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Psychometric properties of the Chinese version of the TeamSTEPPS teamwork perceptions questionnaire to measure teamwork perceptions of Chinese residents: a cross-sectional study

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Psychometric properties of the Chinese version of the TeamSTEPPS teamwork perceptions questionnaire to measure teamwork perceptions of Chinese residents: a cross-sectional study

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ABSTRACT

Objectives The purpose of the research was to evaluate the psychometric properties of the T-TPQ among Chinese residents.

Design Cross-sectional study.

Setting A clinical hospital of the China Medical University, in Liaoning Province, China.

Participants A sample of 664 residents was enrolled in the research, the valid response rate was 83.0% (664 of 800 residents).

Main outcome measures The internal consistency and test–retest reliability were used to assess the reliability of the questionnaire. The construct validity of the Chinese T-TPQ was evaluated by Confirmatory factor analysis. Furthermore, the concurrent, convergent, and discriminant validity were analyzed.

Results The Cronbach’s alpha coefficient of the T-TPQ in Chinese language was 0.923. Except for the communication dimension (0.649), The Cronbach’s alpha coefficient of all dimensions were satisfactory. The T-TPQ and its five dimensions reported good test–retest reliability (0.740–0.881, $p<0.01$). Moreover, the results of the confirmatory factor analysis demonstrated that the construct validity of the Chinese T-TPQ was satisfactory. All dimensions significantly correlated with the Hospital Survey on Patient Safety Culture (HSOPSC) teamwork within units dimension and the Safety Attitudes Questionnaire (SAQ) teamwork climate dimension ($p<0.01$), and the questionnaire showed satisfactory convergent and discriminant validity.

Conclusions The T-TPQ in Chinese language demonstrated good psychometric characteristics and is a reliable and valid questionnaire to measure Chinese health professionals’ perception of teamwork. Thus, the Chinese version of the T-TPQ could be applied in teamwork training programs and medical education research.

Keywords Teamwork , Questionnaire, Cross-cultural validation, Healthcare quality, Patient safety

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Strengths and limitations of this study

- ▶ To our knowledge, this is the first study to translate and validate the T-TPQ questionnaire in China.
- ▶ In our study, we used international standards to examine the psychometric properties of the Chinese version of the T-TPQ.
- ▶ This study provide a benchmarked instrument, which may act as a basis for future studies on teamwork perception in Chinese medical education.
- ▶ The study was conducted only in one university hospital, resulting in the study sample that may not be representative of all Chinese health professionals.

INTRODUCTION

Teamwork is important for improving healthcare quality and increasing patient safety, effective teamwork in healthcare not only augments patient satisfaction but also decreases burnout among health professionals.[1-4] The Agency for Healthcare Research and Quality (AHRQ), the Joint Commission, and other institutions ranked teamwork as dominant factor to enhancing healthcare quality.[5,6] Furthermore, teamwork has been classified as an important competency to help optimize healthcare services, and poor teamwork could increase medical errors and reduce patient safety.[7-11] Meanwhile, team training has been widely recognized to enhance teamwork, and there is a great need in improving patient safety and healthcare quality.[12-14] Health professionals today may not be competent in teamwork, and teamwork training has not attracted the attention of medical institutions.[15-17] The Chinese Hospital Association reported that in Chinese healthcare institutions, adverse patient events consumes a lot of medical resources every year.[18,19] Therefore, cultivating teamwork competency of health professionals has become a crucial and urgent factor for improving patient safety in China.

Evaluation of health professionals' competency in teamwork has proven to be important in both team training and medical education,[20,21] and an inaccurate evaluation may lead to

unreliable conclusions regarding team training and performance management.[22] Teamwork evaluation is recommend as a key process in residency training.[23] For the past few years, much research has been conducted on evaluating the teamwork perceptions of health professionals to better understand their teamwork competency. Therefore, a good measuring tool is very important to evaluate teamwork perceptions of health professionals.[24-26] The TeamSTEPPS Teamwork Perception Questionnaire (T-TPQ), as one of the most frequently applied tools for the evaluation of teamwork perception among health professionals, is a self-report questionnaire, which evaluates a health professional's perception of group-level teamwork situation in a medical team.[27]

The American Institutes for Research developed the T-TPQ in 2010.[27] When considering the importance of teamwork in healthcare and medical education, the AHRQ developed the TeamSTEPPS. The TeamSTEPPS is a teamwork training course and framework which is useful for promoting healthcare quality and reducing medical errors.[28,29] The T-TPQ was based on the five important teamwork factors of the TeamSTEPPS, including team structure dimension, leadership dimension, situation monitoring dimension, mutual support dimension, and communication dimension. The questionnaire has been cross-culturally validated in different countries and languages, including the United States of America,[30] Norway,[31] Korea,[32] Brazil,[33] Scotland,[34] among others. Furthermore, the T-TPQ has shown to be reliable and valid among physicians, nurses, medical students, residents, and pharmacists.[30-34] All versions of the T-TPQ contain the same contents, with small modifications to reflect clinical practice.

The T-TPQ in Chinese language was translated by our research team.[35] Adapting the Chinese version, we followed the process of translation and adaptation suggested by WHO guidelines for validation of a scale.[36] The main steps included the following: forward translation, specialist review, back-translation, pre-testing, cognitive interviewing, formation of the questionnaire. Currently, no researches have used the questionnaire in health professionals of China, therefore, the psychometric properties of the Chinese T-TPQ have not yet been assessed. The purpose of our research was to investigate the psychometric properties of the Chinese T-TPQ in residents. The results of our research may be useful to well understand the teamwork perception of residents and other health professionals in China.

Meanwhile, the progress and results of the research may be helpful to other countries considering developing the T-TPQ for their medical institutions and health professionals.

METHODS

Ethics statement

The study was based on data regarding teamwork perception of Chinese residents. All respondents provided written informed consent and participation was voluntary, and data was collected anonymously. We have got the permission to make the cross-cultural translation and adaptation of the T-TPQ from the developer of the questionnaire. The study was approved by the Bioethics Advisory Commission of China Medical University, Shenyang, China.

Participants and procedures

For the present study, 800 residents from three grades were recruited, and the study was conducted between June 2018 and October 2018 at a clinical hospital of the China Medical University, Shenyang, China. The training program of Chinese residents lasts about 3 years, and during this period, young residents acquire the knowledge and skills of their specialties or subspecialties, and develop attitudes, behaviors, habits, and values that last their entire professional lifetime. Residents experience most of their study and assessment in the clinical context.

All participants completed a self-filling questionnaire individually. In the process of questionnaire collection, experienced researchers checked the questionnaires, and verified any invalid/incomplete questionnaires. One questionnaire was deemed invalid when more than 20% of the data in the questionnaire was missing. Of the 800 residents, 664 completed the questionnaire, the valid response rate was 83.0%. The study size was based on the item per respondent ratio of 1:10 principle.[37] In a previous study, it was reported that the sample size to evaluate test–retest reliability coefficient was 52.[38] In our study, a total of 72 respondents were randomly selected to answer the questionnaire again after two weeks, among which 60 respondents completed the questionnaire.

Measures

The questionnaire comprised four parts included basic information (gender, age, marital status, grade, and monthly income), as well as the Chinese version of the T-TPQ, the HSOPSC,[39] and the SAQ.[40] The T-TPQ assessed the respondents’ perception of group-level teamwork competency in a department, and consisted of 35 items in five dimensions namely teamwork structure dimension, leadership dimension, situation monitoring dimension, mutual support dimension, communication dimension. The T-TPQ responses are given on a five-point Likert scale, each dimension of the questionnaire is compute to an average score.[27]

The HSOPSC and the SAQ are generic patient’s safety measurement scales that are deemed to be reliable and valid to evaluate a hospital’s teamwork and patient safety climate.[41,42] A dimension of the HSOPSC (teamwork within units dimension) and a dimension of the SAQ (teamwork climate dimension) were used to demonstrate concurrent validity, and the reliability was found to be satisfactory (Cronbach’s α coefficient =0.891 and 0.909 respectively).

Statistical analysis

To satisfy the requirements of the study, missing data were replaced by the median value. Descriptive statistics (means, SD, skewness (Sk), kurtosis (Ku), floor and ceiling effects) were performed on all items and dimensions of the Chinese version of the T-TPQ. The absolute values of Sk and Ku higher than 3 and 10, respectively, showed significant deviance from a normal subjects distribution.[37,43,44] If the percentage of items with the lowest or the highest score was more than 20%, floor or ceiling effects were considered significant. In our study, the Cronbach’s α coefficient was computed to evaluate internal consistency of the T-TPQ. The internal consistency was deemed to be acceptable when the Cronbach’s α coefficient value was higher than 0.7.[45-47] If the Intraclass Correlation Coefficient (ICC) was higher than 0.7, the test–retest reliability was considered satisfactory.[48]

Regarding construct validity, the original five-factor model of the T-TPQ was tested using a confirmatory factor analysis (CFA). In many studies, it has been suggested that the CFA is very important for scales that have been culturally adapted.[49,50] The goodness of fit was assessed through the following indicators: χ^2 , the root mean square error of approximation

(RMSEA), the comparative fit index (CFI), the adjusted goodness-of-fit index (AGFI), among which the RMSEA was considered the best index.[31,50] If the RMSEA was higher than 0.08, the CFI was higher than 0.90, we deemed that it was a good fit. An AGFI value was higher than 0.85 was deemed a satisfactory model fit.[49] The correlations between each dimension of the T-TPQ were evaluated by computing the Pearson's correlation coefficient.

To test the concurrent validity, the T-TPQ was correlated with the HSOPSC teamwork within the units dimension and the SAQ teamwork climate dimension. The item-domain Pearson's correlations was employed to demonstrate the convergent and discriminant validity of the questionnaire, and a correlation coefficient of >0.4 for item and its respective dimension was deemed satisfactory.[51,52] Items showing correlations with other dimensions that were lower than those with their own dimensions showed satisfactory discriminant validity.[53] In the research, we used SPSS 20.0, AMOS 21.0 software for Windows. A p-value of less than 0.05 was defined to be statistically significant.

Patient and public involvement statement

Patients or the public were not involved in the design, conduct or the analysis of our research.

RESULTS

Characteristics of respondents

The valid response rate of the overall research was 83.0 % (664/800) and the retest valid response rate was 83.3 % (60/72). The average age of the respondents was 25.83 years (SD=1.61). Most respondents were female, the residence of more than half of the participants were urban. Sociodemographic characteristics of responders are summarized in table 1.

Table 1 Basic characteristics of respondents (n=664)

Characteristic	Number	Percentage (%)
Gender		
Male	228	34.3
Female	436	65.7
Age		
≤25 years old	312	47.0
>25 years old	352	53.0
Residence		
Urban	429	64.6
Rural	235	35.4
Grade		
One	205	30.9
Two	266	40.0
Three	193	29.1
Marital status		
Married	34	5.1
Unmarried	630	94.9
Monthly income (Yuan)		
≤1000	156	23.5
1001-2000	494	74.4
2001-3000	14	2.1
Region		
Eastern China	425	64.0
Central China	154	23.2
Western China	85	12.8

The score of the T-TPQ among Chinese residents was 4.10±0.37.Regarding dimensions, the team structure dimension had the highest score (4.24±0.44), while the mutual support dimension score was the lowest (3.95±0.45). All items and dimensions displayed acceptable

Sk (ranging from -1.02 to -0.07) and Ku (ranging from -0.38 to 3.53) coefficients. No significant floor effects were observed in all items and dimensions. None of the dimensions showed significant ceiling effect. However, most items displayed significant ceiling effects, except for items 15, 16, 26, 27, 28, and 33.

Reliability

The internal consistency of the overall T-TPQ was excellent. All dimensions were considered to have satisfactory internal consistency, except for the communication dimension, which was slightly below the acceptable internal consistency coefficient (0.700). The split-half reliability coefficient for the total T-TPQ was satisfactory (0.843). In addition, the test-retest reliability of the Chinese T-TPQ was satisfactory, the ICC of all dimensions was good. Those results are shown in table 2.

Table 2 Reliability of the T-TPQ in Chinese language

Dimensions	Cronbach's a coefficient	
	(n=664)	ICC (95%CI) (n=60)
Team Structure	0.801	0.877 (0.749-0.948)**
Leadership	0.831	0.749 (0.507-0.917)**
Situation Monitoring	0.820	0.740 (0.530-0.908)**
Mutual Support	0.720	0.849 (0.702-0.932)**
Communication	0.649	0.745 (0.449-0.910)**
T-TPQ	0.923	0.881 (0.783-0.945)**

**p<0.01.

Construct validity

In this study, the CFA was performed to test the five-factor model, which displayed an acceptable fit with the data ($\chi^2=1815.176$, $df=550$, $p<0.001$; CFI=0.837; RMSEA=0.059 [90% CI: 0.056 to 0.062]; AGFI=0.829). Each item had an acceptable factor load with its respective dimension, and the path coefficients between each dimension were acceptable, as displayed in figure 1.

Correlations among the dimensions of the questionnaire

The Chinese version of the T-TPQ showed significant correlations between each dimension of the questionnaire. The correlations among dimensions of the questionnaire were determined by the Pearson’s correlation coefficient, and shown in table 3.

Table 3 Correlations among the dimensions of the T-TPQ in Chinese language (n=664)

Dimensions	Team		Situation	Mutual	
	Structure	Leadership	Monitoring	Support	Communication
Team Structure	—	0.667**	0.625**	0.517**	0.565**
Leadership		—	0.641**	0.495**	0.474**
Situation Monitoring			—	0.619**	0.548**
Mutual Support				—	0.532**
Communication					—

**p<0.01.

Concurrent validity

The correlation coefficients of the T-TPQ with the HSOPSC teamwork within units dimension and the SAQ teamwork climate dimension are shown in table 4. The total questionnaire and its five dimensions significantly correlated with the two subscales, all correlation coefficients were higher than 0.40, except for the association between “mutual support”, “communication” dimension, and the HSOPSC teamwork within units dimension, and the association between the “mutual support” dimension and the SAQ teamwork climate dimension. These findings revealed acceptable concurrent validity of the adapted Chinese version of the T-TPQ.

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Table 4 Concurrent validity of the T-TPQ in Chinese language (n=664)

Dimensions	Correlation coefficient	
	HSOPSC	SAQ
	teamwork within units dimension	teamwork climate dimension
Team Structure	0.465**	0.446**
Leadership	0.511**	0.506**
Situation Monitoring	0.497**	0.501**
Mutual Support	0.384**	0.398**
Communication	0.360**	0.419**
T-TPQ	0.551**	0.563**

**p<0.01.

Convergent and discriminant validity

In the present study, the Chinese version of T-TPQ showed good convergent validity, and that the correlation coefficients of each item correlated well with its respective dimension. In addition, the discriminant validity was acceptable, and all items displayed a better correlation with their respective dimensions than with other dimensions (table 5).

Table 5 Summary of convergent and discriminant validity (n=664)

Dimensions	Correlation coefficient range		Convergent validity		Discriminant validity	
	Convergent validity	Discriminant validity	Success/total	Percentage (%)	Success/total	Percentage (%)
Team Structure	0.541-0.743**	0.236-0.586**	7/7	100	7/7	100
Leadership	0.632-0.741**	0.276-0.566**	7/7	100	7/7	100
Situation Monitoring	0.608-0.749**	0.331-0.486**	7/7	100	7/7	100
Mutual Support	0.571-0.655**	0.228-0.478**	7/7	100	7/7	100
Communication	0.537-0.624**	0.100-0.495*	7/7	100	7/7	100

**p < 0.01; *p < 0.05.

DISCUSSION

Standardized and effective evaluation of teamwork is critical to improve perceived functioning of a medical team.[54,55] The results of our research suggest that the Chinese version of the T-TPQ shown acceptable levels of reliability and validity. The response rate of the current study was 83.0%, which was similar to that of the Korean study,[32] and better than the Norwegian study.[31] All items and dimensions of the Chinese version of the T-TPQ displayed acceptable Ku and Sk coefficients, and the floor effects of all items and dimensions were below the accepted threshold of 20%. However, in our study, several items showed significant ceiling effects. The ceiling effect of our research was understandable, because most residents would be more comfortable when their teamwork perception was good and be approved by others.[43]

In our study, we found that the Chinese T-TPQ had a satisfactory internal consistency, which was similar to other cross-cultural studies performed in different countries and regions, for instance, Norway, Korea, and the USA.[30-32] Our study displayed that the Cronbach's alpha coefficient of the questionnaire was relatively high, and that the internal consistency of most dimensions were satisfactory. A good internal consistency of the questionnaire reveals that most items and dimensions measured the same concept, namely the perceptions of residents about teamwork in their typical workplace. The satisfactory Cronbach's alpha coefficient values on the dimensions could illustrate the high internal consistency of the total questionnaire.[56] In line with research findings among healthcare personnel in Norway,[31] in our study, we showed that the Chinese T-TPQ had good test-retest reliability. In some previous studies, it was suggested that test-retest reliability can be used to evaluate temporal fluctuations.[57] In healthcare studies, many measurement experts find that, compared with internal consistency, test-retest reliability is considered to be of more consequence.[57]

The CFA displayed that the original five-dimension structures of the T-TPQ provide a generally satisfactory fit for our research data, the result was in line with the previous validation study of T-TPQ.[30,31] The results of our study revealed that, on the basis of the goodness-of-fit indices, the construct validity of the Chinese T-TPQ, was acceptable. We found that the RMSEA index was 0.059, indicating a satisfactory fit. The CFI (0.837) and AGFI (0.829) were slightly below the cut-off values for a satisfactory evidence of model fit.

Anyhow, literature studies suggested that the most effective and informative criteria is RMSEA in covariance structure modeling.[31,50] When compared to the findings of our research, the Norwegian study by Ballangrud *et al*[31] reported a CFI index of 0.833, which was similar to that in our study, and the RMSEA index was 0.069. The study by Keebler *et al*[30] displayed a better CFI (0.925), and the RMSEA index was 0.068. The study samples may have had an impact on the findings of these researches, and a larger sample size may lead to a better fit with data.[58] The samples of the study in America was 1700 participants from the US Army medical facilities.[30] However, only 247members of healthcare personnel in different hospitals responded to the Norwegian study that was performed by Ballangrud *et al*[31] The sample size of our research included 664 residents. The factor load of each item with its respective dimension and path coefficients among the dimensions was acceptable, and the findings were similar to the American study performed by Keebler *et al*[30] Overall, the results of our research reported that the model of the Chinese version of the T-TPQ was appropriate for future studies in China.

Significant correlations were observed among dimensions of the Chinese version of the T-TPQ. Significant correlations between each dimension were also revealed by the research in America and Norway.[30,31] The result of our research reported that the correlation coefficient between team structure and leadership was the highest, indicating that if a medical team had a better team structure, the leadership of the team could be improved. The Norwegian study by Ballangrud *et al*[31] revealed the highest correlation coefficient between team structure and communication. The result of the study in America[30] displayed that the situation monitoring strongly correlated with mutual support, thereby showing that the situation monitoring skill of health professionals could be enhanced by improving mutual support.

Concurrent validity was revealed by significant correlations with the HSOPSC teamwork within units dimension and the SAQ teamwork climate dimension. Our study reported that the T-TPQ and its five dimensions significantly correlated with the HSOPSC teamwork within units dimension ($r=0.360-0.551$, $p<0.01$), and the SAQ teamwork climate dimension ($r=0.398-0.563$, $p<0.01$). However, the correlation with the HSOPSC teamwork within units dimension were somewhat lower than the findings of the validation study by the American

Institutes for Research($r=0.60-0.81$, $p<0.01$).[27] More specifically, our study demonstrated that the convergent and discriminant validity of the Chinese T-TPQ was satisfactory. These results are important and noteworthy, because if one item reported better correlation with one of the other dimensions than with its initially assigned dimension, it could be argued that this item should be modified or reassigned to the other dimension.[59]

The strength of our study is that we provide a Chinese language version of the T-TPQ, which may act as a basis for future studies on teamwork perception and climate in healthcare and medical education in China. However, there are some limitations in our study. Firstly, the respondents of the research were from a single medical institution in China. Moreover, the findings of our study were limited by the representativeness and scale of the study population. Furthermore, the nature of the cross-sectional study hinders an appropriate assessment of this questionnaire's sensitivity to change. The Chinese version of the T-TPQ displays promised to be a benchmarked instrument for future studies that focus on teamwork in healthcare settings in China. Further studies could enhance representativeness of the study population by expanding the respondent's diversity and sample size. Determination of teamwork perception is of clinical relevance. We suggested researchers of medical education to consider using this questionnaire for teamwork study among not only residents but also other health professionals in China. Meanwhile, for future studies, it is required to use the T-TPQ as measuring instrument to verify the impact of training programs related to teamwork in health professionals.

CONCLUSIONS

In the research, we evaluated the psychometric properties of the T-TPQ in Chinese language. Our findings confirmed that the T-TPQ in Chinese language is a reliable and valid questionnaire for measuring teamwork perception of Chinese residents, and in cross-cultural comparative studies on teamwork perception of health professionals, and can therefore be applied in teamwork training programs and medical education research.

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Contributors BQ and JQ conceived the study and wrote the manuscript. YZ and LC coordinated data-management. XY and JQ did the data-analysis. YZ, LY and YL contributed to reviewed the manuscript. All authors read and approved the final manuscript.

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Competing interests None declared.

Patient consent Not required.

Provenance and peer review Commissioned; externally peer reviewed.

Ethics Approval The study was approved by the Bioethics Advisory Commission of China Medical University.

Data sharing statement The data used in this study can be provided upon request. The de-identified data can be provided by email.

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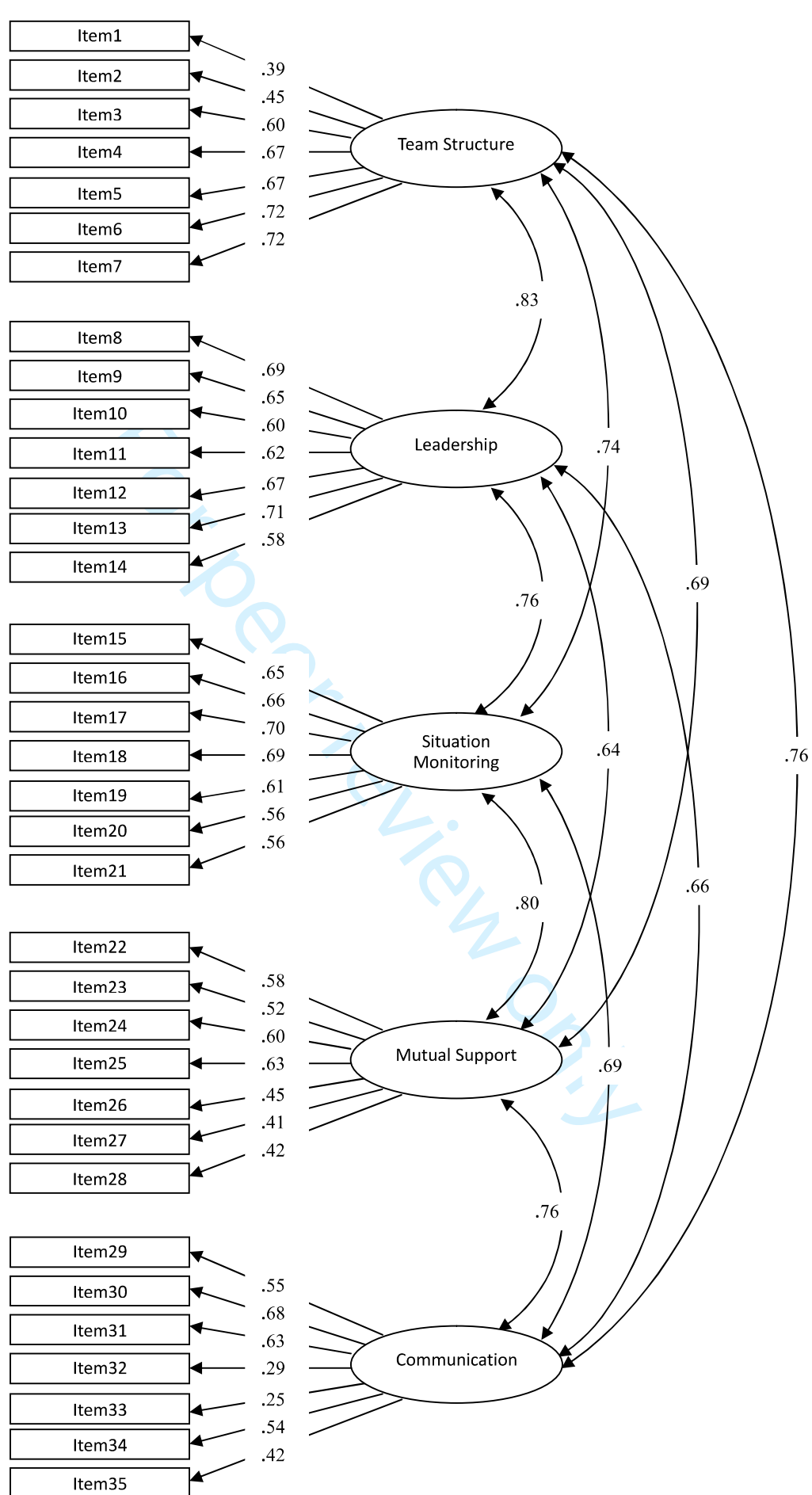


Figure 1. Overview of the structure of the Chinese version of the T-TPQ based on confirmatory factor analysis.

STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation	Page No
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	2
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	3,4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4,5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6,7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6,7
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7
Bias	9	Describe any efforts to address potential sources of bias	6
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7,8
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7,8
		(b) Describe any methods used to examine subgroups and interactions	7,8
		(c) Explain how missing data were addressed	7
		(d) If applicable, describe analytical methods taking account of sampling strategy	7,8
		(e) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8,9
		(b) Give reasons for non-participation at each stage	6,8
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8,9
		(b) Indicate number of participants with missing data for each variable of interest	8,9
Outcome data	15*	Report numbers of outcome events or summary measures	8-13
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-13

		(b) Report category boundaries when continuous variables were categorized	N/A
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11
Discussion			
Key results	18	Summarise key results with reference to study objectives	14,15,16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14,15,16
Generalisability	21	Discuss the generalisability (external validity) of the study results	16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	17

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Psychometric properties of the Chinese version of the TeamSTEPPS teamwork perceptions questionnaire to measure teamwork perceptions of Chinese residents: a cross-sectional study

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ABSTRACT

Objectives The purpose of this research was to evaluate the psychometric properties of the TeamSTEPPS Teamwork Perception Questionnaire (T-TPQ) among the Chinese residents.

Design Cross-sectional study.

Setting A clinical hospital of the China Medical University in Liaoning Province, China.

Participants A total of 664 residents were enrolled in this research. The valid response rate was 83.0% (664 of 800 residents).

Main outcome measures Internal consistency and test–retest reliability were used to assess the reliability of the questionnaire. The construct validity of the Chinese T-TPQ was evaluated by confirmatory factor analysis. Furthermore, the concurrent, convergent, and discriminant validity were analyzed.

Results Cronbach’s alpha coefficient of the T-TPQ in Chinese language was 0.923. Except for the communication dimension (0.649), the Cronbach’s alpha coefficient of all dimensions were satisfactory. The T-TPQ and its five dimensions reported a good test–retest reliability (0.740–0.881, $p<0.01$). Moreover, the results of the confirmatory factor analysis demonstrated that the construct validity of the Chinese T-TPQ was satisfactory. All dimensions significantly correlated with the Hospital Survey on Patient Safety Culture (HSOPSC) teamwork within units dimension and the Safety Attitudes Questionnaire (SAQ) teamwork climate dimension ($p<0.01$), and the questionnaire showed satisfactory convergent and discriminant validity.

Conclusions The T-TPQ in Chinese language demonstrated good psychometric characteristics and was a reliable and valid questionnaire to measure the Chinese health professionals’ perception of teamwork. Thus, the Chinese version of the T-TPQ could be applied in teamwork training programs and medical education research.

Keywords Teamwork, Questionnaire, Cross-cultural validation, Healthcare quality, Patient safety

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Strengths and limitations of this study

- ▶ To our knowledge, this is the first study to translate and validate the T-TPQ questionnaire in China.
- ▶ In our study, we used international standards to examine the psychometric properties of the Chinese version of the T-TPQ.
- ▶ This study provides a benchmarked instrument, which may act as a basis for future studies on teamwork perception in Chinese medical education.
- ▶ This study was conducted only in one university hospital, therefore study population may not be representative of all the Chinese health professionals.

INTRODUCTION

Teamwork is important for improving healthcare quality and increasing patient safety. Effective teamwork in healthcare not only augments patient's satisfaction but also decreases burnout among the health professionals.[1-4] The Agency for Healthcare Research and Quality (AHRQ), the Joint Commission, and other institutions ranked teamwork as a dominant factor for enhancing the healthcare quality.[5,6] Furthermore, teamwork has been classified as an important competency to help optimize the healthcare services, and poor teamwork could increase the medical errors and reduce patient safety.[7-11] As there is great need in improving patient safety and healthcare quality, team training has been widely recognized to enhance teamwork.[12-15] However, health professionals today are not competent in teamwork, and team training has not attracted the attention of medical institutions.[16-18] The Chinese Hospital Association has reported that, adverse patient events consumes extensive medical resources every year in Chinese healthcare institutions.[19,20] Therefore, cultivating teamwork competency in healthcare professionals has become a crucial and urgent factor for improving the patient safety in China.

Evaluation of competency of health professionals' in teamwork has proven to be important

in both, team training and medical education [21,22], and an inaccurate evaluation may lead to unreliable conclusions.[23] Teamwork evaluation is recommend as a key process in residency training.[24] For the past few years, much research has been conducted on evaluating the perceptions of health professionals to better understand their teamwork competency. Therefore, a good measuring tool is especially important to evaluate teamwork perceptions of the health professionals.[25-27] The TeamSTEPPS Teamwork Perception Questionnaire (T-TPQ), is one of the most frequently applied tools used for such evaluation. It is a self-report questionnaire, which evaluates perceptions of a healthcare professional on group-level teamwork situation in a medical team.[28]

The T-TPQ was developed by American Institutes for Research developed in year 2010.[28] When considering the importance of teamwork in healthcare and medical education, the AHRQ developed the TeamSTEPPS. TeamSTEPPS is a teamwork training course and framework which is useful for improving quality of healthcare and reducing medical errors.[29,30] The T-TPQ was based on the five important teamwork factors of the TeamSTEPPS, including team structure dimension, leadership dimension, situation monitoring dimension, mutual support dimension, and communication dimension. The questionnaire was cross-culturally validated in different countries and languages, including the United States of America,[31] Norway,[32] Korea,[33] Brazil,[34] and Scotland,[35] among others. Furthermore, the T-TPQ has shown to be reliable and valid tool among the physicians, nurses, medical students, residents, and pharmacists.[31-35] All versions of the T-TPQ contains the same content, with minor modifications to reflect the clinical practices.

The T-TPQ in Chinese language was translated by our research team.[36] In adapting to the Chinese version, we followed the process of translation and adaptation as suggested by WHO guidelines for validation of the scale.[37] In this the main steps were: forward translation, specialist review, back-translation, pre-testing, cognitive interviewing, and formation of the questionnaire. So far, no research had used the questionnaire in healthcare professionals of China, therefore, the psychometric properties of the Chinese T-TPQ have not yet been assessed. The purpose of this research was to evaluate the psychometric properties of the T-TPQ among the Chinese residents. The results of our research may be useful to fully understand the teamwork perception of residents and other healthcare professionals in China.

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Further, the findings of this research may be helpful to other countries in developing the T-TPQ for their medical institutions and healthcare professionals.

METHODS

Ethics statement

This study was based on the data of teamwork perception of the Chinese residents. All participants provided written informed consent and participation was voluntary and confidential. We acquired permissions from the developer of the questionnaire to make cross-cultural translation and adaptation of the T-TPQ. The study was approved by the Bioethics Advisory Commission of China Medical University, Shenyang, China.

Participants and procedures

For this study, 800 residents from three grades were recruited, and the study was conducted between June 2018 and October 2018 at a clinical hospital of the China Medical University, Shenyang, China. The training program of Chinese residents typically lasts for about 3 years, during which, young residents acquire the knowledge and skills of their specialties or subspecialties, and develop attitudes, behaviors, habits, and values that are helpful for their subsequent professional life. Most studies and assessments are based on the clinical context.

The coded paper version of the questionnaires were handed out to the residents on-site, and each participant completed a self-administered questionnaire. Experienced researchers then checked the questionnaires and verified if there were any invalid/incomplete questionnaires. A questionnaire was deemed as invalid if more than 20% of the data was missing. Of the 800 residents, 664 completed the questionnaire, the valid response rate was 83.0%. The study size was based on the item per participant ratio of 1:10 principle.[38] A previous study reported that the sample size to evaluate test-retest reliability coefficient was 52. [39] In our study, a total of 72 respondents were randomly selected to answer the questionnaire, and again after two weeks 60 among them completed the questionnaire.

Measures

The questionnaire comprised of four parts including basic information (gender, age, marital

status, grade, and monthly income), the Chinese version of the T-TPQ, the HSOPSC [40], and the SAQ.[41] The T-TPQ assessed the respondents' perception of group-level teamwork competency in a department, and it consisted of 35 items in five dimensions namely—teamwork structure, leadership, situation monitoring, mutual support, and communication. Each dimension contained 7 items, the response to which were given on a five-point Likert scale (1=disagree strongly to 5=agree strongly). The T-TPQ and its dimension scores were computed to an average score.[28]

The HSOPSC and the SAQ are generic scales for patient's safety measurement that are reliable and valid to evaluate a hospital's teamwork and patient safety.[42,43] The HSOPSC consists of 42 items in twelve dimensions, and the SAQ consists of 36 items in six dimensions. A dimension of the HSOPSC (teamwork within units dimension) and a dimension of the SAQ (teamwork climate dimension) were used to test the concurrent validity in this study. The two dimensions were scored on a five-point Likert scale (ranging from 1=disagree strongly to 5=agree strongly). The reliability of these two dimensions were found to be satisfactory (Cronbach's α coefficients were 0.891 and 0.909, respectively).

Statistical analysis

To satisfy the requirements of the study, twenty-four missing data distributed in 18 respondents were replaced by each respondent's median value in the relevant dimension. Descriptive statistics (mean, standard deviation (SD), skewness (Sk), kurtosis (Ku), floor and ceiling effects) were performed on all items and dimensions in the Chinese version of the T-TPQ. The absolute values of Sk and Ku higher than 3 and 10, respectively, showed a significant deviance from a normal subjects distribution.[38,44,45] If the percentage of items with the lowest or the highest score was more than 20%, floor or ceiling effects were considered as significant. In our study, the Cronbach's α coefficient was computed to evaluate the internal consistency of the T-TPQ. The internal consistency was deemed to be acceptable when the Cronbach's α coefficient value was higher than 0.7.[46-48] The test-retest reliability was evaluated by the Intraclass Correlation Coefficient (ICC) with the Two-Way Random model. If the ICC was higher than 0.7, the test-retest reliability was considered satisfactory.[49]

Regarding construct validity, the original five-factor model of the T-TPQ was tested using a confirmatory factor analysis (CFA). CFA is a robust method of statistical analysis to test a predetermined factor structure or a hypothetical theory, and it can describe how well each item evaluates the measure's dimensionality. In many studies, it has been suggested that the CFA is very important for scales that have been culturally adapted.[50,51] The goodness of fit was assessed through the following indicators: the chi-square goodness of fit (χ^2), the root mean square error of approximation (RMSEA), the comparative fit index (CFI), and the adjusted goodness-of-fit index (AGFI); among which the RMSEA was considered as the best index.[32,51] If the RMSEA was below 0.08, and the CFI was higher than 0.90, we deemed that it was a good fit. An AGFI value higher than 0.85 was deemed a satisfactory model fit.[50] The correlations between each dimension of the T-TPQ were evaluated by computing the Pearson's correlation coefficient.

To test the concurrent validity, the Pearson's correlation analysis of T-TPQ with the HSOPSC teamwork within the units dimension and the SAQ teamwork climate dimension was conducted. Regarding convergent and discriminant validity, we only used the T-TPQ for this analysis. A Pearson's correlation coefficient of >0.4 for an item with its respective dimension indicated satisfactory convergent validity.[52,53] Items showing lower correlations with other dimensions than those with their respective dimensions showed satisfactory discriminant validity.[54] In this research, we used SPSS 20.0, AMOS 21.0 software of the Windows. A p -value <0.05 was defined to be statistically significant.

Patient and public involvement statement

Patients or the public were not involved in the design, conduct or the analysis of our research.

RESULTS

Characteristics of respondents

The valid response rate of the overall research was 83.0% (664/800) and that of retest was 83.3% (60/72). The average age of the respondents was 25.83 years (SD=1.61). Most respondents were female and more than half of the participants were urban residents. The sociodemographic characteristics of responders has been summarized in table 1.

Table 1 Basic characteristics of respondents (n=664)

Characteristic	Number	Percentage (%)
Gender		
Male	228	34.3
Female	436	65.7
Age		
≤25 years old	312	47.0
>25 years old	352	53.0
Residence		
Urban	429	64.6
Rural	235	35.4
Grade		
One	205	30.9
Two	266	40.0
Three	193	29.1
Marital status		
Married	34	5.1
Unmarried	630	94.9
Monthly income (Yuan)		
≤1000	156	23.5
1001-2000	494	74.4
2001-3000	14	2.1
Region		
Eastern China	425	64.0
Central China	154	23.2
Western China	85	12.8

The mean of the T-TPQ among the Chinese residents was 4.10±0.37. Regarding dimensions, the team structure dimension had the highest score (4.24±0.44), while the mutual

support dimension had the lowest score (3.95 ± 0.45). The score of the T-TPQ were as shown in Supplemental Material 1. All items and dimensions displayed acceptable Sk (1.02 to -0.07) and Ku (-0.38 to 3.53) coefficients. No significant floor effects were observed in all items and dimensions. None of the dimensions showed significant ceiling effects. However, most items displayed significant ceiling effects, except for items 15, 16, 26, 27, 28, and 33.

Reliability

The internal consistency of the overall T-TPQ was excellent. All dimensions had satisfactory internal consistency, except the communication dimension, which was slightly below the acceptable internal consistency coefficient (0.700). The split-half reliability coefficient for the total T-TPQ was satisfactory (0.843). Additionally, the test-retest reliability of the Chinese T-TPQ was satisfactory, and the ICC of all dimensions was good. These results are shown in table 2.

Table 2 Reliability of the T-TPQ in Chinese language

Dimensions	Cronbach's α coefficient	
	(n=664)	ICC (95%CI) (n=60)
Team Structure	0.801	0.877 (0.749-0.948)**
Leadership	0.831	0.749 (0.507-0.917)**
Situation Monitoring	0.820	0.740 (0.530-0.908)**
Mutual Support	0.720	0.849 (0.702-0.932)**
Communication	0.649	0.745 (0.449-0.910)**
T-TPQ	0.923	0.881 (0.783-0.945)**

** $p < 0.01$.

Construct validity

In this study, the CFA was performed to test the five-factor model, which displayed an acceptable fit with the data ($\chi^2=1815.176$, $df=550$, $p < 0.001$; CFI=0.837; RMSEA=0.059 [90% CI: 0.056 to 0.062]; and AGFI=0.829). Except for the eight items, all other items had an acceptable factor load with its respective dimension (factor load > 0.5), and the path

coefficients between each dimension was acceptable, as displayed in figure 1.

Correlations among the dimensions of the questionnaire

The Chinese version of the T-TPQ showed significant correlation between each dimension of the questionnaire. The correlations among the dimensions of the questionnaire were determined by the Pearson’s correlation coefficient and are shown in table 3.

Table 3 Correlations among the dimensions of the T-TPQ in Chinese language (n=664)

Dimensions	Team		Situation	Mutual	
	Structure	Leadership	Monitoring	Support	Communication
Team Structure	—	0.667**	0.625**	0.517**	0.565**
Leadership		—	0.641**	0.495**	0.474**
Situation Monitoring			—	0.619**	0.548**
Mutual Support				—	0.532**
Communication					—

***p*<0.01.

Concurrent validity

The correlation coefficients of the T-TPQ with the HSOPSC teamwork within units dimension and the SAQ teamwork climate dimension were as shown in table 4. The total questionnaire and its five dimensions significantly correlated with the two subscales. All the correlation coefficients were higher than 0.40, except the association between “mutual support”, “communication” dimension, and the HSOPSC teamwork within units dimension, and the association between the “mutual support” dimension and the SAQ teamwork climate dimension. These findings showed acceptable concurrent validity of the adapted Chinese version of the T-TPQ.

Table 4 Concurrent validity of the T-TPQ in Chinese language (n=664)

Dimensions	Pearson's correlation coefficient	
	HSOPSC	SAQ
	teamwork within units dimension	teamwork climate dimension
Team Structure	0.465**	0.446**
Leadership	0.511**	0.506**
Situation Monitoring	0.497**	0.501**
Mutual Support	0.384**	0.398**
Communication	0.360**	0.419**
T-TPQ	0.551**	0.563**

** $p < 0.01$.

Convergent and discriminant validity

In this study, convergent and discriminant validity of the T-TPQ was analyzed. The Pearson's correlation coefficients for each item with its respective dimension were satisfactory (>0.4) and showed a good convergent validity. For the discriminant validity, all items displayed a higher correlation with their respective dimensions than with other dimensions of the T-TPQ, which were satisfactory (table 5).

Table 5 Summary of the convergent and discriminant validity (n=664)

Dimensions	Pearson's correlation coefficient		Convergent validity		Discriminant validity	
	r ₁	r ₂	Success/total	Percentage (%)	Success/total	Percentage (%)
Team Structure	0.541-0.743**	0.236-0.586**	7/7	100	7/7	100
Leadership	0.632-0.741**	0.276-0.566**	7/7	100	7/7	100
Situation Monitoring	0.608-0.749**	0.331-0.486**	7/7	100	7/7	100
Mutual Support	0.571-0.655**	0.228-0.478**	7/7	100	7/7	100
Communication	0.537-0.624**	0.100-0.495*	7/7	100	7/7	100

** $p < 0.01$; * $p < 0.05$.

r₁, the correlation coefficients for each item with its respective dimension;

r₂, the correlation coefficients for each item with other dimensions of the T-TPQ.

DISCUSSION

Standardized and effective evaluation of the teamwork is critical to improve the perceived functioning of a medical team.[55,56] The results of our research showed that the Cronbach's α coefficient of the Chinese T-TPQ was 0.923. Except the communication dimension, the Cronbach's α coefficient of all dimensions were satisfactory. The T-TPQ reported a good test-retest reliability. Moreover, the construct validity of the questionnaire was satisfactory. The Chinese version of the T-TPQ showed acceptable concurrent validity, satisfactory convergent and discriminant validity.

The response rate of the current study was 83.0%, which was similar to that of the Korean study,[33] and was better than the Norwegian study.[32] All items and dimensions of the Chinese version of the T-TPQ displayed acceptable Ku and Sk coefficients, and the floor effects of all the items and dimensions were below the accepted threshold of 20%. However, in our study, several items showed significant ceiling effects. The ceiling effect of our research was understandable, as most residents felt more comfortable when their teamwork perception was good and approved by others.[44] In our study, we found that the Chinese T-TPQ had a satisfactory internal consistency, that was similar to other cross-cultural studies performed in different countries and regions, for instance, Norway, Korea, and the USA.[31-33] Our study showed that the Cronbach's α coefficient of the questionnaire was relatively high, and that the internal consistency of most dimensions was satisfactory. A good internal consistency of the questionnaire suggests that most items and dimensions measured the same concept, namely the perceptions of residents about the teamwork at their typical workplace. The satisfactory Cronbach's α coefficient values on the dimensions illustrates the high internal consistency of the total questionnaire.[57] In line with research findings among the healthcare personnel of Norway,[32] our study showed that the Chinese T-TPQ had good a test-retest reliability. In some previous studies, it was suggested that test-retest reliability can be used to evaluate the temporal fluctuations.[58] Many measurement experts suggest that, in healthcare studies, compared with internal consistency, the test-retest reliability is considered to be of more consequence.[58]

The CFA showed that the original five-dimension structures of the T-TPQ provides a generally satisfactory fit for our research data, and the result was in lines with the previous

validation study of T-TPQ.[31,32] Our results revealed that, based on the goodness-of-fit indices, the construct validity of the Chinese T-TPQ was acceptable. We found that the RMSEA index was 0.059, indicating a good fit. The model derived in this study was a better fit compared to the Norwegian study by Ballangrud *et al.*[32] (RMSEA index=0.069) and the study by Keebler *et al.*[31] (RMSEA index=0.068). The CFI (0.837) and AGFI (0.829) were slightly below the cut-off values for a satisfactory evidence of model fit. However, the literature suggests that the most effective and informative criteria is RMSEA in covariance structure modeling.[32,51] The Norwegian study by Ballangrud *et al.*[32] reported a CFI index of 0.833, which was similar to that in our study, while, the study by Keebler *et al.*[31] displayed a better CFI index (0.925). The study samples may have had an impact on the findings of these researches, and a larger sample size may have led to a better fit within this data.[59]The sample size of American study of participants from the US Army medical facilities was 1700.[31] A total of 247 healthcare personnel in different hospitals responded to the Norwegian study by Ballangrud *et al.*[32] The sample size in our research included 664 residents. The factor load of each item with its respective dimension were acceptable, except the eight items, and the path coefficients among the dimensions were also acceptable. The study of T-TPQ performed in American healthcare settings showed better factor load than that in our study.[31] Keebler *et al.* suggested that some items within T-TPQ dimensions, such as items 26 and 27 under the mutual support dimension, containing highly similar content may lead to their corrected errors, which should be modified to get the better model fit indices.[31] Overall, our results suggest that the model of the Chinese version of the T-TPQ was appropriate for the future studies in China.

Significant correlations were observed among the dimensions of the Chinese version of the T-TPQ. Significant correlations between each dimension were also revealed by the research in the America and Norway.[31,32] Our results showed that the correlation coefficient between team structure and leadership was the highest, indicating that if a medical team had a better team structure, the leadership of the team could be improved. The Norwegian study by Ballangrud *et al.*[32] revealed that the highest correlation coefficient was between the team structure and communication. The American study[31] displayed that the situation monitoring strongly correlated with the mutual support, thereby showing that the situation monitoring

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skill of health professionals could be enhanced by improving the mutual support.

Concurrent validity was shown to have significant correlations with the HSOPSC teamwork within units dimension and the SAQ teamwork climate dimension. Our study reported that the T-TPQ and its five dimensions significantly correlated with the HSOPSC teamwork within units dimension ($r=0.360-0.551$, $p<0.01$), and the SAQ teamwork climate dimension ($r=0.398-0.563$, $p<0.01$). However, the correlation with the HSOPSC teamwork within units dimension was bit lower than the findings of the validation study by the American Institutes for Research ($r=0.60-0.81$, $p<0.01$).^[28] More specifically, our study demonstrated that the convergent and discriminant validity of the Chinese T-TPQ was satisfactory. These results are important and noteworthy, because if one item reported a better correlation with one of the other dimensions, than with its initially assigned dimension, then it could be argued that this item should be modified or reassigned to the other dimension.^[60]

The strength of our study is that we provided a Chinese language version of the T-TPQ, which may act as a basis for the future studies on teamwork perception and climate in healthcare and medical education setting of China. However, there were some limitations in our study. Firstly, the respondents of the research were from only a single medical institution in China. Moreover, the findings of our study were limited by the representativeness and scale of the study population. Furthermore, the nature of the cross-sectional study hinders with an appropriate assessment of this questionnaire's sensitivity to change. Third, the factor loadings of some items were lower than the critical value, especially some items in the dimensions of "Mutual Support" and "Communication". These items may have cultural adaptability problem, which may be further studied. The Chinese version of the T-TPQ seems to be promising benchmark that is instrumental for future studies focusing on teamwork in healthcare settings in China. Further studies could enhance representativeness by expanding the respondent's diversity and sample size. Determination of teamwork perception is of clinical relevance. We thereby suggested the researchers of medical education to consider using this questionnaire for teamwork studies not only among the residents but also other healthcare professionals of China. The T-TPQ could also be used to identify interprofessional teamwork in healthcare setting, and it may suggest researchers to use this questionnaire for the relevant studies of China in the future. For future studies, the T-TPQ could be used as a

measuring tool to verify the impact of training programs related to teamwork on healthcare professionals.

CONCLUSIONS

In this study, we evaluated the psychometric properties of the T-TPQ in Chinese language. Our findings provided evidence that the T-TPQ in Chinese language is a reliable and valid questionnaire for measuring teamwork perception of the Chinese residents, and in cross-cultural comparative studies on the teamwork perception of health professionals. It can therefore be applied in teamwork training programs and medical education research.

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Contributors BQ conceived the study. JQ wrote the manuscript. YZ and JQ revised the manuscript. YZ and LC coordinated data-management. YZ, XY and JQ did the data-analysis. YZ, LY and YL contributed to reviewed the manuscript. All authors read and approved the final manuscript.

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Competing interests None declared.

Provenance and peer review Commissioned; externally peer reviewed.

Ethics Approval The study was approved by the Bioethics Advisory Commission of China Medical University.

Data sharing statement All data from the current study were reported in the manuscript. Participant-level data are not publicly available due to ethical and legal obligations to the participants in the study. Data are available upon request to the corresponding author and with permission of the local ethics committee.

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40 Figure 1. Overview of the structure of the Chinese version of the T-TPQ based on
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42 confirmatory factor analysis. The results of CFA demonstrated that the construct validity of
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44 the Chinese version of T-TPQ was satisfactory.

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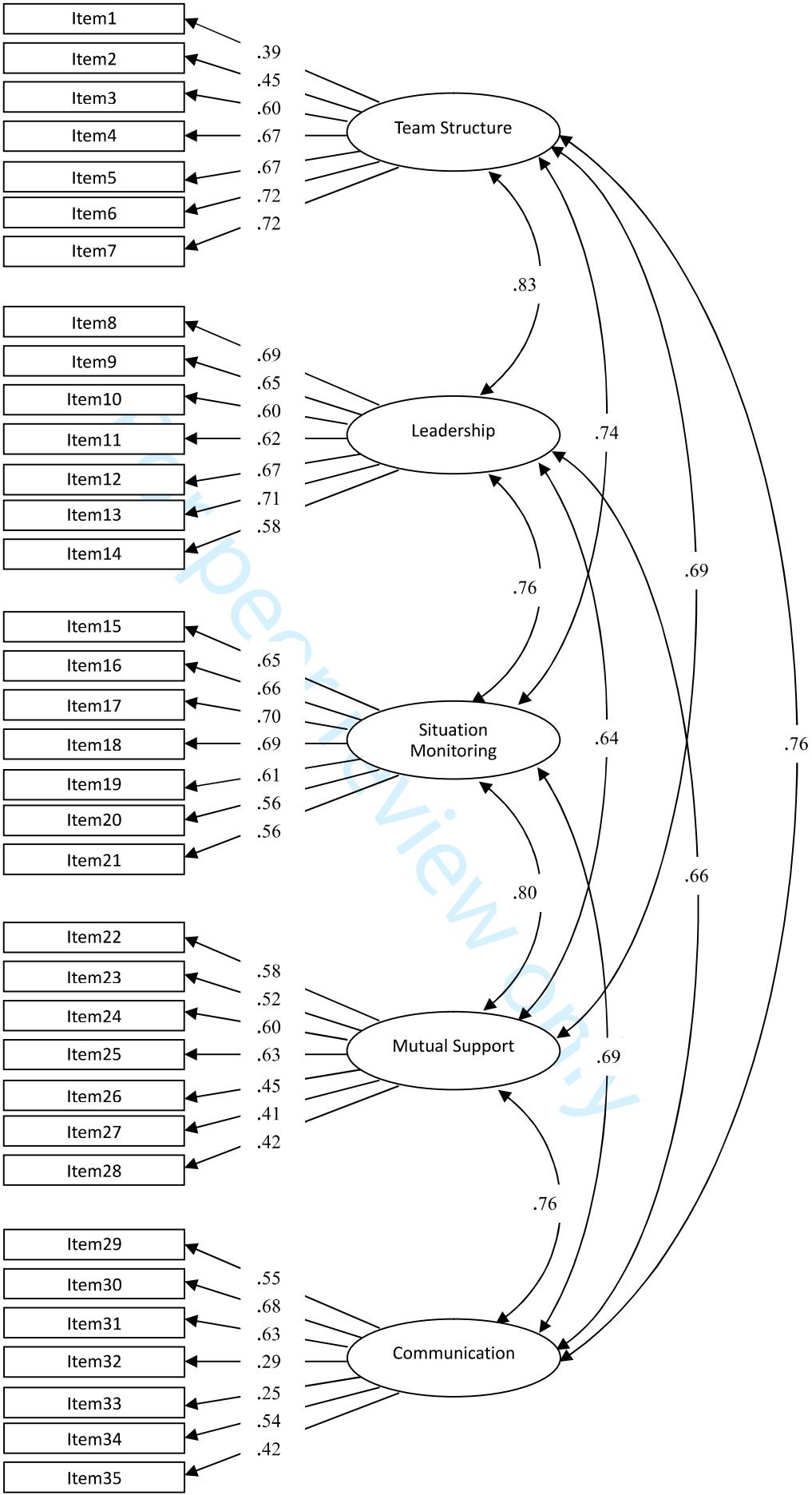


Figure 1. Overview of the structure of the Chinese version of the T-TPQ based on confirmatory factor analysis.

Supplemental Material 1. The score of the T-TPQ among Chinese residents.

Items and dimensions	Mean \pm SD
T-TPQ	4.10 \pm 0.37
Team Structure	4.24 \pm 0.44
1. The skills of staff overlap sufficiently so that work can be shared when necessary.	4.09 \pm 0.67
2. Staff are held accountable for their actions.	4.45 \pm 0.55
3. Staff within my unit share information that enables timely decision making by the direct patient care team.	4.23 \pm 0.65
4. My unit makes efficient use of resources (e.g., staff supplies, equipment, information).	4.16 \pm 0.73
5. Staff understand their roles and responsibilities.	4.26 \pm 0.65
6. My unit has clearly articulated goals.	4.28 \pm 0.67
7. My unit operates at a high level of efficiency.	4.22 \pm 0.68
Leadership	4.17 \pm 0.50
8. My supervisor/manager considers staff input when making decisions about patient care.	4.19 \pm 0.71
9. My supervisor/manager provides opportunities to discuss the unit's performance after an event.	3.98 \pm 0.81
10. My supervisor/manager takes time to meet with staff to develop a plan for patient care.	4.17 \pm 0.71
11. My supervisor/manager ensures that adequate resources (e.g., staff, supplies, equipment, information) are available.	4.12 \pm 0.75
12. My supervisor/manager resolves conflicts successfully.	4.32 \pm 0.65
13. My supervisor/manager models appropriate team behavior.	4.31 \pm 0.66
14. My supervisor/manager ensures that staff are aware of any situations or changes that may affect patient care.	4.06 \pm 0.69
Situation Monitoring	4.09 \pm 0.48
15. Staff effectively anticipate each other's needs.	3.78 \pm 0.78
16. Staff monitor each other's performance.	3.87 \pm 0.74
17. Staff exchange relevant information as it becomes available.	4.16 \pm 0.66
18. Staff continuously scan the environment for important information.	4.07 \pm 0.68
19. Staff share information regarding potential complications (e.g., patient changes, bed availability).	4.20 \pm 0.67
20. Staff meets to reevaluate patient care goals when aspects of the situation have changed.	4.31 \pm 0.65
21. Staff correct each other's mistakes to ensure that procedures are followed properly.	4.24 \pm 0.64
Mutual Support	3.95 \pm 0.45
22. Staff assist fellow staff during high workload.	4.26 \pm 0.67
23. Staff request assistance from fellow staff when they feel overwhelmed.	4.15 \pm 0.65
24. Staff caution each other about potentially dangerous situations.	4.26 \pm 0.66

25. Feedback between staff is delivered in a way that promotes positive interactions and future change.	4.24±0.70
26. Staff advocate for patients even when their opinion conflicts with that of a senior member of the unit.	3.38±0.86
27. When staff have a concern about patient safety, they challenge others until they are sure the concern has been heard.	3.83±0.76
28. Staff resolve their conflicts, even when the conflicts have become personal.	3.50±0.86
Communication	4.02±0.43
29. Information regarding patient care is explained to patients and their families in lay term.	4.41±0.61
30. Staff relay relevant information in a timely manner.	4.33±0.58
31. When communicating with patients, staff allow enough time for questions.	4.15±0.71
32. Staff use common terminology when communicating with each other.	3.86±0.92
33. Staff verbally verify information that they receive from one another.	3.39±0.94
34. Staff follow a standardized method of sharing information when handing off patients.	4.15±0.64
35. Staff seek information from all available sources.	3.87±0.83

STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation	Page No
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	2
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	3,4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4,5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6,7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6,7
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7
Bias	9	Describe any efforts to address potential sources of bias	6
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7,8
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7,8
		(b) Describe any methods used to examine subgroups and interactions	7,8
		(c) Explain how missing data were addressed	7
		(d) If applicable, describe analytical methods taking account of sampling strategy	7,8
		(e) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8,9
		(b) Give reasons for non-participation at each stage	6,8
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8,9
		(b) Indicate number of participants with missing data for each variable of interest	8,9
Outcome data	15*	Report numbers of outcome events or summary measures	8-13
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-13

		(b) Report category boundaries when continuous variables were categorized	N/A
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11
Discussion			
Key results	18	Summarise key results with reference to study objectives	14,15,16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14,15,16
Generalisability	21	Discuss the generalisability (external validity) of the study results	16,17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	17

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Psychometric properties of the Chinese version of the TeamSTEPPS teamwork perceptions questionnaire to measure teamwork perceptions of Chinese residents: a cross-sectional study

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ABSTRACT

Objectives The purpose of this research was to evaluate the psychometric properties of the TeamSTEPPS Teamwork Perception Questionnaire (T-TPQ) among the Chinese residents.

Design Cross-sectional study.

Setting A clinical hospital of the China Medical University in Liaoning Province, China.

Participants A total of 664 residents were enrolled in this research. The valid response rate was 83.0% (664 of 800 residents).

Main outcome measures Internal consistency and test–retest reliability were used to assess the reliability of the questionnaire. The construct validity of the Chinese T-TPQ was evaluated by confirmatory factor analysis. Furthermore, the concurrent, convergent, and discriminant validity were analyzed.

Results Cronbach’s alpha coefficient of the T-TPQ in Chinese language was 0.923. Except for the communication dimension (0.649), the Cronbach’s alpha coefficient of all dimensions were satisfactory. The T-TPQ and its five dimensions reported a good test–retest reliability (0.740–0.881, $p<0.01$). Moreover, the results of the confirmatory factor analysis demonstrated that the construct validity of the Chinese T-TPQ was satisfactory. All dimensions significantly correlated with the Hospital Survey on Patient Safety Culture (HSOPSC) teamwork within units dimension and the Safety Attitudes Questionnaire (SAQ) teamwork climate dimension ($p<0.01$), and the questionnaire showed satisfactory convergent and discriminant validity.

Conclusions The T-TPQ in Chinese language demonstrated good psychometric characteristics and was a reliable and valid questionnaire to measure the Chinese health professionals’ perception of teamwork. Thus, the Chinese version of the T-TPQ could be applied in teamwork training programs and medical education research.

Keywords Teamwork, Questionnaire, Cross-cultural validation, Healthcare quality, Patient safety

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Strengths and limitations of this study

- ▶ To our knowledge, this is the first study to translate and validate the T-TPQ questionnaire in China.
- ▶ In our study, we used international standards to examine the psychometric properties of the Chinese version of the T-TPQ.
- ▶ This study provides a benchmarked instrument, which may act as a basis for future studies on teamwork perception in Chinese medical education.
- ▶ This study was conducted only in one university hospital, therefore study population may not be representative of all the Chinese health professionals.

INTRODUCTION

Teamwork is important for improving healthcare quality and increasing patient safety. Effective teamwork in healthcare not only augments patient's satisfaction but also decreases burnout among the health professionals.[1-4] The Agency for Healthcare Research and Quality (AHRQ), the Joint Commission, and other institutions ranked teamwork as a dominant factor for enhancing the healthcare quality.[5,6] Furthermore, teamwork has been classified as an important competency to help optimize the healthcare services, and poor teamwork could increase the medical errors and reduce patient safety.[7-11] As there is great need in improving patient safety and healthcare quality, team training has been widely recognized to enhance teamwork.[12-15] However, health professionals today are not competent in teamwork, and team training has not attracted the attention of medical institutions.[16-18] The Chinese Hospital Association has reported that, adverse patient events consumes extensive medical resources every year in Chinese healthcare institutions.[19,20] Therefore, cultivating teamwork competency in healthcare professionals has become a crucial and urgent factor for improving the patient safety in China.

Evaluation of competency of health professionals' in teamwork has proven to be important in both, team training and medical education [21,22], and an inaccurate evaluation may lead to unreliable conclusions.[23] Teamwork evaluation is recommend as a key process in

residency training.[24] For the past few years, much research has been conducted on evaluating the perceptions of health professionals to better understand their teamwork competency. Therefore, a good measuring tool is especially important to evaluate teamwork perceptions of the health professionals.[25-27] The TeamSTEPPS Teamwork Perception Questionnaire (T-TPQ), is one of the most frequently applied tools used for such evaluation. It is a self-report questionnaire, which evaluates perceptions of a healthcare professional on group-level teamwork situation in a medical team.[28]

The T-TPQ was developed by American Institutes for Research developed in year 2010.[28] When considering the importance of teamwork in healthcare and medical education, the AHRQ developed the TeamSTEPPS. TeamSTEPPS is a teamwork training course and framework which is useful for improving quality of healthcare and reducing medical errors.[29,30] The T-TPQ was based on the five important teamwork factors of the TeamSTEPPS, including team structure dimension, leadership dimension, situation monitoring dimension, mutual support dimension, and communication dimension. The questionnaire was cross-culturally validated in different countries and languages, including the United States of America,[31] Norway,[32] Korea,[33] Brazil,[34] and Scotland,[35] among others. Furthermore, the T-TPQ has shown to be reliable and valid tool among the physicians, nurses, medical students, residents, and pharmacists.[31-35] All versions of the T-TPQ contains the same content, with minor modifications to reflect the clinical practices.

The T-TPQ in Chinese language was translated by our research team.[36] In adapting to the Chinese version, we followed the process of translation and adaptation as suggested by WHO guidelines for validation of the scale.[37] In this the main steps were: forward translation, specialist review, back-translation, pre-testing, cognitive interviewing, and formation of the questionnaire. So far, no research had used the questionnaire in healthcare professionals of China, therefore, the psychometric properties of the Chinese T-TPQ have not yet been assessed. The purpose of this research was to evaluate the psychometric properties of the T-TPQ among the Chinese residents. The results of our research may be useful to fully understand the teamwork perception of residents and other healthcare professionals in China. Further, the findings of this research may be helpful to other countries in developing the T-TPQ for their medical institutions and healthcare professionals.

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METHODS

Ethics statement

This study was based on the data of teamwork perception of the Chinese residents. All participants provided written informed consent and participation was voluntary and confidential. We acquired permissions from the developer of the questionnaire to make cross-cultural translation and adaptation of the T-TPQ. The study was approved by the Bioethics Advisory Commission of China Medical University, Shenyang, China.

Participants and procedures

For this study, 800 residents from three grades were recruited, and the study was conducted between June 2018 and October 2018 at a clinical hospital of the China Medical University, Shenyang, China. The training program of Chinese residents typically lasts for about 3 years, during which, young residents acquire the knowledge and skills of their specialties or subspecialties, and develop attitudes, behaviors, habits, and values that are helpful for their subsequent professional life. Most studies and assessments are based on the clinical context.

The paper version of the questionnaires were handed out to the residents on-site, and each participant completed a self-administered questionnaire. Every questionnaire was coded by number (e.g. 1, 2, 3) after participants submitting their questionnaire. Experienced researchers then checked the questionnaires and verified if there were any invalid/incomplete questionnaires. A questionnaire was deemed as invalid if more than 20% of the data was missing. Of the 800 residents, 664 completed the questionnaire, the valid response rate was 83.0%. The study size was based on the item per participant ratio of 1:10 principle.[38] A previous study reported that the sample size to evaluate test-retest reliability coefficient was 52. [39] In our study, a total of 72 respondents were randomly selected to answer the questionnaire, and again after two weeks 60 among them completed the questionnaire.

Measures

The questionnaire comprised of four parts including basic information (gender, age, marital status, grade, and monthly income), the Chinese version of the T-TPQ, the HSOPSC [40], and

the SAQ.[41] The T-TPQ assessed the respondents’ perception of group-level teamwork competency in a department, and it consisted of 35 items in five dimensions namely—teamwork structure, leadership, situation monitoring, mutual support, and communication. Each dimension contained 7 items, the response to which were given on a five-point Likert scale (1=disagree strongly to 5=agree strongly). The T-TPQ and its dimension scores were computed to an average score.[28]

The HSOPSC and the SAQ are generic scales for patient’s safety measurement that are reliable and valid to evaluate a hospital’s teamwork and patient safety.[42,43] The HSOPSC consists of 42 items in twelve dimensions, and the SAQ consists of 36 items in six dimensions. A dimension of the HSOPSC (teamwork within units dimension) and a dimension of the SAQ (teamwork climate dimension) were used to test the concurrent validity in this study. The two dimensions were scored on a five-point Likert scale (ranging from 1=disagree strongly to 5=agree strongly). The reliability of these two dimensions were found to be satisfactory (Cronbach’s α coefficients were 0.891 and 0.909, respectively).

Statistical analysis

Twenty-four missing data distributed in 18 respondents. To satisfy the requirements of the study, each item’ missing data was replaced by the median value of all item scores in the relevant dimension.[32] Descriptive statistics (mean, standard deviation (SD), skewness (Sk), kurtosis (Ku), floor and ceiling effects) were performed on all items and dimensions in the Chinese version of the T-TPQ. The absolute values of Sk and Ku higher than 3 and 10, respectively, showed a significant deviance from a normal subjects distribution.[38,44,45] If the percentage of items with the lowest or the highest score was more than 20%, floor or ceiling effects were considered as significant. In our study, the Cronbach’s α coefficient was computed to evaluate the internal consistency of the T-TPQ. The internal consistency was deemed to be acceptable when the Cronbach’s α coefficient value was higher than 0.7.[46-48] The test-retest reliability was evaluated by the Intraclass Correlation Coefficient (ICC) with the Two-Way Random model. If the ICC was higher than 0.7, the test–retest reliability was considered satisfactory.[49]

Regarding construct validity, the original five-factor model of the T-TPQ was tested using

a confirmatory factor analysis (CFA). CFA is a robust method of statistical analysis to test a predetermined factor structure or a hypothetical theory, and it can describe how well each item evaluates the measure's dimensionality. In many studies, it has been suggested that the CFA is very important for scales that have been culturally adapted.[50,51] The goodness of fit was assessed through the following indicators: the chi-square goodness of fit (χ^2), the root mean square error of approximation (RMSEA), the comparative fit index (CFI), and the adjusted goodness-of-fit index (AGFI); among which the RMSEA was considered as the best index.[32,51] If the RMSEA was below 0.08, and the CFI was higher than 0.90, we deemed that it was a good fit. An AGFI value higher than 0.85 was deemed a satisfactory model fit.[50] The correlations between each dimension of the T-TPQ were evaluated by computing the Pearson's correlation coefficient.

To test the concurrent validity, the Pearson's correlation analysis of T-TPQ with the HSOPSC teamwork within the units dimension and the SAQ teamwork climate dimension was conducted. Regarding convergent and discriminant validity, we only used the T-TPQ for this analysis. A Pearson's correlation coefficient of >0.4 for an item with its respective dimension indicated satisfactory convergent validity.[52,53] Items showing lower correlations with other dimensions than those with their respective dimensions showed satisfactory discriminant validity.[54] In this research, we used SPSS 20.0, AMOS 21.0 software of the Windows. A p -value <0.05 was defined to be statistically significant.

Patient and public involvement statement

Patients or the public were not involved in the design, conduct or the analysis of our research.

RESULTS

Characteristics of respondents

The valid response rate of the overall research was 83.0% (664/800) and that of retest was 83.3% (60/72). The average age of the respondents was 25.83 years (SD=1.61). Most respondents were female and more than half of the participants were urban residents. The sociodemographic characteristics of responders has been summarized in Table 1.

Table 1 Basic characteristics of respondents (n=664)

Characteristic	Number	Percentage (%)
Gender		
Male	228	34.3
Female	436	65.7
Age		
≤25 years old	312	47.0
>25 years old	352	53.0
Residence		
Urban	429	64.6
Rural	235	35.4
Grade		
One	205	30.9
Two	266	40.0
Three	193	29.1
Marital status		
Married	34	5.1
Unmarried	630	94.9
Monthly income (Yuan)		
≤1000	156	23.5
1001-2000	494	74.4
2001-3000	14	2.1
Region		
Eastern China	425	64.0
Central China	154	23.2
Western China	85	12.8

The mean of the T-TPQ among the Chinese residents was 4.10±0.37. Regarding dimensions, the team structure dimension had the highest score (4.24±0.44), while the mutual support dimension had the lowest score (3.95±0.45). The score of the T-TPQ were as shown

in Supplemental Material 1. All items and dimensions displayed acceptable Sk (1.02 to -0.07) and Ku (-0.38 to 3.53) coefficients. No significant floor effects were observed in all items and dimensions. None of the dimensions showed significant ceiling effects. However, most items displayed significant ceiling effects, except for items 15, 16, 26, 27, 28, and 33.

Reliability

The internal consistency of the overall T-TPQ was excellent. All dimensions had satisfactory internal consistency, except the communication dimension, which was slightly below the acceptable internal consistency coefficient (0.700). The split-half reliability coefficient for the total T-TPQ was satisfactory (0.843). Additionally, the test-retest reliability of the Chinese T-TPQ was satisfactory, and the ICC of all dimensions was good. These results are shown in Table 2.

Table 2 Reliability of the T-TPQ in Chinese language

Dimensions	Cronbach's α coefficient	
	(n=664)	ICC (95%CI) (n=60)
Team Structure	0.801	0.877 (0.749-0.948)**
Leadership	0.831	0.749 (0.507-0.917)**
Situation Monitoring	0.820	0.740 (0.530-0.908)**
Mutual Support	0.720	0.849 (0.702-0.932)**
Communication	0.649	0.745 (0.449-0.910)**
T-TPQ	0.923	0.881 (0.783-0.945)**

** $p < 0.01$.

Construct validity

In this study, the CFA was performed to test the five-factor model, which displayed an acceptable fit with the data ($\chi^2=1815.176$, $df=550$, $p < 0.001$; CFI=0.837; RMSEA=0.059 [90% CI: 0.056 to 0.062]; and AGFI=0.829). Except for the eight items (items 1, 2, 26, 27, 28, 32, 33 and 35), all other items had an acceptable factor load with its respective dimension (factor load > 0.5), and the path coefficients between each dimension was acceptable, as

displayed in Figure 1.

Correlations among the dimensions of the questionnaire

The Chinese version of the T-TPQ showed significant correlation between each dimension of the questionnaire. The correlations among the dimensions of the questionnaire were determined by the Pearson’s correlation coefficient and are shown in Table 3.

Table 3 Correlations among the dimensions of the T-TPQ in Chinese language (n=664)

Dimensions	Team		Situation	Mutual	
	Structure	Leadership	Monitoring	Support	Communication
Team Structure	—	0.667**	0.625**	0.517**	0.565**
Leadership		—	0.641**	0.495**	0.474**
Situation Monitoring			—	0.619**	0.548**
Mutual Support				—	0.532**
Communication					—

**p<0.01.

Concurrent validity

The correlation coefficients of the T-TPQ with the HSOPSC teamwork within units dimension and the SAQ teamwork climate dimension were as shown in Table 4. The total questionnaire and its five dimensions significantly correlated with the two subscales. All the correlation coefficients were higher than 0.40, except the association between “mutual support”, “communication” dimension, and the HSOPSC teamwork within units dimension, and the association between the “mutual support” dimension and the SAQ teamwork climate dimension. These findings showed acceptable concurrent validity of the adapted Chinese version of the T-TPQ.

Table 4 Concurrent validity of the T-TPQ in Chinese language (n=664)

Dimensions	Pearson's correlation coefficient	
	HSOPSC	SAQ
	teamwork within units dimension	teamwork climate dimension
Team Structure	0.465**	0.446**
Leadership	0.511**	0.506**
Situation Monitoring	0.497**	0.501**
Mutual Support	0.384**	0.398**
Communication	0.360**	0.419**
T-TPQ	0.551**	0.563**

** $p < 0.01$.

Convergent and discriminant validity

In this study, convergent and discriminant validity of the T-TPQ was analyzed. The Pearson's correlation coefficients for each item with its respective dimension were satisfactory (>0.4) and showed a good convergent validity. For the discriminant validity, all items displayed a higher correlation with their respective dimensions than with other dimensions of the T-TPQ, which were satisfactory (Table 5).

Table 5 Summary of the convergent and discriminant validity (n=664)

Dimensions	Pearson's correlation coefficient		Convergent validity		Discriminant validity	
	r ₁	r ₂	Success/total	Percentage (%)	Success/total	Percentage (%)
Team Structure	0.541-0.743**	0.236-0.586**	7/7	100	7/7	100
Leadership	0.632-0.741**	0.276-0.566**	7/7	100	7/7	100
Situation Monitoring	0.608-0.749**	0.331-0.486**	7/7	100	7/7	100
Mutual Support	0.571-0.655**	0.228-0.478**	7/7	100	7/7	100
Communication	0.537-0.624**	0.100-0.495*	7/7	100	7/7	100

** $p < 0.01$; * $p < 0.05$.

r₁, the correlation coefficients for each item with its respective dimension;

r₂, the correlation coefficients for each item with other dimensions of the T-TPQ.

DISCUSSION

Standardized and effective evaluation of the teamwork is critical to improve the perceived functioning of a medical team.[55,56] The results of our research showed that the Cronbach's α coefficient of the Chinese T-TPQ was 0.923. Except the communication dimension, the Cronbach's α coefficient of all dimensions were satisfactory. The T-TPQ reported a good test-retest reliability. Moreover, the construct validity of the questionnaire was satisfactory. The Chinese version of the T-TPQ showed acceptable concurrent validity, satisfactory convergent and discriminant validity.

The response rate of the current study was 83.0%, which was similar to that of the Korean study,[33] and was better than the Norwegian study.[32] All items and dimensions of the Chinese version of the T-TPQ displayed acceptable Ku and Sk coefficients, and the floor effects of all the items and dimensions were below the accepted threshold of 20%. However, in our study, several items showed significant ceiling effects. The ceiling effect of our research was understandable, as most residents felt more comfortable when their teamwork perception was good and approved by others.[44] In our study, we found that the Chinese T-TPQ had a satisfactory internal consistency, that was similar to other cross-cultural studies performed in different countries and regions, for instance, Norway, Korea, and the USA.[31-33] Our study showed that the Cronbach's α coefficient of the questionnaire was relatively high, and that the internal consistency of most dimensions was satisfactory. A good internal consistency of the questionnaire suggests that most items and dimensions measured the same concept, namely the perceptions of residents about the teamwork at their typical workplace. The satisfactory Cronbach's α coefficient values on the dimensions illustrates the high internal consistency of the total questionnaire.[57] In line with research findings among the healthcare personnel of Norway,[32] our study showed that the Chinese T-TPQ had good a test-retest reliability. In some previous studies, it was suggested that test-retest reliability can be used to evaluate the temporal fluctuations.[58] Many measurement experts suggest that, in healthcare studies, compared with internal consistency, the test-retest reliability is considered to be of more significance.[58]

The CFA showed that the original five-dimension structures of the T-TPQ provides a generally satisfactory fit for our research data, and the result was in lines with the previous

validation study of T-TPQ.[31,32] Our results revealed that, based on the goodness-of-fit indices, the construct validity of the Chinese T-TPQ was acceptable. We found that the RMSEA index was 0.059, indicating a good fit. The model derived in this study was a better fit compared to the Norwegian study by Ballangrud *et al.*[32] (RMSEA index=0.069) and the study by Keebler *et al.*[31] (RMSEA index=0.068). The CFI (0.837) and AGFI (0.829) were slightly below the cut-off values for a satisfactory evidence of model fit. However, the literature suggests that the most effective and informative criteria is RMSEA in covariance structure modeling.[32,51] The Norwegian study by Ballangrud *et al.*[32] reported a CFI index of 0.833, which was similar to that in our study, while, the study by Keebler *et al.*[31] displayed a better CFI index (0.925). The study samples may have had an impact on the findings of these researches, and a larger sample size may have led to a better fit within this data.[59]The sample size of American study of participants from the US Army medical facilities was 1700.[31] A total of 247 healthcare personnel in different hospitals responded to the Norwegian study by Ballangrud *et al.*[32] The sample size in our research included 664 residents. The factor load of each item with its respective dimension were acceptable, except the eight items (items 1, 2, 26, 27, 28, 32, 33 and 35), and the path coefficients among the dimensions were also acceptable. The study of T-TPQ performed in American healthcare settings showed better factor load than that in our study.[31] Keebler *et al.* suggested that some items within T-TPQ dimensions, such as items 26 and 27 under the mutual support dimension, containing highly similar content may lead to their corrected errors, which should be modified to get the better model fit indices.[31] Overall, our results suggest that the model of the Chinese version of the T-TPQ was appropriate for the future studies in China.

Significant correlations were observed among the dimensions of the Chinese version of the T-TPQ. Significant correlations between each dimension were also revealed by the research in the America and Norway.[31,32] Our results showed that the correlation coefficient between team structure and leadership was the highest, indicating that if a medical team had a better team structure, the leadership of the team could be improved. The Norwegian study by Ballangrud *et al.*[32] revealed that the highest correlation coefficient was between the team structure and communication. The American study[31] displayed that the situation monitoring strongly correlated with the mutual support, thereby showing that the situation monitoring

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skill of health professionals could be enhanced by improving the mutual support.

Concurrent validity was shown to have significant correlations with the HSOPSC teamwork within units dimension and the SAQ teamwork climate dimension. Our study reported that the T-TPQ and its five dimensions significantly correlated with the HSOPSC teamwork within units dimension ($r=0.360-0.551$, $p<0.01$), and the SAQ teamwork climate dimension ($r=0.398-0.563$, $p<0.01$). However, the correlation with the HSOPSC teamwork within units dimension was bit lower than the findings of the validation study by the American Institutes for Research ($r=0.60-0.81$, $p<0.01$).^[28] More specifically, our study demonstrated that the convergent and discriminant validity of the Chinese T-TPQ was satisfactory. These results are important and noteworthy, because if one item reported a better correlation with one of the other dimensions, than with its initially assigned dimension, then it could be argued that this item should be modified or reassigned to the other dimension.^[60]

The strength of our study is that we provided a Chinese language version of the T-TPQ, which may act as a basis for the future studies on teamwork perception and climate in healthcare and medical education setting of China. However, there were some limitations in our study. Firstly, the respondents of the research were from only a single medical institution in China. Moreover, the findings of our study were limited by the representativeness and scale of the study population. Furthermore, the nature of the cross-sectional study hinders with an appropriate assessment of this questionnaire's sensitivity to change. Third, the factor loadings of some items were lower than the critical value, especially some items in the dimensions of "Mutual Support" and "Communication". These items may have cultural adaptability problem, which may be further studied. The Chinese version of the T-TPQ seems to be promising benchmark that is instrumental for future studies focusing on teamwork in healthcare settings in China. Further studies could enhance representativeness by expanding the respondent's diversity and sample size. Determination of teamwork perception is of clinical relevance. We thereby suggested the researchers of medical education to consider using this questionnaire for teamwork studies not only among the residents but also other healthcare professionals of China. The T-TPQ could also be used to identify interprofessional teamwork in healthcare setting, and it may suggest researchers to use this questionnaire for the relevant studies of China in the future. For future studies, the T-TPQ could be used as a

measuring tool to verify the impact of training programs related to teamwork on healthcare professionals.

CONCLUSIONS

In this study, we evaluated the psychometric properties of the T-TPQ in Chinese language. Our findings provided evidence that the T-TPQ in Chinese language is a reliable and valid questionnaire for measuring teamwork perception of the Chinese residents, and in cross-cultural comparative studies on the teamwork perception of health professionals. It can therefore be applied in teamwork training programs and medical education research.

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Contributors BQ conceived the study. JQ wrote the manuscript. YZ and JQ revised the manuscript. YZ and LC coordinated data-management. YZ, XY and JQ did the data-analysis. YZ, LY and YL contributed to reviewed the manuscript. All authors read and approved the final manuscript.

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Provenance and peer review Commissioned; externally peer reviewed.

Ethics Approval The study was approved by the Bioethics Advisory Commission of China Medical University.

Data sharing statement All data from the current study were reported in the manuscript. Participant-level data are not publicly available due to ethical and legal obligations to the participants in the study. Data are available upon request to the corresponding author and with permission of the local ethics committee.

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40 Figure 1. Overview of the structure of the Chinese version of the T-TPQ based on
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42 confirmatory factor analysis. The results of CFA demonstrated that the construct validity of
43
44 the Chinese version of T-TPQ was satisfactory.

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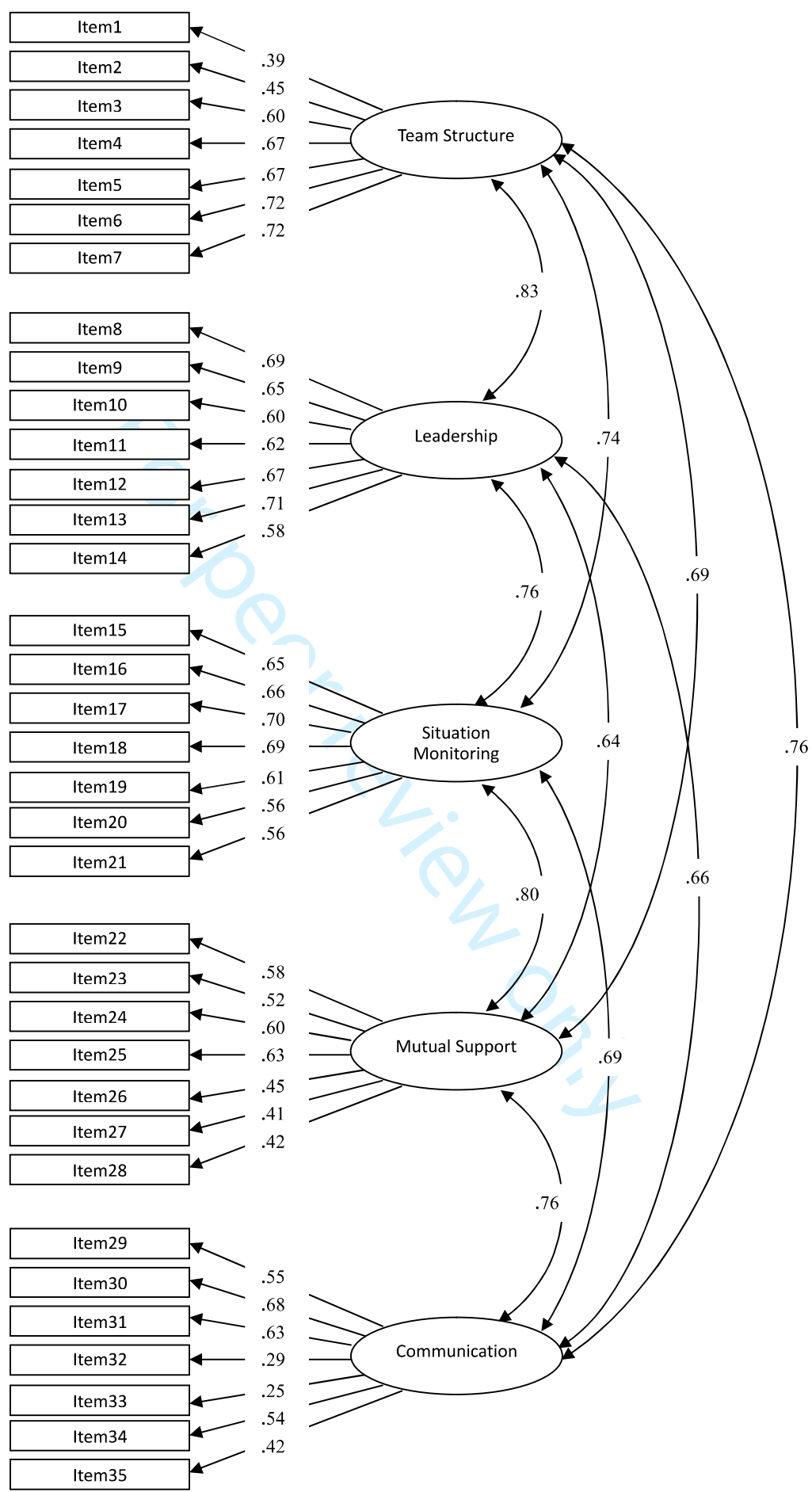


Figure 1. Overview of the structure of the Chinese version of the T-TPQ based on confirmatory factor analysis.

Supplemental Material 1. The score of the T-TPQ among Chinese residents.

Items and dimensions	Mean \pm SD
T-TPQ	4.10 \pm 0.37
Team Structure	4.24 \pm 0.44
1. The skills of staff overlap sufficiently so that work can be shared when necessary.	4.09 \pm 0.67
2. Staff are held accountable for their actions.	4.45 \pm 0.55
3. Staff within my unit share information that enables timely decision making by the direct patient care team.	4.23 \pm 0.65
4. My unit makes efficient use of resources (e.g., staff supplies, equipment, information).	4.16 \pm 0.73
5. Staff understand their roles and responsibilities.	4.26 \pm 0.65
6. My unit has clearly articulated goals.	4.28 \pm 0.67
7. My unit operates at a high level of efficiency.	4.22 \pm 0.68
Leadership	4.17 \pm 0.50
8. My supervisor/manager considers staff input when making decisions about patient care.	4.19 \pm 0.71
9. My supervisor/manager provides opportunities to discuss the unit's performance after an event.	3.98 \pm 0.81
10. My supervisor/manager takes time to meet with staff to develop a plan for patient care.	4.17 \pm 0.71
11. My supervisor/manager ensures that adequate resources (e.g., staff, supplies, equipment, information) are available.	4.12 \pm 0.75
12. My supervisor/manager resolves conflicts successfully.	4.32 \pm 0.65
13. My supervisor/manager models appropriate team behavior.	4.31 \pm 0.66
14. My supervisor/manager ensures that staff are aware of any situations or changes that may affect patient care.	4.06 \pm 0.69
Situation Monitoring	4.09 \pm 0.48
15. Staff effectively anticipate each other's needs.	3.78 \pm 0.78
16. Staff monitor each other's performance.	3.87 \pm 0.74
17. Staff exchange relevant information as it becomes available.	4.16 \pm 0.66
18. Staff continuously scan the environment for important information.	4.07 \pm 0.68
19. Staff share information regarding potential complications (e.g., patient changes, bed availability).	4.20 \pm 0.67
20. Staff meets to reevaluate patient care goals when aspects of the situation have changed.	4.31 \pm 0.65
21. Staff correct each other's mistakes to ensure that procedures are followed properly.	4.24 \pm 0.64
Mutual Support	3.95 \pm 0.45
22. Staff assist fellow staff during high workload.	4.26 \pm 0.67
23. Staff request assistance from fellow staff when they feel overwhelmed.	4.15 \pm 0.65
24. Staff caution each other about potentially dangerous situations.	4.26 \pm 0.66

25. Feedback between staff is delivered in a way that promotes positive interactions and future change.	4.24±0.70
26. Staff advocate for patients even when their opinion conflicts with that of a senior member of the unit.	3.38±0.86
27. When staff have a concern about patient safety, they challenge others until they are sure the concern has been heard.	3.83±0.76
28. Staff resolve their conflicts, even when the conflicts have become personal.	3.50±0.86
Communication	4.02±0.43
29. Information regarding patient care is explained to patients and their families in lay term.	4.41±0.61
30. Staff relay relevant information in a timely manner.	4.33±0.58
31. When communicating with patients, staff allow enough time for questions.	4.15±0.71
32. Staff use common terminology when communicating with each other.	3.86±0.92
33. Staff verbally verify information that they receive from one another.	3.39±0.94
34. Staff follow a standardized method of sharing information when handing off patients.	4.15±0.64
35. Staff seek information from all available sources.	3.87±0.83

STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation	Page No
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	2
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	3,4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4,5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6,7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6,7
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7
Bias	9	Describe any efforts to address potential sources of bias	6
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7,8
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7,8
		(b) Describe any methods used to examine subgroups and interactions	7,8
		(c) Explain how missing data were addressed	7
		(d) If applicable, describe analytical methods taking account of sampling strategy	7,8
		(e) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8,9
		(b) Give reasons for non-participation at each stage	6,8
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8,9
		(b) Indicate number of participants with missing data for each variable of interest	8,9
Outcome data	15*	Report numbers of outcome events or summary measures	8-13
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-13

		(b) Report category boundaries when continuous variables were categorized	N/A
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11
Discussion			
Key results	18	Summarise key results with reference to study objectives	14,15,16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14,15,16
Generalisability	21	Discuss the generalisability (external validity) of the study results	16,17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	17

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.