jennings PhD, Clinical Manager[2]; Brett Williams PhD, FPA is Professor and Head of Department[2]

Affiliations:
[1]Department of Emergency Medical Care, College of Applied Medical Sciences, Imam Abdulrahman bin Faisal University, Dammam, Saudi Arabia
[2]Department of Community Emergency Health and Paramedic Practice, Monash University, Victoria, Australia

https://doi.org/10.33151/ajp.16.706

Abstract

Introduction
Internationally, the development of emergency medical services (EMS) educational standards from a post-employment to pre-employment model has gained considerable momentum. In Saudi Arabia specifically, the evolution to university-based EMS degrees has proceeded swiftly. However, the fast pace of development has contributed to considerable disparities in educational approaches between university programs. Therefore, the development of an empirically-based core competency framework is of considerable importance. The aim of this paper is to utilise confirmatory factor analysis (CFA) through structural equation modelling to confirm the theoretically developed Saudi ParamEdic Competency Scale (SPECS) model.

Methods
A national cross-sectional study design with purposive sampling technique was utilised with Saudi Red Crescent Authority healthcare providers. The SPECS instrument included 41 core competency items measured on a self-reported Likert scale. The maximum likelihood method was used with all the one factor congeneric and complete CFA models.

Results
In total, 477 EMS healthcare professionals contributed to the study: 444 (93.1%) men and 33 (6.9%) women. Of the participants, 282 (59.1%) were 29–39 years of age and 264 (55.3%) had 5 to 9 years' experience. A CFA of the SPECS model confirmed five congeneric factors within the adequate fit measurement indices: professionalism, preparedness, communication, clinical, and personal. There was one higher order factor titled 'paramedic competency'.

Conclusion
The CFA results support the SPECS as a reliable, valid, unidimensional and psychometrically sound model for operationalisation into Saudi university curricula. The confirmed model is made up of 27 items with five factors and an overarching latent higher order construct. The SPECS model represents an empirically developed blueprint for adoption into Saudi Arabian university programs.

Keywords:
allied health personnel; attributes; competence; EMS; paramedic; Saudi Arabia

Corresponding Author: Talal AlShammari, tmaalshammri@iau.edu.sa

Introduction

The emergency medical services (EMS) represent the first point of patient contact in emergency conditions and the vital role that EMS plays in the overall healthcare system is therefore of considerable importance. While EMS in Saudi Arabia has a long history dating back to 1934, the universal and centralised provision of pre-hospital care was only initiated in 1963, through the Saudi Red Crescent Association (SRCA) (1).

Initially, the Saudi Arabian EMS educational approach was based on a post-employment training model (1) that offered limited first aid training and basic provision of care before patient transport (2). However, over the past decade the country has witnessed a fast pace of evolution and since 2012 the minimum EMS educational qualification offered has been a university level Bachelor degree (1). In terms of the expected level of educational qualification, this requirement surpasses countries such as the United States, Canada and the United Kingdom (3).

The introduction of Bachelor degree programs for EMS is important, especially when compared to different medical disciplines, as they are seen to improve outcomes and research output (4). University level education can also be a source of progress for a professionally effective, reliable and ethical paramedic (5). However, with the establishment of many university programs, which were based on either local or international programs, considerable educational disparities have developed (1). This inconsistency between university programs can create an adverse mismatch between industry competency needs and actual educational output for paramedics. Therefore, the empirical identification of a Saudi competency framework and its alignment into EMS university programs will enable the development of a competent EMS workforce, thereby improving patient care. The aim of this paper is to use confirmatory factor analysis (CFA) through structural equation modelling (SEM) in order to determine if the hypothesised theoretical Saudi ParamEdic Competency Scale (SPECS) model fits the available data. The SPECS model was developed through an exploratory factor analysis (EFA) and a different sample data set.

Author contributions

Talal Alshammari: Study conception, collated and analysed data, provided statistical assistance and helped write the paper. Paul Jennings: Study conception, and helped write the paper. Brett Williams: Study conception, discussed core ideas to study, and helped write the paper.

Methods

Study design

The study adopted a CFA statistical method in analysing a national quantitative cross-sectional survey design of SRCA healthcare professionals.

Setting

In Saudi Arabia the SRCA is the centralised national pre-hospital care provider, and its remit extends across the entire country (1). This centralised pre-hospital care system includes EMS organisational policy development, health policies and other organisational governance operationalised by the SRCA (1). Nevertheless, the types of crews being utilised, including the number of EMS providers and the type of medical provider, are different for each SRCA pre-hospital station. Even station locations are geographically diverse, ranging from metropolitan to rural regions and industrial sites. Distribution of the study instrument was carried out using the SRCA email system and utilised the internet-based Qualtrics. In addition, the study was also distributed to 42 SRCA EMS stations in the eastern and central regions of Saudi Arabia.

Participants

The study utilised a purposive sample technique and the population encompassed all healthcare providers working in SRCA. The exclusion and inclusion criteria were: a minimum age of 18 years; the capacity to read and write in the English language; currently working for the SRCA as a healthcare provider, in any capacity including management, training or clinical; or a minimum qualification of a healthcare certificate.

The study was attentively designed to retain different perspectives and the sample population sought was large to attain reliable factor analysis (6). Moreover, to achieve a representative sample the study was electronically disseminated within all 13 regions of Saudi Arabia. The paper form survey was also distributed in the central and eastern regions, which are some of the most populated areas in Saudi Arabia. The study included all levels of qualification and all medical disciplines contributing to the field of EMS.

Instrumentation

The aim of the national study was to confirm an EMS instrument: the 'Saudi ParamEdic Competency Scale'. The first part of the instrument was made up of seven demographic questions: gender, age, qualification, experience, medical discipline, professional role, and nationality. The second part was made up of 41 core competency items that were rated on a 1 to 10 Likert scale, where 10 represents 'extremely important' and 1 represents 'not important at all'.

The SPECS instrument was established using a combination of local Saudi-based requirements and international standards, and included seven core competency statements from a review of Saudi universities and colleges (1) and 33 international core competency statements acquired from a systematic scoping review of the literature (2). Following a face and content validity study of the 40 extracted items and a Delphi consensus study involving Saudi EMS experts and all Saudi universities offering

an EMS Bachelor degree, an additional item was added (7). The instrument was analysed using EFA for item reduction and model generation, resulting in 27 items and five factors: 'professionalism', 'preparedness', 'communication', 'clinical' and 'personal'.

Procedures

The study participants were presented with an explanatory statement before completing the questionnaire. Invitations sent via email were entitled 'EMS Research Participants Invitation' and contained a Qualtrics software link to the study and an explanatory statement. The survey was sent to all SRCA staff email accounts and contained information regarding procedures to assure anonymity in all published outputs, the voluntary nature of participation and the purpose of the study. Although electronic collection of data has the advantages of speed and flexibility, a typical disadvantage is the expected low response rate (8). Therefore, a paper-based data collection round was conducted concurrently with the electronic form.

Data analysis

The purpose of the CFA was to view how well the proposed factors and variables explained the data (9) and the procedure was performed to determine if the hypothesised theoretical structure fitted the available empirical data (10). In keeping with the highly desirable approach proposed by Jöreskog (11), the hypothesised model was developed via exploratory methods, and then statistically confirmed with a different data set. Data analysis also followed Hair et al's (12) recommendation for validating the results by splitting the data in half and confirming the findings with confirmatory statistical analysis. Therefore, the data were initially randomly split to approximately 50% through SPSS; one half was used to conduct the EFA and the other half was used to perform the CFA for this study.

The data was stored and analysed using IBM SPSS Statistics Version 23 and the AMOS 25 statistical package, respectively. The maximum likelihood method is considered superior to other estimation methods in medium to large samples of less than 2500 and was therefore the method of choice for this study (13,14). The $\chi 2$ is aimed to be non-significant, which indicates the model to be a good illustration of the relations between the observed variables, namely their variance and covariance. However, as the $\chi 2$ test is sensitive to large sample sizes (14-16), the $\chi 2$ will be presented with the ratio of $\chi 2$ to the degrees of freedom (CMIN/DF), where a model with a value of CMIN/DF <5.0 is acceptable for model fit (12,15,17).

As a SEM measurement index, the root mean square error of approximation (RMSEA) indication of a model fit is generally considered to be <.08 (12). In addition, the standardised root mean square residual (SRMR) can be utilised via an AMOS software plugin, with a good fitting model value of <.08 (18). The Bentler-Bonett normed fit index (NFI) is regarded as an incremental fit index, the NFI has other similarly scaled indexes such as the Bentler (19) comparative fit index (CFI) and the Bentler-Bonett non-normed fit index (NNFI), otherwise called the Tucker-Lewis Index (TLI) (12,14,17). All the aforementioned incremental measurement indices are recommended to have a value of >.90 for a good fitting model (12-14).

The testing of the theorised SPECS model involved a congeneric approach, where each factor and the associated observed variables were tested separately before the entire model was combined for analysis (13). As the observed variables were accounted for by their correlation and association with an underlying latent factor, by the same rationale, since all EFA factors (sometimes called latent variables in SEM) were strongly correlated with each other, there is a strong indication that a higher order underlying construct was the cause for this correlation (13). Moreover, hierarchical higher order analysis can be a more accurate presentation of reality than first order factor analyses alone (20). Therefore, the CFA was utilised to test the final model fit using a higher order factor categorised as 'paramedic competency'.

Ethics

The consent of participants was implied when the questionnaire was filled out or when the Qualtrics email link was opened and the survey electronically completed. Ethics approval was granted from the Monash University Human Research Ethics Committee on 28 February 2017 (project number 8072). The SRCA granted approval on 18-5-1438 Hijra, equivalent to 15 February 2017 (project number 81211).

Results

Of a total 1260 surveys distributed, 909 surveys were returned (a response rate of 72.14%) and the online survey produced 104 responses, generating a total of 1013 responses. Of these, 86 were list-wise removed from the analyses as they had one or more missing values. Accordingly, a total of 927 participants had a complete data set which was randomly split and only 477 were used in this study, thus exceeded the acceptable case to variable ratio of 10:1. A diverse range of disciplines, expertise and qualifications were found among the expert participants. Of the 477 participants, only 33 (6.9%) were female, which reflects male dominance of the EMS sector in Saudi Arabia. Most of the participants were aged 29–39 years (59.1%), with a mid-range of experience between 5 and 9 years (55.3%). The majority held a diploma degree (76.1%) and were paramedics (61.8%). More than three-quarters were Saudi (84.7%) nationals and the participants were well distributed in their professional roles (Table 1).

Table 1. Study demographics

	Category	Frequency	Percent
Gender	Male	444	93.1
	Female	33	6.9
	Total	477	100.0
Age (years)	18-28	121	25.4
	29-39	282	59.1
	40-49	61	12.8
	50 or above	13	2.7
	Total	477	100.0
Highest qualification	Certificate	39	8.2
	Diploma	363	76.1
	Bachelor degree	59	12.4
	Master degree	8	1.7
	PhD	8	1.7
	Total	477	100.0
Years of EMS experience	1-4	167	35.0
	5-9	264	55.3
	10 or more	46	9.6
	Total	477	100.0
Primary medical discipline	Paramedic	295	61.8
	Nurse	134	28.1
	Physician	47	9.9
	Pharmacist	1	0.2
	Total	477	100.0
Main professional role		81	17.0
	Education/ academic	175	36.7
	Clinical/ patient care	221	46.3
	Total	477	100.0
Nationality	Saudi	404	84.7
	Egyptian	25	5.2
	Jordanian	23	4.8
	Syrian	14	2.9
	Indian	6	1.3
	Sudanese	3	0.6
	Pakistani	2	0.4
	Total	477	100.0

For the final SEM model in this study, 'competency' presents an abstract second order factor, sometimes also referred to as a higher order factor (Figure 1). The model in this case is represented by an overarching inclusive higher order factor 'competency', which has five latent variables: professionalism', 'preparedness', 'communication', 'clinical' and 'personal'. The first order latent variables are represented with 27 observed variables split in nine, six, five, four and three observed variables, respectively. The final model contains 32 error estimates divided between five for each of the first order latent variables and 27 for the observed variables. As per the modification indices identified from the previous congeneric models for each factor, four co-variances were accounted for: e14 to e10; e19 to e18; e19 to e16; and e21 to e23. The results of the final CFA model presented an adequate SEM model fit within the acceptable fit indices ranges. The model fit results were presented as $\chi 2$ value of 959.88 (df=315, p=.00), CMIN/DF 3.04, RMSEA .06, NFI .91, TLI .93, CFI .94 and a SRMR of .03.

The reliability and validity of the scale have also been supported. The internal consistency reliability measured using Cronbach alpha was >.85 for all factors (Table 2). In addition, the item reliability was also tested using the squared multiple correlation. The conventional cut-off point for the squared multiple correlation is any value below .5, which has been achieved by all the observed variables (21).

The unidimensionality of the scale has also been achieved, as all factor loadings are above the loading value of .5 and all are positively loaded (22-24). Furthermore, the convergent validity has been supported, as the minimum standardised regression weight for each observed variable has achieved a value of >.7 (21).

Discussion

All the previously presented fit indices have met their respective commonly acceptable fit values and the results verify an acceptable fit for the SPECS model with regard to the national study data set. The CFA results for the SPECS model therefore represent a confirmed model. Construct validity has also been established as an adequately fitting model in CFA represents a confirmation of construct validity (21). The model's reliability has also been supported with strong measures of internal consistency using Cronbach alpha factor coefficients. Item reliability was supported by tests that used the squared multiple correlation which indicated that the underlying factors roughly explain more than 50% of the variance in each observed variable.

Given the importance of developing empirical core competency frameworks for EMS healthcare providers, previous studies have explored different EMS competency frameworks by conducting an EFA (25-27). However, the current study is the first to confirm and validate a theoretical EFA model using CFA through SEM in the field of EMS. The CFA for the SPECS model represents the final empirical step in the development of a Saudi EMS competency framework. The SPECS model was

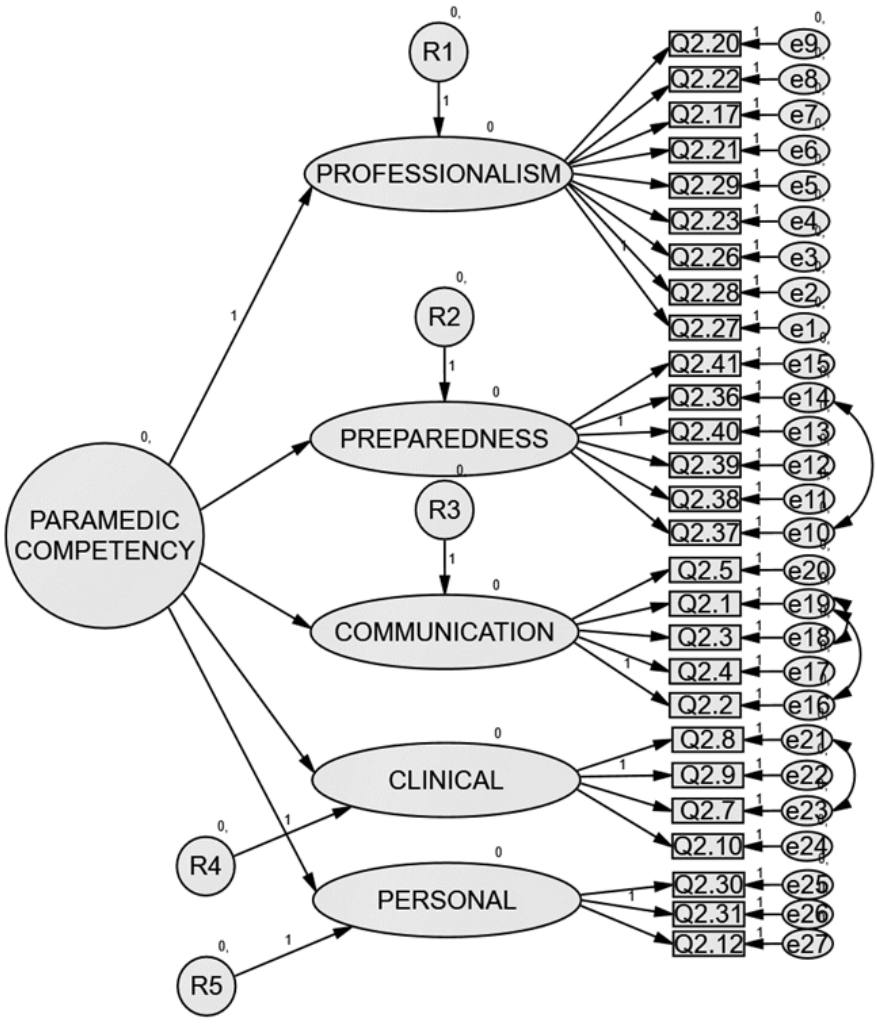
composed of local and international core competency items and subjected to initial validation and expert consensus. Finally, the SPECS model was a product of this study's statistical exploratory generation, reduction and confirmation (14). Generally, EMS competency framework standards are represented by long lists of items that are often based on vocational training or are direct adaptations from different organisations, rather than classified under specific empirically developed factors (28-30). However, internationally recognised competency standards from other healthcare disciplines are represented by six factors and an overarching concept such as 'medical expert' or 'health practitioner' (31,32).

The SPECS model structure is similar to international medical norms, with core competency items grouped under specific factors and an overarching higher order concept representing paramedic competency (Figure 2). However, as the model was developed for Saudi Arabian EMS, the actual factors are somewhat different. For example, the leadership factor was accommodated as an item under the SPECS model 'preparedness' factor, emphasising the importance of the EMS leadership role in preparedness for disaster, terrorist incidents and Islamic Hajj.

The SPECS model was represented by four co-variances within three factors. Although the co-varying items seem natural, those such as item 8 'be able to provide appropriate and effective clinical care' and item 7 'have the theoretical knowledge of key concepts in the EMS profession', naturally link clinical skills with theoretical knowledge. Nevertheless, the

Table 2. Reliability measure for the CFA factors

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Cronbach alpha	.94	.91	.89	.90	.87
Number of items	9	6	5	4	3



Note: The bidirectional arrows between the 'e' indicates a covariance between items under each factor
Figure 1. Confirmed SPECS model

communication factor represented the most interesting relationships with co-variances identified between item 1 'be able to effectively communicate information verbally and non-verbally to patients, colleagues and others' on the one hand and items 2 'be able to practice with respect and non-discriminatory manner' and 3 'be able to work as part of a team in a collaborative and professional approach' on the other.

The link between improved communication in item 1 and non-discrimination in item 2 is not well researched in EMS. However, the concept is important in the current multi-cultural context of Saudi society and specifically during the multi-lingual and multi-national Islamic Hajj (33). Such a link is highly recommended when looking at improving communication in the wider health care system (34). Even within the medical profession, the link between communication and non-discrimination is important and should be a source of learning and integration (35).

The association between item 1 communication and item 3 teamwork is very important in complex environments such as critical cases in the pre-hospital setting (36). Furthermore, communication is an essential component of team dynamics where breakdowns in communication can endanger the quality of care and patient safety (36,37). Overall, interprofessional educational exercises or simulated wilderness exercises for paramedic students may be useful in researching and improving the link between communication and teamwork (38,39).

As previously mentioned, this CFA study is part of a larger project aimed at developing a Saudi Arabian EMS core competency framework, which has now been realised. The next step in the research is to utilise the large sample in the national study data to explore how participants' professional profiles compare to the confirmed SPECS model factors. This will improve understanding of the current status and paradigms specific to Saudi EMS.

Limitations

It is acknowledged that although the SPECS model represents the first EMS competency framework to be confirmed with CFA through SEM, the current model cannot be compared to other CFA EMS models, as none have yet been developed. The self-reporting nature of the study is another limitation; this approach, however, was the only viable one as a large sample size was required for advanced statistical analysis.

Conclusion

The results of this study support the SPECS as a reliable, valid, unidimensional and psychometrically sound model for operationalisation into Saudi university curricula. The overall outcome of the national study data identified and confirmed 27 items represented by five factors and a higher order construct. The SPECS model offers all Saudi universities an EMS program blueprint to ensure curricula standardisation that will facilitate EMS university programs to maintain excellence in curriculum standards based on empirical input from the local and international EMS industry.

Acknowledgements

An acknowledgment of gratitude to all the Saudi EMS industry personnel who participated in this study.

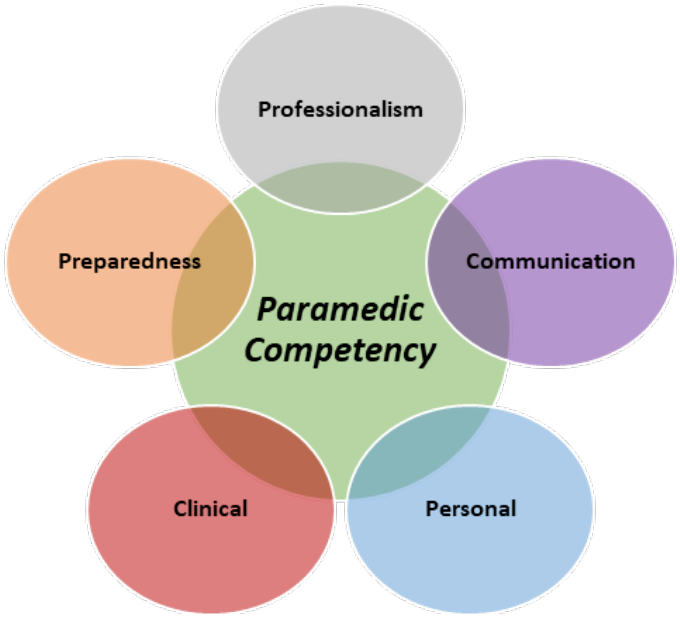


Figure 2. SPECS representation

Conflict of interest

The authors declare no competing interests. Each author of this paper has completed the ICMJE conflict of interest statement. Brett Williams is an Associate Editor of the Australasian Journal of Paramedicine.

References

1. AlShammari T, Jennings P, Williams B. Evolution of emergency medical services in Saudi Arabia. Journal of Emergency Medicine, Trauma and Acute Care 2017;(1):4.
2. AlShammari T, Jennings P, Williams B. Emergency medical services core competencies: a scoping review. Health Professions Education 2018;4:245-58.
3. Caffrey S, Barnes L, Olvera D. Joint Position Statement on degree requirements for paramedics. Prehosp Emerg Care 2018;1-4.
4. Kutney L, Sloane D, Aiken L. An increase in the number of nurses with baccalaureate degrees is linked to lower rates of postsurgery mortality. Health Affairs 2013;32:579-86.
5. Givati A, Markham C, Street K. The bargaining of professionalism in emergency care practice: NHS paramedics and higher education. Adv Health Sci Educ Theory Pract 2018;23:353-69.
6. Comrey A, Lee H. A first course in factor analysis. Hillsdale, NJ: Psychology Press; 2013.
7. AlShammari T, Jennings P, Williams B. Emergency medical services core competencies: a Delphi study. Australasian Journal of Paramedicine 2019;16.
8. Melnyk B, Fineout-Overholt E. Evidence-based practice in nursing & healthcare: a guide to best practice. 2nd edn. Philadelphia: Lippincott Williams & Wilkins; 2011.
9. Nunnally J, Bernstein I. Psychometric theory. New York: McGraw-Hill; 1994.
10. Meyers L, Gamst G, Guarino A. Applied multivariate research: design and implication: CA: Sage Publications, Inc; 2006.
11. Jöreskog K, Sörbom D. LISREL 8: structural equation modeling with the SIMPLIS command language. Hillsdale, NJ: Scientific Software International; 1993.
12. Hair J, Anderson R, Tatham R Black W. Multivariate data analyses with readings. 4 edn. Englewood Cliffs, NJ Prentice Hall; 1995.
13. Schumacker R, Lomax R. A beginner's guide to structural equation modeling. Fourth edn. New York, NY: Psychology Press; 2016.
14. Tabachnick B, Fidell L. Using multivariate statistics. 6 edn. Harlow, Essex: Allyn & Bacon/Pearson Education; 2014.
15. Gefen D, Straub D, Boudreau M. Structural equation modeling and regression: guidelines for research practice. Communications of the Association for Information Systems 2000;4(1):7.
16. Segars A, Grover V. Re-examining perceived ease of use and usefulness: a confirmatory factor analysis. MIS Q 1993;17:517-25.
17. Kline R. Principles and practice of structural modeling: New York: Guilford Press; 1998.
18. Hu L, Bentler P. Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. Struct Equ Modeling 1999;6:1-55.
19. Bentler P. Comparative fit indexes in structural models. Psychol Bull 1990;107:238.
20. Evans V. Higher-order factor analysis: an introductory primer. Annual meeting of the Southwest Educational Research Association; San Antonio, TX, 1999.
21. Holmes-Smith P. Structural equation modeling: from the fundamentals to advanced topics. Melbourne: Sreams; 2016.
22. López S, Peón J, Ordás C. Human resource management as a determining factor in organizational learning. Manag Learn 2006;37:215-39.
23. Nazim A, Ahmad S. Assessing the unidimensionality, reliability, validity and fitness of influential factors of 8th grade student's mathematics achievement in Malaysia'. Int J Adv Res 2013;1:1-7.
24. Awang Z. A handbook on structural equation modeling using AMOS. Malaysia, Universiti Technologi MARA Press; 2012.
25. Chang Y, Tsai K, Williams B. Development of new core competencies for Taiwanese Emergency Medical Technicians. Adv Med Educ Pract 2018;9:147-58.
26. Williams B, Onsman A, Brown T. Australian paramedic graduate attributes: a pilot study using exploratory factor analysis. Emerg Med J 2010;27:794-9.
27. Kilner T. Educating the ambulance technician, paramedic, and clinical supervisor: using factor analysis to inform the curriculum. ibid. 2004;21:379-85.
28. Council of Ambulance Authorities. Paramedic professional competency standards. Melbourne; 2016. Available at: www.caa.net.au/images/documents/accreditation_resources/Paramedic_Professional_Competency_Standards_V2.2_February_2013_PEPAS.pdf
29. National Highway Traffic Safety Administration. National EMS Education Standards Washington, DC2009. Available at: www.ems.gov/pdf/811077a.pdf
30. Health and Care Professions Council. Standards of proficiency for paramedics. London: HCPC; 2014. Available at: www.hpc-uk.org/assets/documents/1000051CStandards_of_Proficiency_Paramedics.pdf
31. Health Professions Council of South Africa. Core competencies for undergraduate students in clinical associate, dentistry and medical teaching and learning programmes in South Africa Pretoria: HPCSA; 2014. Available at: www.hpcsa.co.za/uploads/editor/UserFiles/downloads/medical_dental/MDB%20Core%20Competencies%20-%20ENGLISH%20-%20FINAL%202014.pdf

References (continued)

32. Frank J, Snell L, Sherbino J. CanMEDS 2015 physician competency framework series IV Ottawa. Royal College of Physicians and Surgeons of Canada; 2015. Available at: www.royalcollege.ca/rcsite/documents/canmeds/canmeds-full-framework-e.pdf
33. Alessandro K, Leggio W, AlMubarak H. Muslim mass pilgrimage poses EMS logistical & planning challenges. J Emerg Med Serv 2013;38:52-7.
34. Nichols P, Horner B, Fyfe K. Understanding and improving communication processes in an increasingly multicultural aged care workforce. J Aging Stud 2015;32:23-31.
35. Beheri W. Diversity within nursing: effects on nurse-nurse interaction, job satisfaction and turnover. Nurs Adm Q 2009;33:216-26.
36. Bergs E, Rutten F, Tadros T, Krijnen P, Schipper I. Communication during trauma resuscitation: do we know what is happening? Injury 2005;36:905-11.
37. Furseth P, Taylor B, Kim S. Impact of interprofessional education among nursing and paramedic students. Nurse Educ 2016;41:75-9.
38. Johnston T, MacQuarrie A, Rae J. Bridging the gap Reflections on teaching interprofessional communication to undergraduate paramedic and nursing students. Australasian Journal of Paramedicine 2014;11(4).
39. Ford R, Webb H, Allen-Craig S, et al. A simulated wilderness exercise: the development of relational competence in paramedic students. Journal of Paramedic Practice 2014;6:574-83.