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Team interaction of tertiary hospital physicians: Preliminary psychometrics and influencing factors: A cross-sectional study in China

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ABSTRACT

Objectives

To conduct the cross-culturally adaptation of the Team Interaction Scale (TIS), to test its psychometric properties, and to investigate team interaction's influencing factors in Chinese tertiary hospital physician population.

Design

Cross-sectional survey

Settings

Two round surveys (the pilot and large sampling survey) were conducted in two and nine tertiary hospitals in Liaoning Province, China, respectively.

Participants

Altogether 364 out of 390 physicians sampled were included in the analysis of pilot survey, resulting an effective response rate of 93.33%. In the large sampling survey, the effective response rate was 89.88% (3,685 among 4,100 physicians).

Outcome measures

The TIS and a short version of burnout scale were administrated to assess physician's team interaction and burnout. Psychometric properties of TIS were tested by confirmatory factor analysis (CFA), expletory factor analysis (EFA) and internal consistency analysis. Gender, age, discipline, education level, hospital scale and burnout were explored as influencing factors with independent sample *t*-tests, one-way ANOVAs and a correlation analysis.

Results

In the pilot survey, a 17-item modified scale was developed based on CFA. In the large sampling survey, EFA was conducted with half of the samples and six dimensions emerged ("Communication", "Coordination", "Mutual help", "Team goals", "Work norms", and "Cohesion and conflict resolution"), which was slightly different from the original structure. The fitness of the modified structure was confirmed by CFA with another half of the samples (RMSEA=0.07, CFI=0.98, NFI=0.97, GFI=0.94, AGFI=0.91). The high Cronbach's α coefficient, 0.98, demonstrated the reliability of the modified scale. The team interaction score was significantly lower in male, younger, paediatrics, or larger scale tertiary hospitals' physicians, and was negatively associated with burnout.

Conclusions

The adapted TIS containing 17 items and six dimensions is reliable and valid in Chinese tertiary hospital physicians. The environment of team interaction should be paid attention in the addressment of physician burnout.

Keywords

Team interaction; Scale; Physician; Burnout; Chinese

ARTICAL SUMMARY

Strengths and limitations of this study

- This is the first study, to the best of our knowledge, to introduce a comprehensive dimension structure to assess physician team interaction, with a sufficient and representative sample in China.
- This study extended the research on physicians' teamwork by identifying the potential influential factors, and could provide empirical research evidence for the team reform.
- The design of this two-round surveys study ensured the validity and convinces of the results.
- The team interaction evaluation was self-reported, which may be subject to reporting bias.
- This study was a cross-sectional study, so, the causality relationships between team interaction and the influencing factors were not clear.

BACKGROUND

Teamwork has been confirmed to be fundamental to team efficiency, physician well-being, and patient safety, and it is generally acknowledged as the core of patient-centred medical reform[1-5]. Team interaction is a dynamic, changing sequence of social actions between individuals that includes such activities as monitoring, coordination, communication, etc, and it is a dominant process of teamwork[6]. Furthermore, the dynamics of the team interaction has been confirmed associated with team efficiency and output in health care teams[7], according to which, we should pay more attention on the health care team interaction research.

Team interaction is vital for physician teams around the world. Modern health care demands successful teamwork between the physicians within teams, particularly with inter-professional teamwork and cross setting teamwork [8]. However, hospitals often have large physician teams, which brings challenges for the coordination and communication processes. Accordingly, the physician interaction is a dominant factor of a high efficiency health care.

The team interaction is particularly important in Chinese physician teams. Chinese tertiary hospitals admit a majority of relatively serious cases in the spectrum of disease and the physicians are in a high intensity work space, contributing to the documented high rate of physician burnout in Chinese tertiary hospitals[9]. As teamwork has been reported to a protector of physician burnout, Chinese tertiary hospitals could benefit from a reform from

the point of team, enabling a release of physician emotional exhaustion and an improvement in team efficiency[3, 10].

However, to date there is a lack of empirical research on team interaction [6, 11]. Although emphasis has been placed on the assessment of team interaction and an accepted scale has been designed for team interaction assessment (e.g. the Team Performance Scale (TPS))[6, 12], the conceptual framework of team interaction in health care field has not been well explored. Lechler's scale of assessing team interaction measures the perceived social interaction within innovation and entrepreneurial team members. This scale was based on the theoretical concept of Hoegl and was widespread in entrepreneurial team research[13, 14]. While there have been studies on teamwork in China[15], there are no known existing studies that examine health care team interactions. Indeed, only a few instruments are particularly oriented towards the measurement of the team interaction within clinical physicians in China and abroad, and none have proposed a comprehensive core dimension of team interaction in healthcare areas[6, 16].

The aim of this study, therefore, is to introduce an instrument to confirm the ability to effectively measure the Chinese physician team interaction within hospital units or departments, to investigate the current status of the physician team interaction, and to explore potential influencing factors. Although the sound dimensional structure of assessing social interaction proposed by Lechler has been widespread in innovative team research, this is the first time it has been adapted and validated for a health care team[14]. As the social interaction within teams generally focused on the team interaction, we made it

as the scale of assessing team interaction for physician population, named by Team Interaction Scale (TIS). The psychometric properties of the scale were verified in the Chinese tertiary hospital physician population through two rounds of surveys. As burnout has been confirmed negatively associated with teamwork[17], the relationship between burnout and team interaction was explored in this study, simultaneously confirming evidence for the validity of the scale.

The introduction of this scale allowed us to possess a valid tool of assessing the perceived team interaction of physicians in the healthcare team, to understand the present status of the team interaction and to gain knowledge on the influencing factors of the team interaction, thus assisting the healthcare policy makers and administrators to promote healthcare quality as well as physician well-being from a long-term team perspective.

METHODS

Two rounds surveys were conducted for the cross-culturally adaptation and validation in this study, and the steps and the methods were described in Figure 1.

Figure 1 Steps and methods of cross-culturally adaptation and validation of TIS

Study design

Pilot survey

Questionnaire

The team interaction scale was translated, independently, into Chinese by one graduate student (W.S.) and one faculty member (N.D.) from the China Medical University and was subsequently compared and reviewed by five experienced clinical experts to confirm the cultural and academic relevance, producing the initial translated version. This version was then back-translated by two faculty members (W.Z. and H.L.) from the China Medical University who were blind to the initial English version scale. The comparison of back-translation scale and original English scale resulted in minor revisions resulting in Chinese version 1.0 of the TIS. This version of the scale contained six factors: “Communication”, “Coordination”, “Mutual support”, “Work norms (effort)”, “Cohesion”, and “Conflict resolution”. All the 31 self-report items were positively worded with a seven-point Likert-type scale scored from 1 (strongly disagree) to 7 (strongly agree). A total score was calculated from the sum of

all items, ranging from 31 to 217, with a higher score indicating a better team interaction.

A socio-demographic questionnaire was also designed and applied to acquire personal characteristics of the physicians, including gender, age, discipline, and educational level.

Study sample

In December 2016, 390 physicians from two tertiary hospitals in Liaoning Province, China, were invited to participate in the pilot survey. In order to provide a representative sample of clinical physicians in these tertiary hospitals, the randomized cluster sampling method was applied. Physicians from the following discipline, Internal Medicine, Surgery, Obstetrics and Gynecology, Paediatrics, and other disciplines, including the departments of anesthesiology, ear-nose-throat, stomatology, medical detection, and traditional Chinese medicine department, were randomly chosen and the total number of physicians in each discipline was used as the sampling weight.

Large sampling survey

Questionnaire

We maintained the seven-point Likert-type scale from 1 to 7 for the modified scale and a socio-demographic questionnaire including gender, age, discipline, and educational level was also given to the participants. A total score was calculated, ranging from 17 to 119, with a higher score indicating a better team interaction. To gather information for the psychometric properties

of the scale and to confirm the relationship between team interaction and physician burnout, a two-item burnout scale, previously confirmed to be reliable and valid, was also applied in the large sampling survey[18].

Study sample

The large sampling survey was conducted in 4,100 physicians from nine tertiary hospitals in Liaoning in February 2017. Considering the potential heterogeneity in the hospitals with different quality, the stratified cluster sampling method was used to select a representative sample from all physicians in Liaoning. On the hospital scale, nine out of 37 tertiary hospitals in the Liaoning province were randomly chosen, including three the top 20 tertiary hospitals in Northeast China (larger scale of tertiary hospitals) and six ordinary tertiary hospitals. In each tertiary hospital, physicians from Internal Medicine, Surgery, Obstetrics and Gynecology, Paediatrics, and other disciplines, including other disciplines include the departments of anesthesiology, ear-nose-throat, stomatology, medical detection, and traditional Chinese medicine department, were randomly chosen and the total number of physicians in each discipline was also used as the sampling weight.

Procedure & Ethics statement

The participants were selected and voluntarily participated in the study. We were permitted to distribute the questionnaire and maintain contact with each clinical physician team to ensure the survey was completed. Each participant was assured of confidentiality and signed a written informed consent prior to completing the questionnaire. The coded self-report questionnaires were

completed independently in approximately 10 minutes. Participants were able to consult trained researchers with any questions regarding the survey. The participants were not compensated and they could withdraw from the survey at any time.

The two rounds surveys in this study were approved by the Bioethics Advisory Commission of China Medical University, Shenyang, China, with the understanding that all information would be used only for our study and would be kept confidential.

Statistical analysis

The data from the pilot survey, was analysed with CFA to test the psychometrics properties and then to modify Lechler's scale. Then the data from the large sampling survey were equally and randomly divided into two parts, and exploratory factor analysis (EFA) and CFA was performed with either part separately. In other words, CFA was used to confirm the factor structure emerged from EFA in a distinct data set.

Specifically, to evaluate the model fit in CFA, we referred to various fit indices, including chi-square value, Root Mean Square Error of Approximation (RMSEA), Goodness of Fit Index (GFI), Adjusted Goodness of Fit Index (AGFI), Comparative Fit Index (CFI) and Normed Fit Index (NFI). If GFI, AGFI, CFI and NFI were greater than 0.90 and the RMSEA was less than 0.08, the fit of the model is acceptable [19]. If the model poorly fit the data, item causing high modification index (MI) values might be revised or even deleted. Particularly, if all the authors agreed the items suffered from cultural gaps, the

entry would be deleted. After the deletion of any item, we reran the model to calculate fit indices and modification index. The process was irritated until an acceptable model fit was achieved.

Before conducting EFA, a Kaiser–Meyer–Olkin (KMO) analysis was performed to test the appropriation of the factor analysis. In EFA, a varimax rotation was employed to illustrate the underlying dimensional structure of the Chinese version of the TIS and maximum likelihood method was used to estimate. The criterion of factor loadings for each item was no less than 0.70.

Cronbach's α coefficients were calculated to estimate the internal consistency of each dimension and of the overall scale. An α coefficient higher than 0.70 was considered acceptable and coefficients higher than 0.90 represent an extremely high level of reliability.

The correlations between the overall score of perceived team interaction and gender, age, discipline, and education level were evaluated with *t*-tests and a univariate Analysis of Variance (ANOVA) with all the samples in the large sampling survey. Moreover, Pearson correlation coefficients were calculated to explore the potential correlation between burnout and perceived team interaction and its each dimension.

Missing values were imputed with the mediums of the corresponding entries. All the data analyses were implemented via SPSS version 23 and AMOS version 24, and a *p*-value of less than 0.05 was considered significant.

Patient and public involvement

Neither patients nor public were involved in the design or conduct of the study.

RESULTS

Preliminary psychometrics of the scale

Pilot survey

In the pilot survey, 390 questionnaires were distributed with 364 effective questionnaires returned for an effective response rate of 93.33%. Males account for 51.50% of the sample and 50.70% of the participants aged between 31 and 40 (Table 1).

Table 1 The distribution of demographic variables for the pilot survey.

Demographic	Category	N (%)
Gender	Male	187(51.50%)
	Female	176(48.50%)
Age	≤30	84(23.10%)
	31-40	184(50.70%)
	41-50	70(19.30%)
	51-60	24(6.60%)
	61-70	1(0.30%)
Discipline	Internal medicine	139(38.30%)
	Surgery	150(41.30%)
	Obstetrics and Gynecology	24(6.60%)
	Paediatrics	11(3.00%)
	Others	39(10.70%)

Education level	Doctor	172(47.40%)
	Master	179(49.30%)
	Bachelor	11(3.00%)
	Others	1(0.30%)

Other disciplines include the departments of anesthesiology, ear-nose-throat, stomatology, medical detection, and traditional Chinese medicine department.

Other education level includes junior college level.

The results of CFA in the pilot survey indicated a poor fit, with a chi square for the original 31-item scale of 2090.43, GFI=0.71, AGFI=0.66, PGFI=0.61, NFI=0.87, CFI=0.89, RMSEA=0.11, suggesting that the original model didn't perform well in a Chinese physician population. Then, according to the modification index and the feedbacks from physicians and experts, we made some semantic changes and deletions to the items, resulting in the Chinese version 2.0 of TIS with 17 items. The revised scale yielded a chi square value of 327.13 with acceptable fit indices (GFI=0.91, AGFI=0.86, PGFI=0.62, NFI=0.96, CFI=0.97, RMSEA=0.08). The factor loadings before and after modification were shown in additional file.

In the pilot survey, internal consistency for each dimension and overall scale were tested with the 17-item model after the modification process. All the α coefficients were higher than 0.80, ranging from 0.90 to 0.98, indicating that all the items provided adequate contributions to the scale after the modification.

Large sampling survey

The 17-item TIS was distributed among nine representative hospitals in Liaoning Province, China. Among the 4,100 questionnaires distributed, 3,685 pieces were effective, leading to an effective response rate of 89.88%. The distribution of all the demographic variables in the two parts of the sample were similar (see Table 2).

Table 2 The distribution of demographic variables in the two parts of the sample in the large sampling survey

Demographic variables	Category	N (%) (Part 1)	N (%) (Part 2)
Gender	Male	890(48.80%)	887(48.50%)
	Female	935(51.20%)	941(51.50%)
Age	21-30	313(17.20%)	363(19.90%)
	31-40	837(45.90%)	773(42.30%)
	41-50	397(21.80%)	432(23.60%)
	≥50	278(15.20%)	260(14.20%)
Discipline	Internal medicine	767(42.00%)	777(42.50%)
	Surgery	610(33.40%)	597(32.70%)
	Obstetrics and Gynecology	93(5.10%)	96(5.30%)
	Paediatrics	57(3.10%)	56(3.10%)
	Others	298(16.30%)	302(16.50%)
Education level	Doctor	376(20.60%)	374(20.50%)
	Master	839(46.00%)	879(48.10%)

	Bachelor	590(32.30%)	562(30.70%)
	Others	20(1.10%)	13(0.70%)
Hospital scale	Northeast top 20 hospital	879(48.20%)	928(50.80%)
	Ordinary tertiary hospital	946(51.80%)	900(49.20%)

Other disciplines include the departments of anesthesiology, ear-nose-throat, stomatology, medical detection, and traditional Chinese medicine department.

Other education level includes junior college level.

A Kaiser–Meyer–Olkin (KMO) analysis was performed among the half of the samples and yielded an index of 0.98. The result of Bartlett test of sphericity was significant at 36101.81 (p<0.01). This allowed us to conduct the EFA using a principal component factor extraction with a varimax rotation to explore the potential factor model (see Table 3 for results). Six factors emerged, called “Communication” (two items), “Coordination” (three items), “Mutual help” (three items), “Team goals” (two items), “Work norms” (three items) and “Cohesion and conflict resolution” (four items) (Chinese version 3.0). The overall 17-item model accounted for 87.20% of the variance (see Table 3).

Table 3 Exploratory factor analysis for the 17-item TIS

Items *	Rotated factor coefficients					
	“Cohesion and conflict resolution”	“Coordination”	“Work norms”	“Mutual help”	“Communication”	“Team goals”
16.The team members solve conflicts and disagreements within the	**0.77**	0.32	0.28	0.23	0.21	0.21

team completely						
17.Disagreements between the team members are solved rapidly	**0.72**	0.31	0.33	0.18	0.23	0.26
15. Strong cohesion is a characteristic of the team.	**0.67**	0.29	0.40	0.30	0.18	0.19
14. Working in the team has the highest priority for every team member (in comparison with other jobs and private life).	**0.59**	0.22	0.48	0.32	0.25	0.18
4. The team members adjust closely the processing of their tasks	0.35	**0.70**	0.27	0.28	0.21	0.26
3. The team members share opinions and information spontaneously	0.32	**0.69**	0.31	0.22	0.34	0.17
5. Within the team related tasks are well coordinated.	0.35	**0.61**	0.23	0.35	0.25	0.37
11. The team members share the workload of the team equally.	0.32	0.28	**0.71**	0.13	0.22	0.36
12. Every team member works as best as she/he can in order to achieve the team's goals.	0.38	0.36	**0.70**	0.25	0.14	0.18
13. Every team member is completely integrated in the team	0.38	0.21	**0.68**	0.36	0.26	0.15
7. Discussions among the team members are always constructive and beneficial.	0.33	0.35	0.30	**0.66**	0.28	0.23
6. The team members	0.31	0.51	0.31	**0.54**	0.19	0.24

support and complement each other as well as they can.						
8. Proposals and contributions of the team members are always respected	0.33	0.38	0.29	**0.53**	0.23	0.42
1. The team members communicate intensively with each other.	0.30	0.32	0.22	0.24	**0.75**	0.27
2. I'm completely content with the exactness of information provided by other team members.	0.23	0.55	0.38	0.23	**0.56**	0.11
9. The team members reach consensus in every important issue	0.30	0.29	0.31	0.39	0.25	**0.63**
10. Every team member perceives herself/himself as responsible for the clinical team's goals	0.43	0.34	0.41	0.20	0.25	**0.54**
% Variance	19.87%	17.89%	17.60%	12.02%	10.13%	9.70%

***items were listed in accordance with the value of coefficients**

Coefficients bold were higher than 0.50

The 17-item model that emerged from EFA was verified with CFA with another half of the samples, yielding an excellent model fit: chi square = 1022.95, RMSEA = 0.07, and CFI, NFI, GFI and AGFI scores were 0.98, 0.97, 0.94, 0.91, respectively, all of which were higher than 0.90. The factor loadings were all higher than 0.80 (details in additional file), suggesting that

each entry was a good explanation of the corresponding factor. The path diagram of the confirmed model was presented in Figure 2.

Figure 2 The path diagram of the 17-item TIS model emerged from EFA

All Cronbach's α coefficients of the six dimensions and overall scale of the final 17-item TIS were higher than 0.85, ranging from 0.87 to 0.98 (see Table 4).

Table 4 Cronbach's α coefficients and mean score of the final 17-item TIS

17-item TIS	α coefficients of final model (Item number of each domain)	Dimension Mean (SD)	Item Mean (SD)
Communication	0.88(2)	12.05(2.07)	6.02(1.04)
Coordination	0.92(3)	18.37(2.93)	6.12(0.98)
Mutual help	0.92(3)	18.52(2.85)	6.17(0.95)
Team goals	0.87(2)	12.36(1.94)	6.18(0.97)
Work norms	0.92(3)	18.38(3.04)	6.13(1.01)
Cohesion and conflict resolution	0.94(4)	24.63(3.92)	6.16(0.98)
Overall	0.98(17)	104.31(15.53)	6.13(0.91)

Factors

Group comparisons

The perceived team interaction score demonstrated significant differences in gender, age, discipline and hospital scale, but had no significant difference between different education level (see Table 5 for results).

Female physicians perceived a better team interaction than the male physicians (t=-3.85, p<0.05) and there was a general positive trend with respect to age and perception of team dynamics, namely physicians aged between 21 to 30 perceived the lowest team interaction and the physicians who were more than 40 years old rated a distinct better team interaction. (F=5.33, p<0.01). Additionally, the perceived team interaction score was significantly higher in those practicing internal medicine than in surgeons, while paediatricians scored lower than both of these groups (F=6.73, p<0.01). Furthermore, team interactions were rated better in ordinary tertiary hospitals than that in the northeast top 20 tertiary hospitals (hospitals of a larger scale) (t=-2.93, p<0.01).

Table 5 Group comparisons of team interaction score within demographic and working variables

Variables	Category	Mean (SD)	*F/t*	*p* -value
Gender	Male	103.29(16.28)	t=-3.85	p<0.05
	Female	105.30(14.72)		
Age	21-30	102.40(17.49)	F=5.33	p<0.01

	31-40	104.26(15.26)		
	41-50	105.40(14.97)		
	≥50	105.15(14.32)		
Discipline	Internal medicine	105.40(14.19)	*F*=6.73	*p*<0.01
	Surgery	102.64(16.81)		
	Obstetrics and Gynecology	105.55(12.81)		
	Paediatrics	101.75(20.43)		
	Others	104.91(15.55)		
Education level	Doctor	104.11(13.44)	*F*=0.85	*p*>0.05
	Master	103.99(14.83)		
	Bachelor	104.87(17.57)		
	Others	105.44(18.96)		
Hospital scale	Northeast top 20 hospital	103.55(14.00)	*t*=-2.93	*p*<0.01
	Ordinary tertiary hospitals	105.05(16.86)		

Correlation analysis

The overall team interaction score was negatively related to burnout and the six factors “Communication”, “Coordination”, “Mutual help”, “Team goals”, “Work norms” and “Cohesion and conflict resolution” were all significantly associated with burnout. (see in Table 6).

Table 6 The correlation analysis between burnout and team interaction

Variables	Communication	Coordination	Mutual help	Team goals	Work norms	Cohesion and conflict resolution	Total score
Burnout	-0.21**	-0.22**	-0.22**	-0.23**	-0.24**	-0.24**	-0.25**

**stands for $p<0.01$

DISCUSSION

The aim of this study is to translate and cross-validate the team interaction scale among the physicians in Chinese tertiary hospitals and to explore potential influencing factors. The structure of the scale was adjusted based on the results of the CFA in pilot survey and EFA in large sampling survey, and the new dimension model was verified through the CFA in large sampling survey. The results suggested that the scale consisting of six dimensions and 17 items was reliable. The perceived team interaction score was significantly lower in male physicians, paediatrics physicians, and the physicians from tertiary hospitals of a larger scale. Additionally, the physicians perceived a significantly better team interaction associated with longevity on the team and physician burnout was confirmed to be negatively associated with team interaction.

In the pilot survey, the model fit indices of the original structure didn't meet the criterion for moderate construct validity, indicating that the cross-cultural validity of the original instrument was low and it was inappropriate to apply among the Chinese tertiary hospital physician[20, 21]. The team interaction is determined mostly by the interpersonal factors, which may be influenced by the politics, economy and culture context[6]. As this scale of assessing team interaction was first introduced into physician population and applied to a Chinese context, the target population difference and the culture gap may have led to the dimensional structure being unadaptable for the Chinese health care context, contributing to the low validity of the scale. The dimension structure of the adapted 17-item model was different from that of Lechler's

original six-dimension structure, with the addition of the “Team goals” dimension and the combination of “Cohesion” and “Conflict resolution” dimensions, but it retained the “Communication”, “Coordination” and “Work norms (effort)” dimensions[22-24]. The two items in newly formed dimension “Team goals” described “reach consensus” and “perception of responsibility for the team’s goals”, both stressing the common goals in the team. Therefore, per the content as well as the stress of team goals in team process research, the dimension was named as “Team goals” [25]. The results implied that “Team goals” was one of the core attributes of team interaction in Chinese tertiary hospital physician teams. The changes in the dimensional structure revealed that the connotation and manifestation of team interaction may be distinguished by the target population and culture context. Among the six dimensions of the modified scale, there are two dimensions consisting of two items each, which may have an influence on the reliability of the scale. However, the Cronbach’s α coefficient of the 17-item scale in large sampling survey (α=0.98) was close to that in the pilot survey (α=0.98), which were an acceptable range for educational and psychological testing[24]. Additionally, the α coefficients of each factor of the final scale were all higher than 0.80, indicating a high internal consistency of the TIS among Chinese tertiary hospital physicians. In the future, we will apply the 17-item short TIS as well as the 31-item full scale at the same time, to make a comparison of the two instruments, validating the short version scale for use to examine the physician team interaction.

The item mean score for the dimension “Communication” was the lowest (mean=6.02, SD=1.04), suggesting that physicians generally perceived worse

communication within their teams. However, it has been reported that the communication was the key component in the team process[26]. Therefore, the administrators should take particular measures to improve the communication within teams, thus realizing a better team interaction.

The score of perceived team interaction was higher in females than that in males, similar to other studies in which the female members tended to experience better team interaction, communication, and team cohesion[27]. Influenced by traditional Chinese culture, females in China are usually considered fragile and are often taken good care of. Furthermore, the females tend to have an excellent ability to relate to others by nature, resulting in a better team interaction. The physicians more than 40 years old apperceived a significant better team interaction, while those in their twenties perceived the worst. We suggest that the age was a positive predicting factor of perceived team interaction. Similar findings also illustrated that the physicians and other health professionals appreciated better teamwork as working years increase [28-30]. It may be that elder physicians tend to have more longevity within their teams, allowing them to be better integrated with the team compared to the younger physicians. Moreover, the elder physicians are qualified in clinical skills, teamwork ability, and other essential competencies, so they would be respected and others would cooperate with them more, resulting in feelings of a better team interaction climate[29]. According to the results in our study, the administration should provide the physicians under 40 years old with more human care and growth opportunities.

In our study, the score of team interaction was significantly different within disciplines, with paediatrics physicians scored the lowest. Facing the population of extreme age, the paediatrics physicians are encountered with more challenges in teamwork[31,32]. First of all, the difficulty in the coordination and cooperation with children brings obstacles to the physician's work, potentially increasing more frequent medical errors, hindering the team interaction within paediatrics physicians[32-34]. Additionally, the feature of the paediatrics discipline often relies on multidisciplinary teamwork, which is more demanding of the physicians' teamwork competencies, increasing potential issues with team interactions[32]. Above all, particular attention should be paid to the team interaction of paediatrics physicians. The physicians in ordinary tertiary hospitals rated a significantly better team interaction than the better tertiary hospitals. In China, the better tertiary hospitals are challenged with the most serious diseases in the disease spectrum, which demands better teamwork and the physicians have higher demands on the team, possibly contributing to the relatively lower team interaction score. The second, the better tertiary hospitals usually have a larger group of physician teams, introducing more challenges to the interaction of the physicians. Furthermore, the physicians in better tertiary hospitals are faced with a busier working environment, more critical cases, and more medical error, which may negatively influence the team process and aggravate the physician burnout, risking the teamwork process[35,36]. Therefore, we suggest that more attention on the team building needs to be paid in better tertiary hospitals.

The results of correlation analysis revealed that physician burnout was negatively associated with team interaction, consistent with other reports that

the teamwork quality was related to health professional burnout. We suggest that the improvement in team interaction environment may potentially relieve physician burnout[3, 10, 37, 38]. Therefore, physician well-being could not only be improved from the perspective of individual characteristics as we known, but also from working environments like the team interaction[39]. Moreover, as the relationship between burnout and teamwork is well accepted, the significant correlation between burnout and team interaction illustrated the validity of the scale from the other side[17].

Limitations

This survey was implemented in only one province of China which may impair the generalization of our conclusions. However, the sample in this study was representative in this province and the demographic characteristic of the sample were quite similar with that of the national physician population shown in China Health Statistics Yearbook 2013[40], thus the limitation in representativeness might not be serious. Furthermore, the causality relationships between team interaction and the influencing factors were not determined due to the cross-sectional nature of the survey. This problem would be tackled by tracing the participants of this survey in the future.

CONCLUSIONS

In a population of Chinese tertiary hospitals physicians, the adapted version of TIS containing 17 items and six dimensions is valid and reliable by taking culture gap into account. The adapted version of TIS has the potential to be a

valid tool for physicians' team interaction evaluation in other countries with similar culture or similar health care context. Hospital administrators should pay more attention to the environment of team interaction, which may help relieving physician burnout.

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Author Contributions

WWS and HHL were responsible for the study design, WWS, ND, HHL and WYZ were in response to the translation of the questionnaire. WWS, WYZ and LS performed the data collection. WWS, HHL and ND contributed to the analysis and interpretation of the data and were involved in drafting the manuscript and revising it critically for important intellectual content and give final approval of the version to be published. All authors have read and approved the final manuscript.

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Competing interests

None declared

Patient consent

Not required

Ethics approval

This study was approved by the Bioethics Advisory Commission of China Medical University, Shenyang, China.

Data sharing statement

No additional data are available

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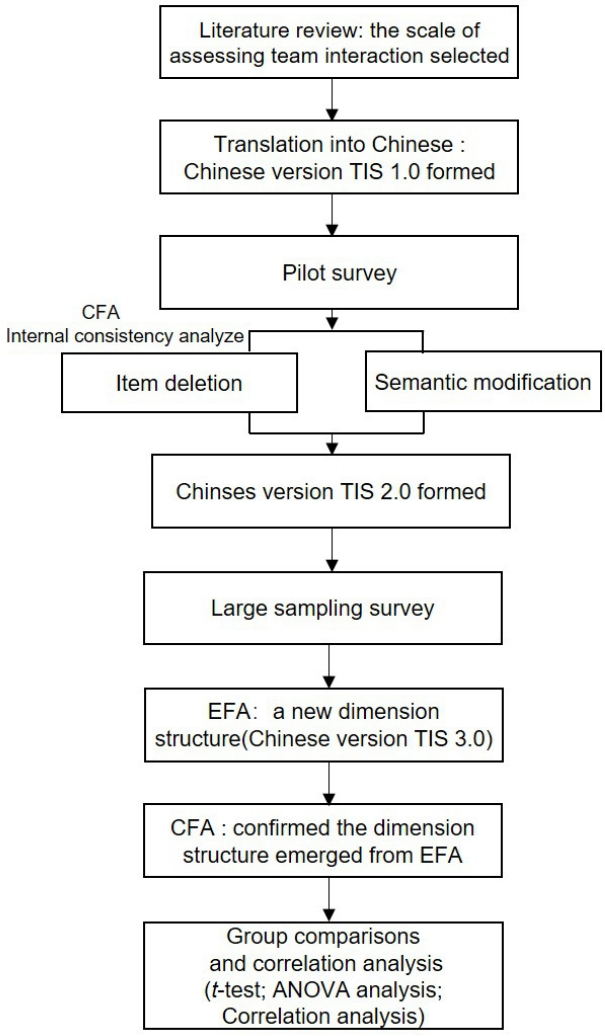

Figure 1 Steps and methods of cross-culturally adaptation and validation of TIS

Figure 1 Steps and methods of cross-culturally adaptation and validation of TIS

167x188mm (150 x 150 DPI)

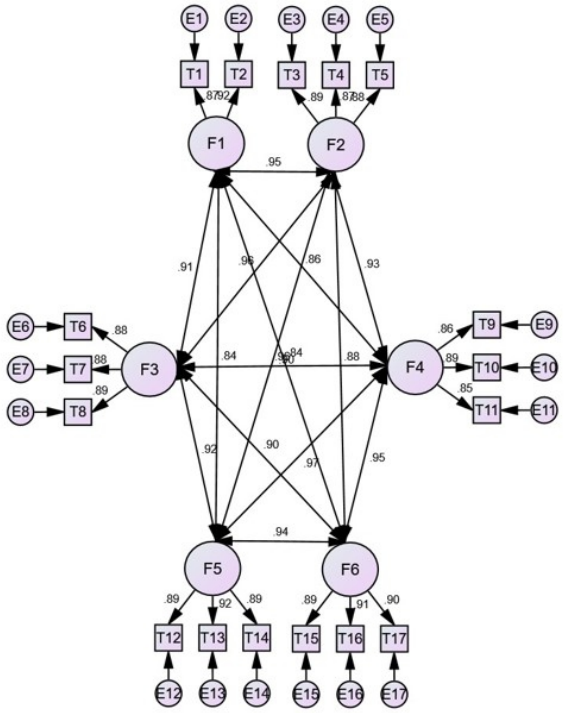

Figure 2 The path diagram of the 17-item TIS model emerged from EFA

Figure 2 The path diagram of the 17-item TIS model emerged from EFA

142x125mm (150 x 150 DPI)

Additional file The factor loadings of the items in CFA before and after the modification process

Item	31-item scale	17-item scale in pilot survey	17-item scale in large sampling survey
1	0.79		
2	0.86	0.84	0.87
3	0.90		
4	0.91	0.90	0.92
5	0.91		
6	0.90	0.91	0.89
7	0.90	0.92	0.88
8	0.74		
9	0.91	0.89	0.88
10	0.74		
11	0.90	0.90	0.88
12	0.92	0.92	0.88
13	0.88		
14	0.83	0.83	0.89
15	0.92	0.91	0.86
16	0.85		
17	0.90	0.91	0.89
18	0.85	0.86	0.85
19	0.91	0.92	0.89
20	0.87		

21	0.91	0.90	0.92
22	0.84	0.85	0.89
23	0.86		
24	0.87	0.86	0.89
25	0.85		
26	0.89		
27	0.91		
28	0.92		
29	0.90	0.94	0.91
30	0.92	0.93	0.90
31	0.84		

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cross sectional reporting guidelines, and cite them as:

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		Reporting Item	Page Number
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	2,3
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	5,6
Objectives	#3	State specific objectives, including any prespecified hypotheses	6,7
Study design	#4	Present key elements of study design early in the paper	8-10
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	9,10
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	9,10

	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	11,12
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. Give information separately for for exposed and unexposed groups if applicable.	11,12
Bias	#9	Describe any efforts to address potential sources of bias	10,11,12
Study size	#10	Explain how the study size was arrived at	n/a
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	8,9
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	11,12
	#12b	Describe any methods used to examine subgroups and interactions	12
	#12c	Explain how missing data were addressed	12
	#12d	If applicable, describe analytical methods taking account of sampling strategy	n/a
	#12e	Describe any sensitivity analyses	n/a
Participants	#13a	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. Give information separately for for exposed and unexposed groups if applicable.	13,15
	#13b	Give reasons for non-participation at each stage	n/a
	#13c	Consider use of a flow diagram	8
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	13-16

	#14b	Indicate number of participants with missing data for each variable of interest	n/a
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	13-16
Main results	#16a	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	16-19
	#16b	Report category boundaries when continuous variables were categorized	13-16
	#16c	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—e.g., analyses of subgroups and interactions, and sensitivity analyses	16-22
Key results	#18	Summarise key results with reference to study objectives	23
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.	27
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	23-27
Generalisability	#21	Discuss the generalisability (external validity) of the study results	23,24,27
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	28,29

BMJ Open

Team interaction of tertiary hospital physicians: Preliminary psychometrics and influencing factors: A cross-sectional study in China

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Keywords:	Team interaction, Scale, Physician, Burnout, Chinese

Team interaction of tertiary hospital physicians: Preliminary psychometrics and influencing factors: A cross-sectional study in China

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Word count: 3742

ABSTRACT

Objectives

To administer a cross-cultural adaptation of the Team Interaction Scale (TIS), test its psychometric properties, and investigate influencing factors of team interactions in a Chinese tertiary hospital physician population.

Design

Cross-sectional survey

Settings

Two rounds of surveys, a pilot and a large sampling survey, were conducted in two and nine tertiary hospitals in Liaoning Province, China, respectively.

Participants

In the pilot survey, 363 of 390 physicians sampled were included in the analysis, resulting in an effective response rate of 93.08%. In the large sampling survey, the effective response rate was 89.10% (3,653 of 4,100 physicians).

Outcome measures

The TIS and a short version of a burnout scale were administrated to assess the physician's team interaction and burnout. Psychometric properties of TIS were tested by confirmatory factor analysis (CFA), exploratory factor analysis (EFA), and internal consistency analysis. Gender, age, discipline, education level, professional title, hospital scale, and burnout were explored as

influencing factors with independent sample *t*-tests, one-way ANOVAs, and a correlation analysis.

Results

Based on CFA, a 17-item modified scale was developed following the pilot survey. In the large sampling survey, EFA was conducted with half of the samples, producing six dimensions: “Communication”, “Coordination”, “Mutual help”, “Team goals”, “Work norms”, and “Cohesion and conflict resolution”. Fit of the modified model was confirmed by CFA with the other half of the samples (RMSEA=0.067, CFI=0.98, NFI=0.97, GFI=0.94, AGFI=0.92). A high Cronbach’s α coefficient of 0.98 demonstrated reliability of the modified scale. The team interaction score was significantly lower in younger physicians, in males, in pediatricians, and in physicians from larger scale tertiary hospitals. Team interaction scores were negatively associated with burnout.

Conclusions

The adapted TIS, containing 17 items and six dimensions, was reliable and valid in Chinese tertiary hospital physicians. To address physician burnout, team interaction should be addressed.

Keywords

Team interaction; Scale; Physician; Burnout; Chinese

ARTICLE SUMMARY

Strengths and limitations of this study

- To the best of our knowledge, this is the first study with a sufficient and representative sample in China to introduce a comprehensive dimensional structure to assess the interaction of the physician's team.
- This study extended the research on physicians' team interaction by identifying the potential influential factors and provides empirical research evidence for the team interaction improvement.
- The design of these this two-survey studies ensured the reliability and validity of the results.
- The evaluation of the team interaction was self-report, which may be subject to reporting bias.
- This study was cross-sectional, so the causal relationships between team interaction and the influencing factors were not clear.

BACKGROUND

Teamwork has been confirmed to be fundamental to team efficiency, physician well-being, and patient safety, and is generally acknowledged as the core of patient-centred medical reform [1-5]. Team interaction is a dynamic, changing sequence of social actions between individuals that includes such activities as monitoring, coordination, and communication, and is a dominant process of teamwork [6]. Furthermore, the dynamics of the team interaction is associated with team efficiency and output in health care teams [7] and as such, we should pay more attention to health care team interactions.

Good team interactions are fundamental for physician teams around the world. Modern health care demands successful physician teamwork, particularly with inter-professional and cross setting teamwork [8], which are becoming increasingly demanding of the coordination and communication processes in the health care teams. Accordingly, the physician team interaction is a dominant factor of high efficiency health care.

A healthy team interaction is particularly important in Chinese physician teams. Chinese tertiary hospitals admit a majority of relatively serious cases on the spectrum of disease, resulting in a high intensity work environment, contributing to a documented high rate of physician burnout in Chinese tertiary hospitals [9]. As teamwork has been reported as a protective factor to physician burnout, Chinese tertiary hospital physicians could benefit from a

better team interaction, enabling a release of emotional exhaustion in physicians and an improvement in team efficiency [3, 10].

To date, however, there is a lack of empirical research on team interactions [6, 11]. Although emphasis has been placed on the assessment of team interaction and an accepted scale has been designed for the assessment of team interactions (e.g. the Team Performance Scale) [6, 12], the conceptual framework of team interaction in health care field has not been well explored. Lechler's scale of assessing team interaction measures the perceived social interaction within innovation and entrepreneurial team members. This scale, based on the theoretical concept of Hoegl, was widespread in entrepreneurial team research [13, 14]. While there have been studies on teamwork in China [15], there are no known existing studies that examine health care team interactions. Indeed, only a few instruments are particularly oriented towards the measurement of the team interaction within clinical physicians in China and abroad and none have proposed a comprehensive core dimension of team interaction in healthcare areas [6, 16].

The aim of this study, therefore, is to introduce an instrument, to confirm its ability to effectively measure the physician's perceived team interaction, to investigate the current status of the physician team interaction, and to explore potential influencing factors. Although the sound dimensional structure of assessing social interaction proposed by Lechler has been widespread in innovative team research, this is the first known time that it has been adapted and validated for a health care team [14]. We made it as the scale of assessing team interactions for physician populations and called it the Team

Interaction Scale (TIS). The psychometric properties of the scale were verified in the Chinese tertiary hospital physician population through two rounds of surveys. As burnout is negatively associated with teamwork [17], the relationship between burnout and team interaction was also explored in this study.

The introduction of this scale allows us to possess a valid tool of assessing the perceived team interaction of physicians in the healthcare team, to understand the present status of the team interaction, and to gain knowledge on the influencing factors of the team interaction, thus assisting healthcare policy makers and administrators to promote healthcare quality as well as physician well-being from a long-term, team perspective.

METHODS

Two rounds of surveys were conducted for the cross-cultural adaptation and validation of this study (see Figure 1 for steps and methods).

Figure 1 Steps and methods of cross-cultural adaptation and validation of TIS

Study design

Pilot survey

Questionnaire

The team interaction scale was translated independently into Chinese by one graduate student (W.S.) and one faculty member (N.D.) from the China Medical University and was subsequently compared and reviewed by five experienced clinical experts to confirm the cultural and academic relevance, which yielded the initial translated version. This version was then back-translated by two faculty members (W.Z. and H.L.) from the China Medical University, both of whom were blind to the initial English version scale. The comparison of back-translated scale and the original English scale lead to minor revisions, resulting in Chinese version 1.0 of the TIS. This version of the scale contained six factors: “Communication”, “Coordination”, “Mutual support”, “Work norms (effort)”, “Cohesion”, and “Conflict resolution”. All 31 self-report items were positively worded with a seven-point Likert-type scale, scored from 1 (strongly disagree) to 7 (strongly agree). A total score was calculated from the sum of all items, ranging from 31 to 217, with a higher score indicating a better team interaction.

A socio-demographic questionnaire was also designed and applied to acquire personal characteristics of the physicians, including gender, age, discipline, and educational level.

Study sample

In December 2016, 390 physicians from two tertiary hospitals in Liaoning Province, China, were invited to participate in the pilot survey. In order to provide a representative sample of clinical physicians in these tertiary hospitals, a randomized cluster sampling method was applied. Physicians from several disciplines, including Internal Medicine, Surgery, Obstetrics and Gynecology, Pediatrics, and other disciplines, including the departments of Pathology, Anesthesiology, Ear-nose-throat (ENT), Stomatology, Ophthalmology, Radiology, Ultrasound, the Intensive care unit (ICU), and the traditional Chinese medicine department were randomly chosen. The total number of physicians in each discipline was used as the sampling weight.

Large sampling survey

Questionnaire

We maintained the seven-point Likert-type scale for the modified scale and also included a socio-demographic questionnaire including gender, age, discipline, and educational level. A total score was calculated, ranging from 17 to 119, with a higher score indicating a better team interaction. To gather information for the psychometric properties of the scale and to confirm the relationship between team interaction and physician burnout, a two-item

burnout scale, previously confirmed to be reliable and valid, was also applied in the large sampling survey [18].

Study sample

The large sampling survey was conducted in 4,100 physicians from nine tertiary hospitals in Liaoning in February 2017. Considering the potential heterogeneity in the hospitals with different quality, a stratified cluster sampling method was used to select a representative sample from all physicians in Liaoning. Nine out of 37 tertiary hospitals in the Liaoning province were randomly chosen, including three of the top 20 tertiary hospitals in Northeast China (larger scale of tertiary hospitals) and six ordinary tertiary hospitals. In each tertiary hospital, physicians from Internal Medicine, Surgery, Obstetrics and Gynecology, Pediatrics, and other disciplines, including the departments of Pathology, Anesthesiology, ENT, Stomatology, Ophthalmology, Radiology, Ultrasound, the ICU, and the traditional Chinese medicine department were randomly chosen. The total number of physicians in each discipline was also used as the sampling weight.

Procedure & Ethics statement

The participants were selected and voluntarily participated in the study. We were permitted to distribute the paper questionnaire offline and maintain contact with each clinical physician team to ensure the survey was completed. Participants were able to consult trained researchers with any questions regarding the survey. Each participant was assured of confidentiality and signed a written informed consent prior to completing the questionnaire. The

coded self-report questionnaires were completed independently in approximately 10 minutes. The participants were not compensated and were able to withdraw from the survey at any time.

Both surveys in this study were approved by the Bioethics Advisory Commission of China Medical University, Shenyang, China, with the understanding that all information would be used only for our study and would be kept confidential.

Statistical analysis

The data from the pilot survey was analysed using CFA to test the psychometrics properties and to subsequently modify Lechler's model. Then the data from the large sampling survey were equally and randomly divided into two parts. Exploratory factor analysis (EFA) and CFA were performed with one of the two parts, separately. In other words, CFA was used to confirm the factor structure that emerged from EFA in a distinct data set.

Specifically, to evaluate the model fit in CFA, we used the maximum likelihood estimation and referred to various fit indices, including the chi-square value, Root Mean Square Error of Approximation (RMSEA), Goodness of Fit Index (GFI), Adjusted Goodness of Fit Index (AGFI), Comparative Fit Index (CFI), and Normed Fit Index (NFI). If GFI, AGFI, CFI and NFI were greater than 0.90 and the RMSEA was less than 0.08, the fit of the model was deemed acceptable [19]. If the model poorly fit the data, the item causing high modification index (MI) values would be revised or even deleted. For example, if all the authors agreed the items suffered from cultural gaps, the entry would

be deleted. After the deletion of any item, the model was rerun to calculate new fit indices and an updated modification index. The process was iterated until an acceptable model fit was achieved.

Before conducting EFA, a Kaiser–Meyer–Olkin (KMO) analysis was performed to test the adoption of the factor analysis. In EFA, a principal component factor extraction and varimax rotation was employed to illustrate the underlying dimensional structure of the Chinese version of the TIS and maximum likelihood method was used to estimate the model. Eigenvalues, relative magnitude, and direction of factor loadings were all examined to explain variance and communality.

Cronbach's α coefficients were calculated to estimate the internal consistency of each dimension and of the overall scale. An α coefficient of higher than 0.70 was considered acceptable and coefficients higher than 0.90 represent an extremely high level of reliability.

The correlations between the overall score of perceived team interaction and gender, age, discipline, education level, professional title, and hospital scale were evaluated with *t*-tests and a univariate Analysis of Variance (ANOVA) with all the samples in the large sampling survey. Moreover, Pearson correlation coefficients were calculated to explore the potential correlation between burnout and perceived team interaction on each dimension.

Missing values were imputed with the medians of the corresponding entries. All the data analyses were implemented via SPSS version 23 and AMOS version 24, and a *p*-value of less than 0.05 was considered significant. Effect

sizes, including cohen's d and partial Eta Squared (η_p^2), were also reported to illustrate the practical meaning of the difference.

Patient and public involvement

Neither patients nor the public were involved in the design or conducting of the study.

RESULTS

Preliminary psychometrics of the scale

Pilot survey

In the pilot survey, 390 questionnaires were distributed, with 363 completed questionnaires returned for an effective response rate of 93.08%. Males account for 51.50% of the sample and 50.70% of the participants were between the ages of 31 and 40 (Table 1).

Table 1. The distribution of demographic variables for the pilot survey.

Demographic	Category	N (%)
Gender	Male	187 (51.50%)
	Female	176 (48.50%)
Age	≤30	84 (23.10%)
	31-40	184 (50.70%)
	41-50	70 (19.30%)

	51-60	24 (6.60%)
	61-70	1 (0.30%)
Discipline	Internal medicine	139 (38.30%)
	Surgery	150 (41.30%)
	Obstetrics and Gynecology	24 (6.60%)
	Pediatrics	11 (3.00%)
	Others	39 (10.70%)
Education level	Doctor	172 (47.40%)
	Master	179 (49.30%)
	Bachelor	11 (3.00%)
	Others	1 (0.30%)
Professional title	Primary title	98 (27.2%)
	Intermediate title	138 (38.3%)
	Associate professor	93 (25.8%)
	Professor	31 (8.6%)

Other disciplines include the departments of Pathology, Anesthesiology, ENT, Stomatology, Ophthalmology, Radiology, Ultrasound, the ICU, and the traditional Chinese medicine department.

Other education level includes a college degree.

The results of the CFA in the pilot survey indicated a poor fit, with a chi square for the original 31-item scale of 2090.43, GFI=0.71, AGFI=0.66, PGFI=0.61, NFI=0.87, CFI=0.89, and RMSEA=0.11, suggesting that the original model didn't perform well in a Chinese physician population. We made semantic modifications and deleted some items per the modification index and feedback from physicians and experts, resulting in the Chinese version 2.0 of the TIS with 17 items. The revised scale yielded a chi square value of 327.13

with acceptable fit indices (GFI=0.91, AGFI=0.86, PGFI=0.62, NFI=0.96, CFI=0.97, RMSEA=0.08). The factor loadings before and after modification were shown in an additional file.

In the pilot survey, internal consistency for each dimension and the overall scale were tested with the 17-item model after the modification process. All α coefficients were higher than 0.80, ranging from 0.90 to 0.98, indicating that all the items provided adequate contributions to the scale after the modification.

Large sampling survey

The 17-item TIS was distributed to physicians within nine representative hospitals in Liaoning Province, China. Among the 4,100 questionnaires distributed, 3,653 pieces were completed, leading to an effective response rate of 89.10%. The distribution of all demographic variables in the two parts of the sample were similar (see Table 2).

Table 2. The distribution of demographic variables in the two parts of the sample in the large sampling survey

Demographic variables	Category	N (%) (Part 1)	N (%) (Part 2)
Gender	Male	890 (48.80%)	887 (48.50%)
	Female	935 (51.20%)	941 (51.50%)
Age	21-30	313 (17.20%)	363 (19.90%)
	31-40	837 (45.90%)	773 (42.30%)
	41-50	397 (21.80%)	432 (23.60%)

	≥50	278 (15.20%)	260 (14.20%)
Discipline	Internal medicine	767 (42.00%)	777 (42.50%)
	Surgery	610 (33.40%)	597 (32.70%)
	Obstetrics and Gynecology	93 (5.10%)	96 (5.30%)
	Pediatrics	57 (3.10%)	56 (3.10%)
	Others	298 (16.30%)	302 (16.50%)
Education level	Doctor	376 (20.60%)	374 (20.50%)
	Master	839 (46.00%)	879 (48.10%)
	Bachelor	590 (32.30%)	562 (30.70%)
	Others	20 (1.10%)	13 (0.70%)
Professional title	Primary title	528 (28.9%)	520 (28.4%)
	Intermediate title	617 (33.8%)	619 (33.9%)
	Associate professor	317 (17.4%)	342 (18.7%)
	Professor	363 (19.9%)	346 (18.9%)
Hospital scale	Northeast top 20 hospital	879 (48.20%)	928 (50.80%)
	Ordinary tertiary hospital	946 (51.80%)	900 (49.20%)

Other disciplines include the departments of Pathology, Anesthesiology, ENT, Stomatology, Ophthalmology, Radiology, Ultrasound, the ICU, and the traditional Chinese medicine department.

Other education level includes a college degree.

A Kaiser–Meyer–Olkin (KMO) analysis was performed among half of the samples, yielding an index of 0.98. The result of Bartlett test of sphericity was significant at 36101.81 (p<0.01). Therefore, we conducted the EFA using a

principal component factor extraction with a varimax rotation to explore the potential factor model (see Table 3 for results). Six factors emerged, called "Communication", "Coordination", "Mutual help", "Team goals", "Work norms" and "Cohesion and conflict resolution" (Chinese version 3.0). The overall 17-item model accounted for 87.20% of the variance (see Table 3).

Table 3. Exploratory factor analysis for the 17-item TIS

Items *	Rotated factor coefficients					
	"Cohesion and conflict resolution"	"Coordination"	"Work norms"	"Mutual help"	"Communication"	"Team goals"
16.The team members solve conflicts and disagreements within the team completely	**0.77**	0.32	0.28	0.23	0.21	0.21
17.Disagreements between the team members are solved rapidly	**0.72**	0.31	0.33	0.18	0.23	0.26
15. Strong cohesion is a characteristic of the team.	**0.67**	0.29	0.40	0.30	0.18	0.19
14. Working in the team has the highest priority for every team member (in comparison with other jobs and private life).	**0.59**	0.22	0.48	0.32	0.25	0.18
4. The team members adjust closely the processing of their tasks	0.35	**0.70**	0.27	0.28	0.21	0.26
3. The team members share opinions and information spontaneously	0.32	**0.69**	0.31	0.22	0.34	0.17
5. Within the team related tasks are well coordinated.	0.35	**0.61**	0.23	0.35	0.25	0.37

11. The team members share the workload of the team equally.	0.32	0.28	**0.71**	0.13	0.22	0.36
12. Every team member works as best as she/he can in order to achieve the team's goals.	0.38	0.36	**0.70**	0.25	0.14	0.18
13. Every team member is completely integrated in the team	0.38	0.21	**0.68**	0.36	0.26	0.15
7. Discussions among the team members are always constructive and beneficial.	0.33	0.35	0.30	**0.66**	0.28	0.23
6. The team members support and complement each other as well as they can.	0.31	0.51	0.31	**0.54**	0.19	0.24
8. Proposals and contributions of the team members are always respected	0.33	0.38	0.29	**0.53**	0.23	0.42
1. The team members communicate intensively with each other.	0.30	0.32	0.22	0.24	**0.75**	0.27
2. I'm completely content with the exactness of information provided by other team members.	0.23	0.55	0.38	0.23	**0.56**	0.11
9. The team members reach consensus in every important issue	0.30	0.29	0.31	0.39	0.25	**0.63**
10. Every team member	0.43	0.34	0.41	0.20	0.25	**0.54**

perceives herself/himself as responsible for the clinical team's goals						
% Variance	19.87%	17.89%	17.60%	12.02%	10.13%	9.70%

***items listed in accordance with the value of coefficients**

Coefficients in bold were higher than 0.50

The 17-item model that emerged from EFA was verified with CFA with another half of the samples, yielding an excellent model fit with chi square = 955.75, RMSEA = 0.067, and CFI, NFI, GFI and AGFI scores all higher than 0.90, at 0.98, 0.97, 0.94, 0.92, respectively. The factor loadings were all higher than 0.80 (details in an additional file), suggesting that all the items provided adequate contributions to each factor. The path diagram of the confirmed model is presented in Figure 2.

Figure 2. The path diagram of the 17-item TIS model emerged from EFA

All Cronbach's α coefficients of the six dimensions and the overall scale of the final 17-item TIS were higher than 0.85, ranging from 0.87 to 0.98 (see Table 4).

Table 4. Cronbach's α coefficients and mean scores of the final 17-item TIS model

17-item TIS	α coefficients of final model (Item number of each domain)	Dimension Mean (SD)	Item Mean (SD)
Communication	0.88 (2)	12.05 (2.07)	6.02 (1.04)
Coordination	0.92 (3)	18.37 (2.93)	6.12 (0.98)

Mutual help	0.92 (3)	18.52 (2.85)	6.17 (0.95)
Team goals	0.87 (2)	12.36 (1.94)	6.18 (0.97)
Work norms	0.92 (3)	18.38 (3.04)	6.13 (1.01)
Cohesion and conflict resolution	0.94 (4)	24.63 (3.92)	6.16 (0.98)
Overall	0.98 (17)	104.31 (15.53)	6.13 (0.91)

Factors

Group comparisons

The perceived team interaction score demonstrated significant differences in gender, age, discipline, and hospital scale, but had no significant difference between different education level and professional title (see Table 5 for results).

Female physicians perceived a better team interaction than the male physicians (t=-3.85, p<0.05) and there was a generally positive trend with respect to age and perception of team dynamics, specifically, physicians between 21 to 30 years old perceived the lowest team interaction and physicians older than 40 years rated a distinctly better team interaction (F=5.33, p<0.01). Additionally, the perceived team interaction score was significantly higher in those practicing internal medicine than in surgeons, while pediatricians scored the lowest of all professions (F=6.73, p<0.01). Furthermore, team interactions were rated better in ordinary tertiary hospitals

than that in the northeast top 20 tertiary hospitals (hospitals of a larger scale) (t=-2.93, p<0.01).

Effect sizes showed that Cohen's d of gender and hospital scale were 0.21 and 0.10, indicating a non-overlap of 14.7% and 7.7% in the two distributions. Using η_p^2 as the measure of association, the value of 0.004, 0.007, 0.001, 0.002 showed a relatively small difference of perceived team interaction among different age groups and disciplines.

Table 5. Group comparisons of team interaction score within demographic and working variables

Variables	Category	Mean (SD)	*F/t*	*p* -value	Effect Size
Gender	Male	103.29 (16.28)	t=-3.85	p<0.05	cohen's d=0.21
	Female	105.30 (14.72)			
Age	21-30	102.40 (17.49)	F=5.33	p<0.01	η_p^2=0.004
	31-40	104.26 (15.26)			
	41-50	105.40 (14.97)			
	⩾50	105.15 (14.32)			
Discipline	Internal medicine	105.40 (14.19)	F=6.73	p<0.01	η_p^2=0.007
	Surgery	102.64 (16.81)			
	Obstetrics and Gynecology	105.55 (12.81)			

	Pediatrics	101.75 (20.43)			
	Others	104.91 (15.55)			
Education level	Doctor	104.11 (13.44)	F=0.85	P=0.467	η_p^2=0.001
	Master	103.99 (14.83)			
	Bachelor	104.87 (17.57)			
	Others	105.44 (18.96)			
Professional title	Primary title	103.89 (16.25)	F=2.44	P=0.062	η_p^2=0.002
	Intermediate title	103.71 (15.30)			
	Associate professor	104.82 (15.13)			
	Professor	105.47 (15.14)			
Hospital scale	Northeast top 20 hospital	103.55 (14.00)	t=-2.93	p<0.01	cohen's d=0.10
	Ordinary tertiary hospitals	105.05 (16.86)			

Correlation analysis

The overall team interaction score was inversely related to burnout and the six factors “Communication”, “Coordination”, “Mutual help”, “Team goals”, “Work norms”, and “Cohesion and conflict resolution” were all significantly associated with burnout (see in Table 6).

Table 6. The correlation analysis between burnout and team interaction

Variables	Communication	Coordination	Mutual	Team	Work	Cohesion	Total

			help	goals	norms	and conflict resolution	score
Burnout	-0.21**	-0.22**	-0.22**	-0.23**	-0.24**	-0.24**	-0.25**

**denotes values significant at $p<0.01$

DISCUSSION

The aim of this study is to cross-culturally adapt and validate the team interaction scale among physicians in Chinese tertiary hospitals and to explore potential influencing factors of team interactions. The structure of the scale was adjusted based on the results of the CFA in the pilot survey and EFA in the large sampling survey, with the new model verified through CFA in the large sampling survey. The results suggest that the scale consisting of six dimensions and 17 items was reliable. The perceived team interaction score was significantly lower in male physicians, pediatricians, and the physicians from the larger scale tertiary hospitals. Additionally, the physicians perceived a significantly better team interaction associated with longevity on the team and physician burnout was negatively related to the perception of the team interaction.

In the pilot survey, the model fit indices of the original structure did not meet the criterion for moderate construct validity, suggesting that the cross-cultural validity of the original instrument was low and was inappropriate to apply to physicians in the Chinese tertiary hospital [20, 21]. The team interaction is determined mostly by the interpersonal factors, which may be influenced by politics, the economy and culture context [6]. As this scale of assessing team interaction was first introduced into a physician population and applied to a Chinese healthcare context, the target population difference and the culture gap may have contributed to the dimensional structure being unadaptable, leading to the low validity of the scale. The dimensional structure of the modified 17-item scale was different from that of Lechler's original six-

dimensional structure, with the addition of the “Team goals” dimension and the combination of the “Cohesion” and “Conflict resolution” dimensions, but it retained the “Communication”, “Coordination”, and “Work norms (effort)” dimensions [22-24]. The two items in the newly formed dimension “Team goals” contained wording for “reaching consensus” and “perception of responsibility for the team’s goals”, both highlighting the common goals in the team. Due to the content as well as the emphasis of team goals in team process research, the dimension was therefore named as “Team goals” [25]. The results implied that “Team goals” was one of the core attributes of team interaction in Chinese tertiary hospital physician teams. Changes in the dimensional structure revealed that the connotation and manifestation of team interaction may be differentiated by the target population and culture context. Among the six dimensions of the modified scale, there are two dimensions consisting of two items each, which may have an influence on the reliability of the scale. However, the Cronbach’s α coefficient of the 17-item scale in large sampling survey (α=0.98) was close to that in the pilot survey (α=0.98), which were an acceptable range for educational and psychological testing [24]. Additionally, the α coefficients of each factor of the final scale were all higher than 0.80, suggesting a high internal consistency of the TIS among Chinese tertiary hospital physicians. In the future, we will apply the 17-item short TIS as well as the 31-item full scale at the same time, to make a comparison of the two instruments, validating the short version scale for use to examine the physician team interaction.

The item mean score for the dimension “Communication” was the lowest (mean=6.02, SD=1.04), suggesting that physicians generally perceived poor

communication within their teams. However, previous research has demonstrated that communication is a key component in the team process [26]. Therefore, the administrators should make a concerted effort to improve communication within teams, resulting in a better team interaction.

Similar to other studies in which the female members tended to experience better team interaction, communication, and team cohesion , the current study demonstrated that perceived team interaction was higher in females than that in males [27]. Females tend to be more relational, which may contribute to a better team interaction [27]. Physicians older than 40 years perceived a significantly better team interaction, while those in their twenties perceived a more poor interaction, suggesting that age is a positive predicting factor of perceived team interaction. Similar findings also illustrated that the physicians and other health professionals appreciated better teamwork as working years increase [28-30]. It may be that elder physicians tend to have more longevity within their teams, allowing them to be better integrated with the team compared to the younger physicians. Moreover, elder physicians are qualified in clinical skills, teamwork ability, and other essential competencies, so they may be more respected and others may cooperate with them more, resulting in feelings of a better team interaction climate [29]. According to the results in our study, the administration should provide the physicians under 40 years old with more human care and growth opportunities.

In the current study, the score of team interaction was significantly different within disciplines, with pediatricians scoring the lowest. Facing the population of extreme age, pediatric physicians may encounter more challenges in

teamwork [31,32]. First of all, the difficulty in the coordination and cooperation with children brings obstacles to the physician's work, potentially increasing medical errors, hindering the team interaction within pediatric physicians [32-34]. Additionally, a feature of the pediatrics discipline is that it often relies on multidisciplinary teamwork, which is more demanding of the physicians' teamwork competencies, increasing potential issues with team interactions [32]. Above all, particular attention should be paid to the team interaction of pediatric physicians. The physicians in ordinary tertiary hospitals rated a significantly better team interaction than the tertiary hospitals of a larger scale. In China, the larger scale of tertiary hospitals are faced with the most serious diseases on the disease spectrum, which demands better teamwork. Additionally, the physicians have higher demands on the team process, possibly contributing to the relatively lower team interaction score. Another potential factor influencing team interactions is that the better tertiary hospitals usually have a larger group of physician teams, introducing more challenges to the interaction of the physicians within their teams. Furthermore, the physicians in the better tertiary hospitals are faced with a busier working environment, more critical cases, and more medical error, which may negatively influence the team process and exacerbate the physician burnout, risking the teamwork process [35,36]. Therefore, we suggest that more attention on team building needs to be paid in the tertiary hospitals of a larger scale.

Consistent with other reports that teamwork quality was related to health professional burnout, the results of the correlation analysis in the current study suggest that physician burnout was negatively associated with team

interaction. We propose that improvement in the environment of the team interaction may potentially relieve physician burnout [3, 10, 37, 38]. Therefore, physician well-being could not only be improved from the perspective of individual characteristics, but also from working environments like the team interaction [39].

Limitations

This survey was implemented in only one province of China, which may impair the generalization of our conclusions. However, the sample in this study was representative of this province and the demographic characteristic of the sample are quite similar with that of the national physician population shown in China Health and Family Planning Yearbook 2017 [40], thus the limitation in representativeness may be negligible. Furthermore, the causality of relationships between team interaction and the influencing factors could not be determined due to the cross-sectional nature of the survey. Future studies could address this problem by tracking their participants.

CONCLUSIONS

In a population of Chinese tertiary hospitals physicians, the adapted version of TIS containing 17 items and six dimensions is valid and reliable, taking culture gap into account. The adapted version of the TIS has the potential to be a valid tool for evaluating physicians' team interaction in other countries with similar culture or similar health care context. Hospital administrators

should increase their attention to the environment of team interaction, which may help to alleviate physician burnout.

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Author Contributions

DLW, WWS and HHL were responsible for the study design, WWS, ND, HHL, and WYZ were responsible for the translation of the questionnaire. WWS, WYZ and LS performed the data collection. WWS, HHL, and ND contributed to the analysis and interpretation of the data and were involved in drafting the manuscript and revising it critically for important intellectual content and gave final approval of the version to be published. All authors have read and approved the final manuscript.

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Competing interests

None declared.

Patient consent

Not required.

Ethics approval

This study was approved by the Bioethics Advisory Commission of China Medical University, Shenyang, China.

Data sharing statement

No additional data are available.

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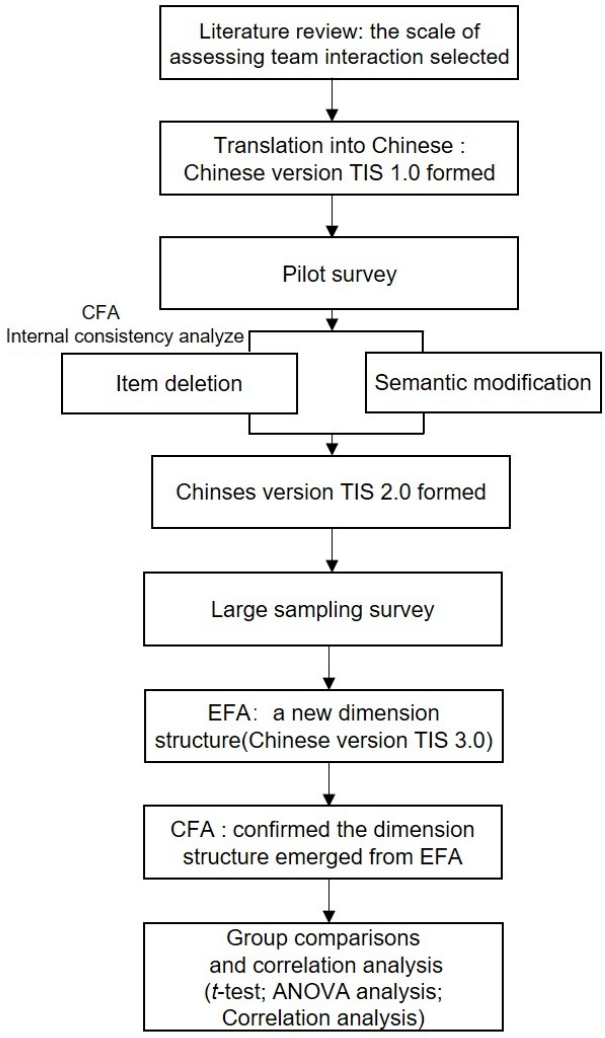

Figure 1 Steps and methods of cross-cultural adaptation and validation of TIS

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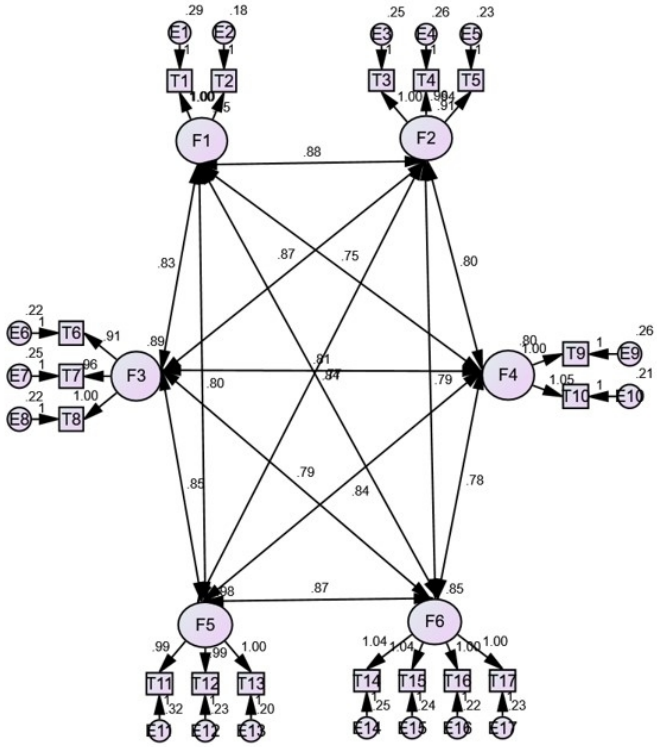

Figure 2 The path diagram of the 17-item TIS model emerged from EFA

142x139mm (150 x 150 DPI)

Additional file The factor loadings of the items in CFA before and after the modification process

Item	31-item scale	17-item scale in pilot survey	17-item scale in large sampling survey
1	0.79		
2	0.86	0.84	0.87
3	0.90		
4	0.91	0.90	0.92
5	0.91		
6	0.90	0.91	0.89
7	0.90	0.92	0.88
8	0.74		
9	0.91	0.89	0.88
10	0.74		
11	0.90	0.90	0.88
12	0.92	0.92	0.88
13	0.88		
14	0.83	0.83	0.89
15	0.92	0.91	0.87
16	0.85		
17	0.90	0.91	0.90
18	0.85	0.86	0.87
19	0.91	0.92	0.90
20	0.87		

21	0.91	0.90	0.91
22	0.84	0.85	0.90
23	0.86		
24	0.87	0.86	0.89
25	0.85		
26	0.89		
27	0.91		
28	0.92		
29	0.90	0.94	0.89
30	0.92	0.93	0.90
31	0.84		

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cross sectional reporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

		Reporting Item	Page Number
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	2,3
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	5,6
Objectives	#3	State specific objectives, including any prespecified hypotheses	6,7
Study design	#4	Present key elements of study design early in the paper	8-10
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	9,10
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	9,10

	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	11,12
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. Give information separately for for exposed and unexposed groups if applicable.	11,12
Bias	#9	Describe any efforts to address potential sources of bias	10,11,12
Study size	#10	Explain how the study size was arrived at	n/a
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	8,9
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	11,12
	#12b	Describe any methods used to examine subgroups and interactions	12
	#12c	Explain how missing data were addressed	12
	#12d	If applicable, describe analytical methods taking account of sampling strategy	n/a
	#12e	Describe any sensitivity analyses	n/a
Participants	#13a	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. Give information separately for for exposed and unexposed groups if applicable.	13,15
	#13b	Give reasons for non-participation at each stage	n/a
	#13c	Consider use of a flow diagram	8
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	13-16

	#14b	Indicate number of participants with missing data for each variable of interest	n/a
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	13-16
Main results	#16a	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	16-19
	#16b	Report category boundaries when continuous variables were categorized	13-16
	#16c	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—e.g., analyses of subgroups and interactions, and sensitivity analyses	16-22
Key results	#18	Summarise key results with reference to study objectives	23
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.	27
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	23-27
Generalisability	#21	Discuss the generalisability (external validity) of the study results	23,24,27
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	28,29

BMJ Open

Team interaction of tertiary hospital physicians: Preliminary psychometrics and influencing factors: A cross-sectional study in China

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Team interaction of tertiary hospital physicians: Preliminary psychometrics and influencing factors: A cross-sectional study in China

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Word count: 3959

ABSTRACT

Objectives

To administer a cross-cultural adaptation of the Team Interaction Scale (TIS), test its psychometric properties, and investigate influencing factors of team interactions in a Chinese tertiary hospital physician population.

Design

Cross-sectional survey

Settings

Two rounds of surveys, a pilot and a large sampling survey, were conducted in two and nine tertiary hospitals in Liaoning Province, China, respectively.

Participants

In the pilot survey, 363 of 390 physicians sampled were included in the analysis, resulting in an effective response rate of 93.08%. In the large sampling survey, the effective response rate was 89.10% (3,653 of 4,100 physicians).

Outcome measures

The TIS and a short version of a burnout scale were administrated to assess the physician's team interaction and burnout. Psychometric properties of TIS were tested by confirmatory factor analysis (CFA), exploratory factor analysis (EFA), and internal consistency analysis. Gender, age, discipline, education level, professional title, hospital scale, and burnout were explored as

influencing factors with independent sample *t*-tests, one-way ANOVAs, and a correlation analysis.

Results

Based on CFA, a 17-item modified scale was developed following the pilot survey. In the large sampling survey, EFA was conducted with half of the samples, producing six dimensions: “Communication”, “Coordination”, “Mutual help”, “Team goals”, “Work norms”, and “Cohesion and conflict resolution”. Fit of the modified model was confirmed by CFA with the other half of the samples (RMSEA=0.067, CFI=0.98, NFI=0.97, GFI=0.94, AGFI=0.92). A high Cronbach’s α coefficient of 0.98 demonstrated reliability of the modified scale. The team interaction score was significantly lower in younger physicians, in males, in pediatricians, and in physicians from larger scale tertiary hospitals. Team interaction scores were negatively associated with burnout.

Conclusions

The adapted TIS, containing 17 items and six dimensions, was reliable and valid in Chinese tertiary hospital physicians. To address physician burnout, team interaction should be highlighted.

Keywords

Team interaction; Scale; Physician; Burnout; Chinese

ARTICLE SUMMARY

Strengths and limitations of this study

- To the best of our knowledge, this is the first study with a sufficient and representative sample in China to introduce a comprehensive dimensional structure to assess the interaction of the physician's team.
- This study extended the research on physicians' team interaction by identifying the potential influential factors and provides empirical research evidence for the team interaction improvement.
- The design of these this two-survey studies ensured the reliability and validity of the results.
- The evaluation of the team interaction was self-report, which may be subject to reporting bias.
- This study was cross-sectional, so the causal relationships between team interaction and the influencing factors were not clear.

BACKGROUND

Teamwork has been confirmed to be fundamental to team efficiency, physician well-being, and patient safety, and is generally acknowledged as the core of patient-centred medical reform [1-5]. Team interaction is a dynamic, changing sequence of social actions between individuals that includes such activities as monitoring, coordination, and communication, and is a dominant process of teamwork [6]. Furthermore, the dynamics of the team interaction is associated with team efficiency and output in health care teams [7] and as such, we should pay more attention to health care team interactions.

Good team interactions are fundamental for physician teams around the world. Modern health care demands successful physician teamwork, particularly with inter-professional and cross setting teamwork [8], which are becoming increasingly demanding of the coordination and communication processes in the health care teams. Accordingly, the physician team interaction is a dominant factor of high efficiency health care.

A healthy team interaction is particularly important in Chinese physician teams. Chinese tertiary hospitals admit a majority of relatively serious cases on the spectrum of disease, resulting in a high intensity work environment, contributing to a documented high rate of physician burnout in Chinese tertiary hospitals [9]. As teamwork has been reported as a protective factor to physician burnout, Chinese tertiary hospital physicians could benefit from a

better team interaction, enabling a release of emotional exhaustion in physicians and an improvement in team efficiency [3, 10].

To date, however, there is a lack of empirical research on team interactions [6, 11]. Although emphasis has been placed on the assessment of team interaction and an accepted scale has been designed for the assessment of team interactions (e.g. the Team Performance Scale) [6, 12], the conceptual framework of team interaction in health care field has not been well explored. Lechler's scale of assessing team interaction measures the perceived social interaction within innovation and entrepreneurial team members. This scale, based on the theoretical concept of Hoegl, was widespread in entrepreneurial team research [13, 14]. While there have been studies on teamwork in China [15], there are no known existing studies that examine health care team interactions. Indeed, only a few instruments are particularly oriented towards the measurement of the team interaction within clinical physicians in China and abroad and none have proposed a comprehensive core dimension of team interaction in healthcare areas [6, 16].

The aim of this study, therefore, is to introduce an instrument, to confirm its ability to effectively measure the physician's perceived team interaction, to investigate the current status of the physician team interaction, and to explore potential influencing factors. Although the sound dimensional structure of assessing social interaction proposed by Lechler has been widespread in innovative team research, this is the first known time that it has been adapted and validated for a health care team [14]. We made it as the scale of assessing team interactions for physician populations and called it the Team

Interaction Scale (TIS). The psychometric properties of the scale were verified in the Chinese tertiary hospital physician population through two rounds of surveys. As burnout is negatively associated with teamwork [17], the relationship between burnout and team interaction was also explored in this study.

The introduction of this scale allows us to possess a valid tool of assessing the perceived team interaction of physicians in the healthcare team, to understand the present status of the team interaction, and to gain knowledge on the influencing factors of the team interaction, thus assisting healthcare policy makers and administrators to promote healthcare quality as well as physician well-being from a long-term, team perspective.

METHODS

Two rounds of surveys were conducted for the cross-cultural adaptation and validation of this study (see Figure 1 for steps and methods).

Figure 1 Steps and methods of cross-cultural adaptation and validation of TIS

Study design

Questionnaire of the pilot survey

The team interaction scale was translated independently into Chinese by one graduate student (W.S.) and one faculty member (N.D.) from the China Medical University and was subsequently compared and reviewed by five experienced clinical experts to confirm the cultural and academic relevance, which yielded the initial translated version. This version was then back-translated by two faculty members (W.Z. and H.L.) from the China Medical University, both of whom were blind to the initial English version scale. The comparison of back-translated scale and the original English scale lead to minor revisions, resulting in Chinese version 1.0 of the TIS. This version of the scale contained six factors: “Communication”, “Coordination”, “Mutual support”, “Work norms (effort)”, “Cohesion”, and “Conflict resolution”. All 31 self-report items were positively worded with a seven-point Likert-type scale, scored from 1 (strongly disagree) to 7 (strongly agree). A total score was

calculated from the sum of all items, ranging from 31 to 217, with a higher score indicating a better team interaction.

A socio-demographic questionnaire was also designed and applied to acquire personal characteristics of the physicians, including gender, age, discipline, and educational level.

Study sample of the pilot survey

In December 2016, 390 physicians from two tertiary hospitals in Liaoning Province, China, were invited to participate in the pilot survey. In order to provide a representative sample of clinical physicians in these tertiary hospitals, a randomized cluster sampling method was applied. Physicians from several disciplines, including Internal Medicine, Surgery, Obstetrics and Gynecology, Pediatrics, and other disciplines, including the departments of Pathology, Anesthesiology, Ear-nose-throat (ENT), Stomatology, Ophthalmology, Radiology, Ultrasound, the Intensive care unit (ICU), and the traditional Chinese medicine department were randomly chosen. The total number of physicians in each discipline was used as the sampling weight.

Questionnaire of the large sampling survey

We maintained the seven-point Likert-type scale for the modified scale and also included a socio-demographic questionnaire including gender, age, discipline, and educational level. A total score was calculated, ranging from 17 to 119, with a higher score indicating a better team interaction. To gather information for the psychometric properties of the scale and to confirm the

relationship between team interaction and physician burnout, a two-item burnout scale, previously confirmed to be reliable and valid, was also applied in the large sampling survey [18].

Study sample of the large sampling survey

The large sampling survey was conducted in 4,100 physicians from nine tertiary hospitals in Liaoning in February 2017. Considering the potential heterogeneity in the hospitals with different quality, a stratified cluster sampling method was used to select a representative sample from all physicians in Liaoning. Nine out of 37 tertiary hospitals in the Liaoning province were randomly chosen, including three of the top 20 tertiary hospitals in Northeast China (larger scale of tertiary hospitals) and six ordinary tertiary hospitals. In each tertiary hospital, physicians from Internal Medicine, Surgery, Obstetrics and Gynecology, Pediatrics, and other disciplines, including the departments of Pathology, Anesthesiology, ENT, Stomatology, Ophthalmology, Radiology, Ultrasound, the ICU, and the traditional Chinese medicine department were randomly chosen. The total number of physicians in each discipline was also used as the sampling weight.

Procedure & Ethics statement

The participants were selected and voluntarily participated in the study. We were permitted to distribute the paper questionnaire offline and maintain contact with each clinical physician team to ensure the survey was completed. Participants were able to consult trained researchers with any questions

regarding the survey. Each participant was assured of confidentiality and signed a written informed consent prior to completing the questionnaire. The coded self-report questionnaires were completed independently in approximately 10 minutes. The participants were not compensated and were able to withdraw from the survey at any time.

Both surveys in this study were approved by the Bioethics Advisory Commission of China Medical University, Shenyang, China, with the understanding that all information would be used only for our study and would be kept confidential.

Statistical analysis

The data from the pilot survey was analysed using CFA to test the psychometrics properties and to subsequently modify Lechler's model. Then the data from the large sampling survey were equally and randomly divided into two parts. Exploratory factor analysis (EFA) and CFA were performed with one of the two parts, separately. In other words, CFA was used to confirm the factor structure that emerged from EFA in a distinct data set.

Specifically, to evaluate the model fit in CFA, we used the maximum likelihood estimation and referred to various fit indices, including the chi-square value, Root Mean Square Error of Approximation (RMSEA), Goodness of Fit Index (GFI), Adjusted Goodness of Fit Index (AGFI), Comparative Fit Index (CFI), and Normed Fit Index (NFI). If GFI, AGFI, CFI and NFI were greater than 0.90 and the RMSEA was less than 0.08, the fit of the model was deemed

acceptable [19]. If the model poorly fit the data, the item causing high modification index (MI) values would be revised or even deleted. For example, if all the authors agreed the items suffered from cultural gaps, the entry would be deleted. After the deletion of any item, the model was rerun to calculate new fit indices and an updated modification index. The process was iterated until an acceptable model fit was achieved.

Before conducting EFA, a Kaiser–Meyer–Olkin (KMO) analysis was performed to test the adoption of the factor analysis. In EFA, a principal component factor extraction and varimax rotation was employed to illustrate the underlying dimensional structure of the Chinese version of the TIS and maximum likelihood method was used to estimate the model. Eigenvalues, relative magnitude, and direction of factor loadings were all examined to explain variance and communality.

Cronbach's α coefficients were calculated to estimate the internal consistency of each dimension and of the overall scale. An α coefficient of higher than 0.70 was considered acceptable and coefficients higher than 0.90 represent an extremely high level of reliability.

The correlations between the overall score of perceived team interaction and gender, age, discipline, education level, professional title, and hospital scale were evaluated with t-tests and a univariate Analysis of Variance (ANOVA) with all the samples in the large sampling survey. Effect sizes, including Cohen's d and partial Eta Squared (η_p^2), were also reported to illustrate the practical meaning of the difference. The effect sizes were referred to as small with d=0.20 and η_p^2=0.01, as medium with d=0.50 and η_p^2=0.06, and as large with d=0.80 and η_p^2=0.14 [20]. Pearson correlation coefficients were

calculated to explore the potential correlation between burnout and perceived team interaction on each dimension.

Missing values were imputed with the medians of the corresponding entries. All the data analyses were implemented via SPSS version 23 and AMOS version 24, and a *p*-value of less than 0.05 was considered significant.

Patient and public involvement

Neither patients nor the public were involved in the design or conducting of the study.

RESULTS

Preliminary psychometrics of the scale

Pilot survey

In the pilot survey, 390 questionnaires were distributed, with 363 completed questionnaires returned for an effective response rate of 93.08%. Males account for 51.50% of the sample and 50.70% of the participants were between the ages of 31 and 40 (Table 1).

Table 1. The distribution of demographic variables for the pilot survey.

Demographic	Category	N (%)
Gender	Male	187 (51.50%)
	Female	176 (48.50%)
Age	≤30	84 (23.10%)

	31-40	184 (50.70%)
	41-50	70 (19.30%)
	51-60	24 (6.60%)
	61-70	1 (0.30%)
Discipline	Internal medicine	139 (38.30%)
	Surgery	150 (41.30%)
	Obstetrics and Gynecology	24 (6.60%)
	Pediatrics	11 (3.00%)
	Others	39 (10.70%)
Education level	Doctor	172 (47.40%)
	Master	179 (49.30%)
	Bachelor	11 (3.00%)
	Others	1 (0.30%)
Professional title	Primary title	98 (27.2%)
	Intermediate title	138 (38.3%)
	Associate professor	93 (25.8%)
	Professor	31 (8.6%)

Other disciplines include the departments of Pathology, Anesthesiology, ENT, Stomatology, Ophthalmology, Radiology, Ultrasound, the ICU, and the traditional Chinese medicine department.

Other education level includes a college degree.

The results of the CFA in the pilot survey indicated a poor fit, with a chi square for the original 31-item scale of 2090.43, GFI=0.71, AGFI=0.66, PGFI=0.61, NFI=0.87, CFI=0.89, and RMSEA=0.11, suggesting that the original model didn't perform well in a Chinese physician population. We made semantic modifications and deleted some items per the modification index and

feedback from physicians and experts, resulting in the Chinese version 2.0 of the TIS with 17 items. The revised scale yielded a chi square value of 327.13 with acceptable fit indices (GFI=0.91, AGFI=0.86, PGFI=0.62, NFI=0.96, CFI=0.97, RMSEA=0.08). The factor loadings before and after modification were shown in an additional file 1.

In the pilot survey, internal consistency for each dimension and the overall scale were tested with the 17-item model after the modification process. All α coefficients were higher than 0.80, ranging from 0.90 to 0.98, indicating that all the items provided adequate contributions to the scale after the modification.

Large sampling survey

The 17-item TIS was distributed to physicians within nine representative hospitals in Liaoning Province, China. Among the 4,100 questionnaires distributed, 3,653 pieces were completed, leading to an effective response rate of 89.10%. The distribution of all demographic variables in the two parts of the sample were similar (see Table 2).

Table 2. The distribution of demographic variables in the two parts of the sample in the large sampling survey

Demographic variables	Category	N (%) (Part 1)	N (%) (Part 2)
Gender	Male	890 (48.80%)	887 (48.50%)
	Female	935 (51.20%)	941 (51.50%)

Age	21-30	313 (17.20%)	363 (19.90%)
	31-40	837 (45.90%)	773 (42.30%)
	41-50	397 (21.80%)	432 (23.60%)
	≥50	278 (15.20%)	260 (14.20%)
Discipline	Internal medicine	767 (42.00%)	777 (42.50%)
	Surgery	610 (33.40%)	597 (32.70%)
	Obstetrics and Gynecology	93 (5.10%)	96 (5.30%)
	Pediatrics	57 (3.10%)	56 (3.10%)
	Others	298 (16.30%)	302 (16.50%)
Education level	Doctor	376 (20.60%)	374 (20.50%)
	Master	839 (46.00%)	879 (48.10%)
	Bachelor	590 (32.30%)	562 (30.70%)
	Others	20 (1.10%)	13 (0.70%)
Professional title	Primary title	528 (28.9%)	520 (28.4%)
	Intermediate title	617 (33.8%)	619 (33.9%)
	Associate professor	317 (17.4%)	342 (18.7%)
	Professor	363 (19.9%)	346 (18.9%)
Hospital scale	Northeast top 20 hospital	879 (48.20%)	928 (50.80%)
	Ordinary tertiary hospital	946 (51.80%)	900 (49.20%)

Other disciplines include the departments of Pathology, Anesthesiology, ENT, Stomatology, Ophthalmology, Radiology, Ultrasound, the ICU, and the traditional Chinese medicine department.

Other education level includes a college degree.

A Kaiser–Meyer–Olkin (KMO) analysis was performed among half of the samples, yielding an index of 0.98. The result of Bartlett test of sphericity was significant at 36101.81 (p<0.01). Therefore, we conducted the EFA using a principal component factor extraction with a varimax rotation to explore the potential factor model (see Table 3 for results). Six factors emerged, called "Communication", "Coordination", "Mutual help", "Team goals", "Work norms" and "Cohesion and conflict resolution" (Chinese version 3.0, see additional file 2 for detail). The overall 17-item model accounted for 87.20% of the variance (see Table 3).

Table 3. Exploratory factor analysis for the 17-item TIS

Items *	Rotated factor coefficients					
	"Cohesion and conflict resolution"	"Coordination"	"Work norms"	"Mutual help"	"Communication"	"Team goals"
16.The team members solve conflicts and disagreements within the team completely	**0.77**	0.32	0.28	0.23	0.21	0.21
17.Disagreements between the team members are solved rapidly	**0.72**	0.31	0.33	0.18	0.23	0.26
15. Strong cohesion is a characteristic of the team.	**0.67**	0.29	0.40	0.30	0.18	0.19
14. Working in the team has the highest priority for every team member (in comparison with other jobs and private life).	**0.59**	0.22	0.48	0.32	0.25	0.18
4. The team members adjust closely the processing of	0.35	**0.70**	0.27	0.28	0.21	0.26

their tasks						
3. The team members share opinions and information spontaneously	0.32	**0.69**	0.31	0.22	0.34	0.17
5. Within the team related tasks are well coordinated.	0.35	**0.61**	0.23	0.35	0.25	0.37
11. The team members share the workload of the team equally.	0.32	0.28	**0.71**	0.13	0.22	0.36
12. Every team member works as best as she/he can in order to achieve the team's goals.	0.38	0.36	**0.70**	0.25	0.14	0.18
13. Every team member is completely integrated in the team	0.38	0.21	**0.68**	0.36	0.26	0.15
7. Discussions among the team members are always constructive and beneficial.	0.33	0.35	0.30	**0.66**	0.28	0.23
6. The team members support and complement each other as well as they can.	0.31	0.51	0.31	**0.54**	0.19	0.24
8. Proposals and contributions of the team members are always respected	0.33	0.38	0.29	**0.53**	0.23	0.42
1. The team members communicate intensively with each other.	0.30	0.32	0.22	0.24	**0.75**	0.27
2. I'm completely content with the exactness of information	0.23	0.55	0.38	0.23	**0.56**	0.11

provided by other team members.						
9. The team members reach consensus in every important issue	0.30	0.29	0.31	0.39	0.25	**0.63**
10. Every team member perceives herself/himself as responsible for the clinical team's goals	0.43	0.34	0.41	0.20	0.25	**0.54**
% Variance	19.87%	17.89%	17.60%	12.02%	10.13%	9.70%

***items listed in accordance with the value of coefficients**
Coefficients in bold were higher than 0.50

The 17-item model that emerged from EFA was verified with CFA with another half of the samples, yielding an excellent model fit with chi square = 955.75, RMSEA = 0.067, and CFI, NFI, GFI and AGFI scores all higher than 0.90, at 0.98, 0.97, 0.94, 0.92, respectively. The factor loadings were all higher than 0.80 (details in additional file 1), suggesting that all the items provided adequate contributions to each factor. The path diagram of the confirmed model is presented in Figure 2.

Figure 2 The path diagram of the 17-item TIS model emerged from EFA

Further, as the significant correlations between team interaction factors were observed (see additional file 3), a second-order confirmatory factor analysis was performed to test the potential structure of the scale. The path diagram of the second-order factor structure was presented in figure 3. The regression

weights of the six first-order factors were all greater than 0.90. The model fit of the second-order factor structure was acceptable with chi square = 1473.22, RMSEA = 0.081, CFI=0.96, NFI = 0.96, GFI = 0.91, and AGFI = 0.88.

Figure 3 The path diagram of the second-order factor structure

All Cronbach's α coefficients of the six dimensions and the overall scale of the final 17-item TIS were higher than 0.85, ranging from 0.87 to 0.98 (see Table 4).

Table 4. Cronbach's α coefficients and mean scores of the final 17-item TIS model

17-item TIS	α coefficients of final model (Item number of each domain)	Dimension Mean (SD)	Item Mean (SD)
Communication	0.88 (2)	12.05 (2.07)	6.02 (1.04)
Coordination	0.92 (3)	18.37 (2.93)	6.12 (0.98)
Mutual help	0.92 (3)	18.52 (2.85)	6.17 (0.95)
Team goals	0.87 (2)	12.36 (1.94)	6.18 (0.97)
Work norms	0.92 (3)	18.38 (3.04)	6.13 (1.01)
Cohesion and conflict resolution	0.94 (4)	24.63 (3.92)	6.16 (0.98)
Overall	0.98 (17)	104.31 (15.53)	6.13 (0.91)

Influencing factors

Group comparisons

The perceived team interaction score demonstrated significant differences in gender, age, discipline, and hospital scale, but had no significant difference between different education level and professional title (see Table 5 for results).

Female physicians perceived a better team interaction than the male physicians (t=-3.85, p<0.05) and there was a generally positive trend with respect to age and perception of team dynamics, specifically, physicians between 21 to 30 years old perceived the lowest team interaction and physicians older than 40 years rated a distinctly better team interaction (F=5.33, p<0.01). Additionally, the perceived team interaction score was significantly higher in those practicing internal medicine than in surgeons, while pediatricians scored the lowest of all professions (F=6.73, p<0.01). Furthermore, team interactions were rated better in ordinary tertiary hospitals than that in the northeast top 20 tertiary hospitals (hospitals of a larger scale) (t=-2.93, p<0.01).

Effect sizes showed that Cohen's d of gender and hospital scale were 0.21 and 0.10, indicating a non-overlap of 14.7% and 7.7% in the two distributions. Using η_p^2 as the measure of association, the value of 0.004, 0.007, 0.001, 0.002 showed a relatively small difference of perceived team interaction among different age groups and disciplines.

Table 5. Group comparisons of team interaction score within demographic and working variables

Variables	Category	Mean (SD)	*F/t*	*p* -value	Effect Size
Gender	Male	103.29 (16.28)	*t*=-3.85	*p*<0.05	cohen's d=0.21
	Female	105.30 (14.72)			
Age	21-30	102.40 (17.49)	*F*=5.33	*p*<0.01	η_p^2=0.004
	31-40	104.26 (15.26)			
	41-50	105.40 (14.97)			
	⩾50	105.15 (14.32)			
Discipline	Internal medicine	105.40 (14.19)	*F*=6.73	*p*<0.01	η_p^2=0.007
	Surgery	102.64 (16.81)			
	Obstetrics and Gynecology	105.55 (12.81)			
	Pediatrics	101.75 (20.43)			
	Others	104.91 (15.55)			
Education level	Doctor	104.11 (13.44)	*F*=0.85	*P*=0.467	η_p^2=0.001
	Master	103.99 (14.83)			
	Bachelor	104.87 (17.57)			
	Others	105.44 (18.96)			
Professional title	Primary title	103.89 (16.25)	*F*=2.44	*P*=0.062	η_p^2=0.002
	Intermediate title	103.71 (15.30)			
	Associate professor	104.82 (15.13)			
	Professor	105.47 (15.14)			

Hospital scale	Northeast top 20 hospital	103.55 (14.00)	*t*=-2.93	*p*<0.01	cohen's d=0.10
	Ordinary tertiary hospitals	105.05 (16.86)			

Correlation analysis

The overall team interaction score was inversely related to burnout and the six factors “Communication”, “Coordination”, “Mutual help”, “Team goals”, “Work norms”, and “Cohesion and conflict resolution” were all significantly associated with burnout (see in Table 6).

Table 6. The correlation analysis between burnout and team interaction

Variables	Communication	Coordination	Mutual help	Team goals	Work norms	Cohesion and conflict resolution	Total score
Burnout	-0.21**	-0.22**	-0.22**	-0.23**	-0.24**	-0.24**	-0.25**

**denotes values significant at *p*<0.01

DISCUSSION

The aim of this study is to cross-culturally adapt and validate the team interaction scale among physicians in Chinese tertiary hospitals and to explore potential influencing factors of team interactions. The structure of the scale was adjusted based on the results of the CFA in the pilot survey and EFA in the large sampling survey, with the new model verified through CFA in the large sampling survey. The results suggest that the Chinese version of the scale consisting of six dimensions and 17 items was reliable. The perceived team interaction score was significantly lower in male physicians, pediatricians, and the physicians from the larger scale tertiary hospitals. Additionally, the physicians perceived a significantly better team interaction associated with longevity on the team and physician burnout was negatively related to the perception of the team interaction.

In the pilot survey, the model fit indices of the original structure did not meet the criterion for moderate construct validity, suggesting that the cross-cultural validity of the original instrument was low and was inappropriate to apply to physicians in the Chinese tertiary hospital [21, 22]. The team interaction is determined mostly by the interpersonal factors, which may be influenced by politics, the economy and culture context [6]. As this scale of assessing team interaction was first introduced into a physician population and applied to a Chinese healthcare context, the target population difference and the culture gap may have contributed to the dimensional structure being unadaptable, leading to the low validity of the scale. The dimensional structure of the modified 17-item scale was different from that of Lechler's original six-

dimensional structure, with the addition of the “Team goals” dimension and the combination of the “Cohesion” and “Conflict resolution” dimensions, but it retained the “Communication”, “Coordination”, and “Work norms (effort)” dimensions [23-25]. The two items in the newly formed dimension “Team goals” contained wording for “reaching consensus” and “perception of responsibility for the team’s goals”, both highlighting the common goals in the team. Due to the content as well as the emphasis of team goals in team process research, the dimension was therefore named as “Team goals” [26]. The results implied that “Team goals” was one of the core attributes of team interaction in Chinese tertiary hospital physician teams. Changes in the dimensional structure revealed that the connotation and manifestation of team interaction may be differentiated by the target population and culture context. Among the six dimensions of the modified scale, there are two dimensions consisting of two items each, which may have an influence on the reliability of the scale. However, the Cronbach’s α coefficient of the 17-item scale in large sampling survey (α=0.98) was close to that in the pilot survey (α=0.98), which were an acceptable range for educational and psychological testing [25]. Additionally, the α coefficients of each factor of the final scale were all higher than 0.80, suggesting a high internal consistency of the TIS among Chinese tertiary hospital physicians. The high regression weights in the second-order confirmatory factor analysis supported that the second-order factor structure existed and the six sub-dimensions contributed equally to explain the team interaction. The acceptable model fit indicated that the team interaction could be manifested through the six sub-dimensions yield by the factorial analysis. In the future, we will apply the 17-item short TIS as well as the 31-item full

scale at the same time, to make a comparison of the two instruments, validating the short version scale for use to examine the physician team interaction.

The item mean score for the dimension “Communication” was the lowest (mean=6.02, SD=1.04), suggesting that physicians generally perceived poor communication within their teams. However, previous research has demonstrated that communication is a key component in the team process [27]. Therefore, the administrators should make a concerted effort to improve communication within teams, resulting in a better team interaction.

Similar to other studies in which the female members tended to experience better team interaction, communication, and team cohesion, the current study demonstrated that perceived team interaction was higher in females than that in males [28]. Females tend to be more relational, which may contribute to a better team interaction [28]. Physicians older than 40 years perceived a significantly better team interaction, while those in their twenties perceived a more poor interaction, suggesting that age is a positive predicting factor of perceived team interaction. Similar findings also illustrated that the physicians and other health professionals appreciated better teamwork as working years increase [29-31]. It may be that elder physicians tend to have more longevity within their teams, allowing them to be better integrated with the team compared to the younger physicians. Moreover, elder physicians are qualified in clinical skills, teamwork ability, and other essential competencies, so they may be more respected and others may cooperate with them more, resulting in feelings of a better team interaction climate [30]. According to the results in

our study, the administration should provide the physicians under 40 years old with more human care and growth opportunities.

In the current study, the score of team interaction was significantly different within disciplines, with pediatricians scoring the lowest. Facing the population of extreme age, pediatric physicians may encounter more challenges in teamwork [32, 33]. First of all, the difficulty in the coordination and cooperation with children brings obstacles to the physician's work, potentially increasing medical errors, hindering the team interaction within pediatric physicians [33-35]. Additionally, a feature of the pediatrics discipline is that it often relies on multidisciplinary teamwork, which is more demanding of the physicians' teamwork competencies, increasing potential issues with team interactions [33]. Above all, particular attention should be paid to the team interaction of pediatric physicians. The physicians in ordinary tertiary hospitals rated a significantly better team interaction than the tertiary hospitals of a larger scale. In China, the larger scale of tertiary hospitals are faced with the most serious diseases on the disease spectrum, which demands better teamwork. Additionally, the physicians have higher demands on the team process, possibly contributing to the relatively lower team interaction score. Another potential factor influencing team interactions is that the better tertiary hospitals usually have a larger group of physician teams, introducing more challenges to the interaction of the physicians within their teams. Furthermore, the physicians in the better tertiary hospitals are faced with a busier working environment, more critical cases, and more medical error, which may negatively influence the team process and exacerbate the physician burnout, risking the teamwork process [36, 37]. Therefore, we suggest that more

attention on team building needs to be paid in the tertiary hospitals of a larger scale.

Consistent with other reports that teamwork quality was related to health professional burnout, the results of the correlation analysis in the current study suggest that physician burnout was negatively associated with team interaction. We propose that improvement in the environment of the team interaction may potentially relieve physician burnout [3, 10, 38, 39]. Therefore, physician well-being could not only be improved from the perspective of individual characteristics, but also from working environments like the team interaction [40].

Limitations

This survey was implemented in only one province of China, which may impair the generalization of our conclusions. However, the sample in this study was representative of this province and the demographic characteristic of the sample are quite similar with that of the national physician population shown in China Health and Family Planning Yearbook 2017 [41], thus the limitation in representativeness may be negligible. In the final structure of the TIS, there were two sub-scales only formed by two items, which may drive to the instabilities of the scale in other samples. However, the validity of the scale has been fully demonstrated in the discussion section, and the TIS has been confirmed a valid instrument for the assessment of team interaction. Furthermore, the causality of relationships between team interaction and the influencing factors could not be determined due to the cross-sectional nature

of the survey. Future studies could address this problem by tracking their participants.

CONCLUSIONS

In a population of Chinese tertiary hospitals physicians, the adapted version of TIS containing 17 items and six dimensions is valid and reliable, taking culture gap into account. The adapted version of the TIS has the potential to be a valid tool for evaluating physicians' team interaction in other countries with similar culture or similar health care context. Hospital administrators should increase their attention to the environment of team interaction, which may help to alleviate physician burnout.

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Author Contributions

DLW, WWS and HHL were responsible for the study design, WWS, ND, HHL, and WYZ were responsible for the translation of the questionnaire. WWS, WYZ and LS performed the data collection. WWS, HHL, and ND contributed to the analysis and interpretation of the data and were involved in drafting the manuscript and revising it critically for important intellectual content and gave final approval of the version to be published. All authors have read and approved the final manuscript.

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Competing interests

None declared.

Patient consent

Not required.

Ethics approval

This study was approved by the Bioethics Advisory Commission of China Medical University, Shenyang, China.

Data sharing statement

No additional data are available.

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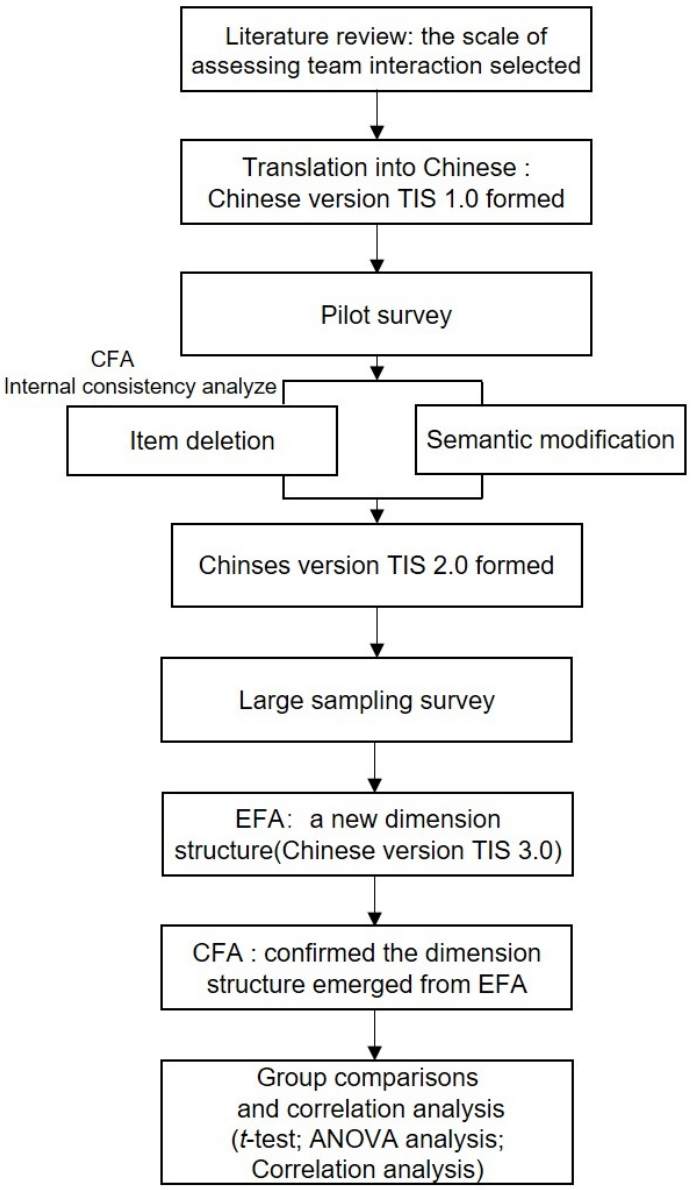

Figure 1 Steps and methods of cross-cultural adaptation and validation of TIS

124x174mm (150 x 150 DPI)

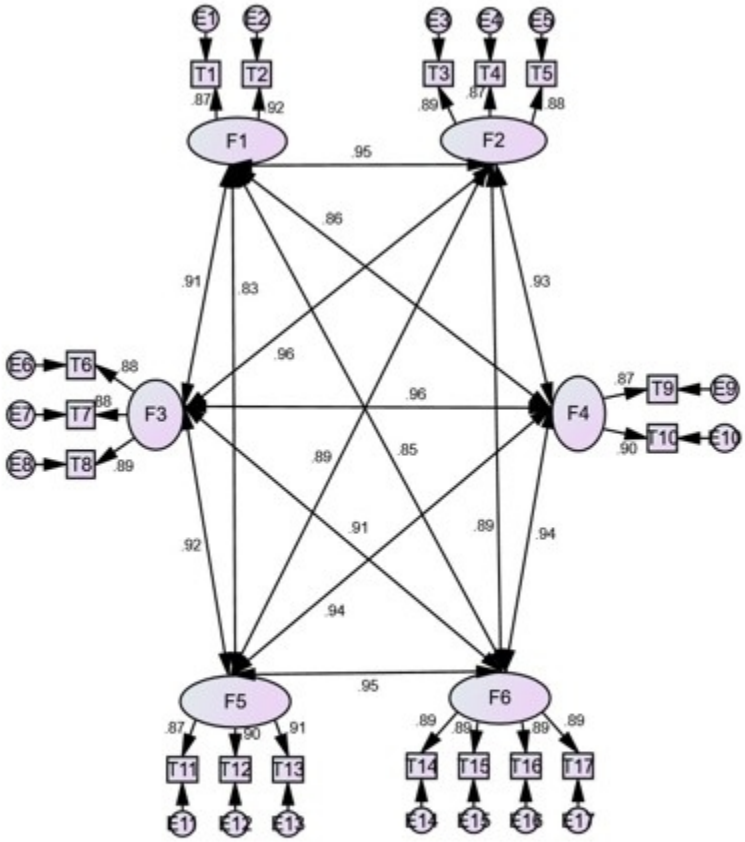

Figure 2 The path diagram of the 17-item TIS model emerged from EFA

115x149mm (96 x 96 DPI)

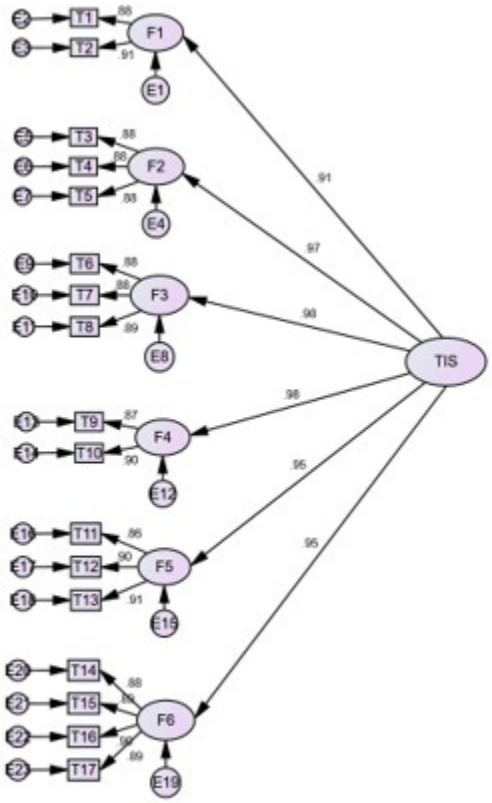

Figure 3 The path diagram of the second-order factor structure

89x116mm (96 x 96 DPI)

Additional file 1 The factor loadings of the items in CFA before and after the modification process

Item	31-item scale	17-item scale in pilot survey	17-item scale in large sampling survey
1	0.79		
2	0.86	0.84	0.87
3	0.90		
4	0.91	0.90	0.92
5	0.91		
6	0.90	0.91	0.89
7	0.90	0.92	0.88
8	0.74		
9	0.91	0.89	0.88
10	0.74		
11	0.90	0.90	0.88
12	0.92	0.92	0.88
13	0.88		
14	0.83	0.83	0.89
15	0.92	0.91	0.87
16	0.85		
17	0.90	0.91	0.90
18	0.85	0.86	0.87
19	0.91	0.92	0.90
20	0.87		

21	0.91	0.90	0.91
22	0.84	0.85	0.90
23	0.86		
24	0.87	0.86	0.89
25	0.85		
26	0.89		
27	0.91		
28	0.92		
29	0.90	0.94	0.89
30	0.92	0.93	0.90
31	0.84		

Additional file 2 The validated 17-item TIS for Chinese tertiary hospital physician (English version and Chinese version).

Items	Dimensions
01. The team members communicate intensively with each other.	Communication
01. 您所在团队的成员之间沟通很深入	沟通
02. I'm completely content with the exactness of information provided by other team members.	Communication
02. 您对团队其他成员所提供信息的准确性感到满意	沟通
03. The team members share opinions and information spontaneously	Coordination
03. 您所在团队成员之间自发地分享意见和信息	协调
04. The team members adjust closely the processing of their tasks	Coordination
04. 团队成员在任务完成的过程中紧密协调	协调
05. Within the team related tasks are well coordinated.	Coordination
05. 在团队内部，工作任务能被很好地组织协调	协调
06. The team members support and complement each other as well as they can.	Mutual help
06. 您所在团队成员之间尽可能地互相帮助和支持	相互支持

07. Discussions among the team members are always constructive and beneficial.	Mutual help
07. 您所在团队成员之间的讨论通常是富有建设性和有利于工作的	相互支持
08. Proposals and contributions of the team members are always respected	Mutual help
08. 团队成员的建议和贡献总是能得到大家的尊重	相互支持
09. The team members reach consensus in every important issue	Team goals
09. 团队成员在重要问题上能达成一致	团队共识
10. Every team member perceives herself/himself as responsible for the clinical team's goals	Team goals
10. 每位团队成员都认为自己对团队的目标有责任	团队共识
11. The team members share the workload of the team equally.	Work norms
11. 每位团队成员平等地分担团队的工作量	工作规范
12. Every team member works as best as she/he can in order to achieve the team's goals.	Work norms
12. 每位团队成员为完成团队目标尽自己最大努力工作	工作规范
13. Every team member is completely integrated in the team	Work norms

13. 每位团队成员都完全融入到团队里	工作规范
14. Working in the team has the highest priority for every team member (in comparison with other jobs and private life).	Cohesion and conflict resolution
14. 与其它工作和个人生活相比，成员最优先考虑团队的工作	凝聚力与冲突解决
15. Strong cohesion is a characteristic of the team.	Cohesion and conflict resolution
15. 您所在团队具有强大的内聚力	凝聚力与冲突解决
16.The team members solve conflicts and disagreements within the team completely	Cohesion and conflict resolution
16. 团队成员能够完全在团队内部解决冲突和分歧	凝聚力与冲突解决
17.Disagreements between the team members are solved rapidly	Cohesion and conflict resolution
17. 团队成员能很快地解决分歧	凝聚力与冲突解决

Additional file 3 The correlations between team interaction factors in first-order confirmatory factor analysis

	F1	F2	F3	F4	F5	F6
F1	1.00					
F2	0.95	1.00				
F3	0.91	0.96	1.00			
F4	0.86	0.93	0.96	1.00		
F5	0.83	0.89	0.92	0.94	1.00	
F6	0.85	0.89	0.91	0.94	0.95	1.00

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cross sectional reporting guidelines, and cite them as:

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		Reporting Item	Page Number
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	2,3

Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	5,6
Objectives	#3	State specific objectives, including any prespecified hypotheses	6,7
Study design	#4	Present key elements of study design early in the paper	9-11
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	9,10
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	9,10
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	11,12
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. Give information separately for for exposed and unexposed groups if applicable.	11,12,13
Bias	#9	Describe any efforts to address potential sources of bias	11,13
Study size	#10	Explain how the study size was arrived at	n/a
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	12,13

Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	12,13
	#12b	Describe any methods used to examine subgroups and interactions	13
	#12c	Explain how missing data were addressed	13
	#12d	If applicable, describe analytical methods taking account of sampling strategy	n/a
	#12e	Describe any sensitivity analyses	n/a
Participants	#13a	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. Give information separately for for exposed and unexposed groups if applicable.	14,16
	#13b	Give reasons for non-participation at each stage	n/a
	#13c	Consider use of a flow diagram	8
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	14-17
	#14b	Indicate number of participants with missing data for each variable of interest	n/a
Outcome data	#15	Report numbers of outcome events or summary measures.	14-17

		Give information separately for exposed and unexposed groups if applicable.	
Main results	#16a	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	17-21
	#16b	Report category boundaries when continuous variables were categorized	14-17
	#16c	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—e.g., analyses of subgroups and interactions, and sensitivity analyses	17-25
Key results	#18	Summarise key results with reference to study objectives	26
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.	30,31
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	26-30
Generalisability	#21	Discuss the generalisability (external validity) of the study results	30,31
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	32

the present article is based