

Impact of team-based learning on radiology education: A systematic review and meta-analysis

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Research article

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Abstract

Background: The team-based learning method has been applied as an educational method in radiology education and there are only inconsistent and inconclusive individual results. A meta-analysis was performed to evaluate the effects of team-based learning on radiology education.

Method: Databases were searched from inception up to August 2019. The standard mean difference (SMD) with its 95% confidence interval (95% CI) was used to determine the over effects of team-based learning teaching method compared with the lecture-based learning or traditional teaching method.

Results: Twelve studies involving 1371 participants were included in this meta-analysis. Of them, the sufficient data of 11 studies suggested team-based learning teaching method had a positive effect on the theoretical scores compared with the lecture-based learning or traditional teaching method (SMD=1.07, 95% CI [0.50, 1.63]). 9 of 10 studies provided sufficient data showing team-based learning teaching method was in favour of improving skill scores (SMD=0.68, 95% CI [0.19, 1.17]). Most of the including studies provided the subjective questionnaire surveys which showed the participants believed team-based learning raise their learning interest, team cooperation ability and interpersonal communication.

Conclusion: The team-based learning teaching method could not only improve the scores of theoretical and skill knowledge in medical imaging courses but also encourage students to learn by themselves. The heterogeneity of the included studies must be noticed, and well-designed studies about this topic are needed for further study.

Background

The traditional teaching method, known as lecture-based learning (LBL), is a teacher-centered, lecture-centered pedagogical approach. Usually, medical students have been accustomed to the traditional lecture courses, in which all they need to do is listening to the instructor, viewing PowerPoint presentations, and taking notes. This approach cannot fulfill the study target of medical imaging course. [1] [2] There are new pedagogical approaches as supplementary teaching methods, for instance, team-based learning (TBL), problem-based learning (PBL) and case-based learning (CBL). To note, TBL was originally developed for use in business courses as a small group learning [3], which can enhance students' learning motivation, and encourage students to apply knowledge to solve problem [1]. In recent times, there are multiple medical schools trying this new pedagogical approach. [3] This approach also attracts a lot of attention for the following reasons: permitting a large student-teacher ratio compared with PBL, raising the interest of students for certain courses, and enhancing their ability of teamwork and critical thinking [4]. Besides, it provides great opportunity and challenge for peer teachers by leading and organizing the class, instead of just giving lecture all the time. [5] There are three phases in the original application of TBL. At the very beginning, students need to learn by themselves before the TBL session following the instructions given by the teachers. In the second phase, students will have an individual assurance test including definitions and advanced knowledge in the self-learning materials, and retake

the same test in teams, usually containing 5 to 7 students. In the third phase, this test is answered by immediate feedback assessment technique, in order to encourage the students to work together to get the right answer. During this whole process, the teams learn some basic knowledge and try their best to solve the clinical problems with immediate feedback from their teammates and teachers[6]

Medical imaging is a highly practical subject which requires more time on identifying specific imaging signs of various diseases.[7] In such a short period of time, it is impossible for students to tell the difference between the pictures. Only by stressing the explanations of words cannot complete the essential practice for students to get correct diagnostic method and build scientific analysis ideas. Emphasizing or skipping one or more phases of TBL is allowable to simplify the TBL process to adapt to the actual teaching situation. [4]. The result of a systematic review involving fourteen studies in health professions education, showed more improvement of grades in the TBL teaching group compared with non-TBL group[8] and without any decrease in grades for the TBL teaching group. Participants' attitudes toward TBL courses are usually supportive, stressing the significance of active learning attitude and interaction with their team members[4]. On the other hand, there are few studies about the effectiveness of TBL teaching in medical imaging education. In the published studies, there are few studies on the effectiveness of TBL teaching in the medical radiology courses between TBL and LBL. In this research, we displayed the first systematic review and meta-analysis of the effects of TBL in medical radiology education.

Method

2.1 Search strategy

We systematically searched the databases, including PubMed, Medline and Embase, China National Knowledge Infrastructure (CNKI), Chinese Wanfang Database, and Chinese VIP information database. Following the procedure in *Figure 1*, we retrieved the studies from inception up to August 2019 with no language limits. The used key words and heading terms were as followed: "(TBL OR team-based learning) AND ((medical imaging) OR radiology or MRI OR CT OR Echo OR ultrasound)". Articles matching the criteria were retrieved for further data extraction and quality assessment. All articles were included by manual operation.

Figure 1. Flowchart of selection process of the included studies.

2.1 Inclusion criteria and exclusion criteria

The selected studies should follow these criteria, including TBL teaching method used in the medical imaging courses and compared to the traditional or LBL teaching, as randomized controlled studies. Studies that did not display the complete examination results or they were reviews or letters were excluded. The included studies are following these properties: Participants: medical students and trainee doctors in the Medical colleges and the teaching hospitals; Intervention: using TBL (team-based learning) in medical imaging related medical course teaching; Comparator: using traditional teaching or LBL

(lecture-based learning) or CBL (case-based learning); Outcomes: theoretical scores and skill scores of medical imaging course; Study design: randomized controlled studies.

2.2 Data extraction and Quality assessment

Screening of the included studies was done by three reviewers independently, considering inclusion criteria. Then, we extracted and cross-checked the data. The information of the included studies including author name, publication year, sample size (total, test and control), medical imaging course's name and type, participant characteristics, theoretical scores and skill score was extracted. Quality assessments of the involved studies were evaluated with the risk of bias table according to the Cochrane Collaboration by Review Manager 5.3 (Cochrane Collaboration, Copenhagen, Denmark).

2.3 Statistical analysis

The extracted data were analysed using Review Manager version 5.3 (Cochrane Collaboration, Copenhagen, Denmark). Since the outcome measure (examination score) of efficacy was a continuous outcome, the standardized mean difference (SMD) with 95% confidence interval (CI) was applied to determine the efficacy of the TBL model for medical imaging course teaching. Forest plots were drawn to show the point estimations of each study. The homogeneity of this included study was based on the Q statistic and I^2 statistic. In this study, I^2 value of $>50\%$ or P -value of <0.05 were assumed to be statistically significant. When moderate to high homogeneity was improved, we used the random-effects model to combine the SMD with 95% CI. If not, a fixed-effects model was used. Funnel plots and Begg's tests were used to evaluate the degree of publication bias with STATA 12.0 software.

Result

3.1 Search results

In this study, we initially found 343 relevant studies, and *Figure. 1* is the flow chart of the article selection process. The potentially eligible studies were identified by the search strategy described in the Search strategy in the related databases. After removing the duplications, we found 215 relevant articles at the beginning. After the title-abstract screening, 182 studies were excluded, if they were reviews or letters, or with different topics. 17 studies were excluded because of their incomplete data. 12 studies were included in this meta-analysis in total, and all of them were published in Chinese.

3.2 Study characteristic and study quality

The characteristics of the included studies are shown in *Table 1*. They were published in Chinese, from Chinese National Knowledge Infrastructure (Chinese database), Wanfang Data (Chinese database), VIP Information (Chinese database) between 2014 and 2019. The effectiveness of TBL on Medical radiology teaching compared with the traditional teaching were evaluated by the theoretical scores and/or skill scores. A total of 1371 participants (697 in test group and 692 in control group). We took the freshmen

and the sophomore as the lower grade, and the older students and the trainee doctors were taken as the higher grade, There were 5 studies carried out with the lower grade[9–13], and 7 studies carried out in higher grade[14–20].

The risk of bias assessment of the 12 included studies are shown in *Figure. 2* including the aspects of random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcomes assessment, incomplete outcome data, selective reporting, and other bias.

Figure. 2 Summary of each methodological quality item presented as percentages across all included studies.

3.3 Effects of TBL on theoretical scores

The theoretical scores were evaluated by the multiple-choice questions, gap fillings, and essay questions to test how well the theoretical knowledge was mastered by the students. The effects of TBL teaching compared to the LBL, CBL, or traditional teaching on theoretical scores were reported in all of the 12 included studies, involving 1371 medical students and the trainee doctors (TBL group = 679, control group = 692), As it is shown in the *Figure.3*, there is a high degree of heterogeneity across the included studies ($I^2 = 95\%$, $P < 0.00001$). We used the random-effects model for this part of analysis. The result showed there is a significant difference in the theoretical scores (SMD = 1.07, 95% CI [0.05, 1.63] in favour of TBL. To know the differences of TBL on different participants, we divided them into two subgroups, including the higher grade subgroup (the students older than the sophomore and the trainee doctors)[14–16, 18–21] and the lower grade subgroup (the freshmen and the sophomore)[9–13, 21, 22]. The statistically significant differences were shown in both of the subgroups, the higher-grade subgroup (SMD = 0.63, 95% CI [0.28,0.97] and the lower grade subgroup (SMD = 1.74, 95% CI [0.47, 3.02]).

Figure.3 Forest plot for the effects of TBL on knowledge scores compared with the traditional teaching or lecture-based learning. TBL = team-based learning

3.4 Effects of TBL on skill scores

The skill scores were evaluated by the film reading, medical record writing, and cases diagnosis to test how well the students use their clinical skills. The effects of TBL teaching compared to the LBL, CBL, or traditional teaching on skill scores were reported in 9 of the 12 included studies, involving 1157 medical students and the trainee doctors (TBL group = 579, control group = 578), As it is shown in the *Figure.4*, there is a high degree of heterogeneity across the included studies ($I^2 = 93\%$, $P < 0.00001$). Random-effects model was used to combine the SMD for this part of analysis. The result suggested that there is a significant difference in the skill scores (SMD = 0.68, 95% CI [0.19, 1.17]) in favour of TBL. To test the differences of TBL on different participants, we divided them into two subgroups, including the higher-grade subgroup (the students older than the sophomore and the trainee doctors)[14–18] and the lower grade subgroup (the freshmen and the sophomore).[9–12] The statistically significant differences were

shown in the lower grade subgroups (SMD = 0.85, 95% CI [0.05, 1.64]. but there were not statistically significant differences in the higher grade subgroup (SMD = 0.56, 95% CI [-0.21,1.33].

Figure.4 Forest plot for the effects of TBL on skill scores compared with the traditional teaching or lecture-based learning. TBL = team-based learning

3.5. Sensitivity analysis and publication bias

Sensitivity analyses were performed to evaluate the stability of the results. Begg's funnel plots of the SMD against the standard error of SMD suggested no substantial asymmetries in theoretical scores (*Figure.5A*) and skill scores analysis (*Figure. 5B*). Egger's regression test also showed no evidence of publication bias in theoretical scores ($t = 0.33, p = 0.748$) and skill scores analysis ($t = 1.01, p = 0.344$)

Figure5. Funnel plot of the included studies for publication bias. (A)Evaluation of knowledge scores, divided into higher-grade subgroup and lower-grade subgroup. (B) Evaluation of skill scores, divided into higher-grade subgroup and lower-grade subgroup.

Discussion

Recently, many new teaching methods have emerged such as PBL, TBL etc. It is very important for teachers to find out which pedagogical approach should be used in each situation.[23, 24] As medical imaging teaching is divided into theoretical courses and practical courses, which are of great significance for improving the students' understanding of theoretical knowledge and practical ability respectively[25] and there are few articles implying the effectiveness of TBL method in medical radiology in the published studies. We carried out this systematic review and meta-analysis, aiming to probe whether TBL is a better pedagogical approach compared to LBL in medical radiology courses.

This systematic analysis showed that TBL was superior to LBL in both theoretical and skill scores. Our results have accumulated the findings of recent TBL studies in Chinese medical imaging education including CT, MRI, and ultrasonic. Their theoretical and skill scores have improved in favour of TBL. Besides, both of theoretical scores and skill scores of lower-grade subgroups is much lower than the higher-grade subgroup. The reason why the lower-grade students will get more benefits reflecting in the theoretical scores from the switching the teaching approach is that they do not have enough basic knowledge of anatomy and pathology so they can improve their ability quickly. It's easy to raise their level from the green-hand to being able to pass the exam, but it takes much more time to raise their scores from 70 to 100. Besides, the elevation of theoretical scores is higher than the skill scores. TBL encourages students to apply their knowledge to solve practical problems. The LBL makes the students rely on passive acceptance of knowledge.

There were not statistically significant differences in the higher-grade subgroup of skill scores. In this study approach, the students are required to search database, read materials, think independently, and work as a team, so it is good chance for the freshman and sophomore to elevate the theoretical level. The ability of film reading, medical record writing, and cases diagnosis requires a lot of accumulation and clinical practice, so their skill scores haven't developed significantly. There are other possible reasons to explain this inconsistent result. The TBL is a novelty for most of lower-grade Chinese medical students, so their learning interests can be more easily and strongly inspired by the PBL teaching method which doesn't work for high-grade students.

Despite many advantages of TBL been described above, there are some problem applying TBL in Chinese radiology education extensively. First, some students find it hard to get used to TBL, some even doubt about it. Feedback from students suggested that they prefer to continue with the traditional approach to case-based learning activities that they were accustomed to, rather than engage in the larger group. At the same time, nonetheless uneasiness question as 'will it really work?' prevails among students. [26]. Second, the pre-class preparation of TBL is time-consuming and laborious. Qualitative evidence has suggested that students liked the opportunities to learn from peers, enjoyed team discussions[27]. A study suggested that as preparation was low among residents and students, the preparatory work may limit potential knowledge acquisition and overall impact of the TBL[28]. Third, problems about discussion and time may emerge during class time. When students discuss, they tend to be magnified and simplistic. The former refers to the purposelessness of discussion; the latter refers to the single diagnosis and then the discussion is forced to stop.[18] Excessive class size and limited class time cause that most students can not get the chance to speak[11]. Fourth, team work may cause some problem in scores and learning attitude.[29] There are some differences in the participation of the group members in the TBL teaching method, but the final results are basically the same, which will cause some students to feel unfair. The effect of teamwork learning will be influenced by the learning attitude of the team members. Although 81% of students said that they had to prepare before TBL class and believed they had to contribute to the learning of their team, only 52% believed that they were accountable for the team learning[30].

There are still many limitations of our study. A shortage of report about large-scale studies on the effects of LBL in radiology education around the world is a very obvious deficiency. The standards of scores and levels of radiology education vary significantly among different medical schools in China. Some schools may focus on final examination while others think the study process is more important. A standard questionnaire needs to be developed to quantitatively evaluate the motivation of students including the students' learning interests, clinical thinking, and communication abilities, which should feedback to teachers. The experimental and control groups were always divided based on the classes rather than individual students, so it is difficult for investigators and participants to implement double blinding method. Therefore, the selection bias and performance bias were unavoidable.

Conclusion

The result shows the using of TBL teaching method in the medical imaging courses took advantages than traditional LBL teaching method in improving theoretical scores and skill scores in most instances, but the improvement of skill scores was not significantly different in the higher grade subgroup. Most of the including studies provided the subjective questionnaire surveys of the courses satisfaction and effectiveness, and the results shown the participants believed TBL raised their learning interest, team cooperation ability and interpersonal communication. However, the heterogeneity among the studies should be considered. As the limitations described above, more standardized and well-designed researches are needed in this field.

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and materials

Not applicable

Competing interests

The authors declare that they have no competing interests

Funding

Not applicable

Authors' contributions

Liang Haoyan, Yan chunyi and Li bingjie searched the databases and cross-checked the data. Yan chunyi analysed and interpreted the extracted data regarding theoretical and skill scores with the TBL study. Li bingjie was a major contributor in writing the manuscript.

All authors read and approved the final manuscript.

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Not applicable

Abbreviation: 95%CI = 95% confidence intervals, SMD = standard mean difference, TBL = team-based learning, PBL = problem-based learning.

References

1. Wiener H, Plass H, Marz R: *Team-based learning in intensive course format for first-year medical students. Croatian medical journal* 2009, 50(1):69–76.
2. Hashmi NR: *Team Based Learning (TBL) in undergraduate medical education. Journal of the College of Physicians and Surgeons–Pakistan: JCPSP* 2014, 24(8):553–556.
3. Burgess AW, McGregor DM, Mellis CM: *Applying established guidelines to team-based learning programs in medical schools: a systematic review. Academic medicine: journal of the Association of American Medical Colleges* 2014, 89(4):678–688.
4. Reimschisel T, Herring AL, Huang J, Minor TJ: *A systematic review of the published literature on team-based learning in health professions education. Medical teacher* 2017, 39(12):1227–1237.
5. Zeng R, Xiang LR, Zeng J, Zuo C: *Applying team-based learning of diagnostics for undergraduate students: assessing teaching effectiveness by a randomized controlled trial study. Advances in medical education and practice* 2017, 8:211–218.
6. Kibble JD, Bellew C, Asmar A, Barkley L: *Team-based learning in large enrollment classes. Advances in physiology education* 2016, 40(4):435–442.
7. So S, Patel RM, Orebaugh SL: *Ultrasound imaging in medical student education: Impact on learning anatomy and physical diagnosis. Anatomical sciences education* 2017, 10(2):176–189.
8. Fatmi M, Hartling L, Hillier T, Campbell S, Oswald AE: *The effectiveness of team-based learning on learning outcomes in health professions education: BEME Guide No. 30. Medical teacher* 2013, 35(12):e1608–1624.
9. Bai R, Yang D: *Research of Medical Image Inspection Technology Class Based on TBL and CBL Teaching Methods. Journal of Imaging Research and Medical Applications* 2019, 3(12):244–246.
10. Jia R, Zhou C, Chen X, Dong F: *Application and Discussion of TBL Teaching in the Medical Imaging Class. Health Vocational Education* 2017, 35(5):98–99.
11. Luan J, Yin Z, Che Y, Lin L, Xu X: *Team-based Learning used in the Radiology Courses of the Traditional Chinese Medicine School University Education* 2014(2):84–85.
12. Pan L, Wang H, Zhu Z: *Study on the Influence of TBL and CBL Teaching Methods on Students' Assessment Results in Medical Imaging. Way of Success* 2017(05):18–19.
13. Zhao N, Song L, Zhang X: *Application of Team-based Learning Combined With Comparative Imaging Teaching in Nuclear Medicine Theoretical Classes. China Continuing Medical Education* 2019, 11(14):25–28.

14. Gu Y, Zhang Y, Zhou X, Miao C: *Application of PBL Combined with TBL Teaching Method in Clinical Practice Teaching of Imaging Department. Western China Quality Education* 2019, 5(13):176–177.
15. Li L, Yang Z, Yang Y, Wang A, Xu M: *Application of TBL combined with CBL teaching mode in medical imaging teaching. China Continuing Medical Education* 2017, 9(33):13–14.
16. Pan L, Wang H, Zhu Z: *Effect Analysis of CBL Teaching Method and TBL Teaching Method in Coronary CT Image Teaching. New West* 2016, 5:128+126.
17. Wang H: *Practice of CBL Teaching Method and TBL Teaching Method in Coronary CT Imaging Teaching. New West* 2016(08):46+42.
18. Wu J, Cheng J, Wang Y: *Practice of CBL Teaching Method and TBL Teaching Method in Coronary CT Imaging Teaching. China Higher Medical Education* 2014, 5:13–14.
19. Zhang H, Qiu S, Zhu Z, Zhang W, Chen F: *The Application Value of New Teaching Method in the Undergraduate Apprenticeship of Ultrasonic Diagnostics. Health Vocational Education* 2018, 36(02):70–72.
20. Zhu Z, Wang H: *Application Analysis of TBL Combined with CBL Teaching Method in Medical Imaging Teaching. Science and Technology* 2016, 26(11):206–207.
21. Wang S, Xiang X, Liu M, Luo B: *Comparison of LBL, PBL and TBL Teaching Modes in Medical Imaging. University Education* 2014(16):136.
22. Zhu Z, Wang H, Pan L: *Effect Analysis of TBL and CBL Teaching Methods in Medical Imaging Teaching. CHANGJIAN CONGKAN* 2017(1):171–172.
23. Dolmans D, Michaelsen L, van Merriënboer J, van der Vleuten C: *Should we choose between problem-based learning and team-based learning? No, combine the best of both worlds! Medical teacher* 2015, 37(4):354–359.
24. Burgess A, Bleasel J, Haq I, Roberts C, Garsia R, Robertson T, Mellis C: *Team-based learning (TBL) in the medical curriculum: better than PBL? BMC medical education* 2017, 17(1):243.
25. Zhang S, Xu J, Wang H, Zhang D, Zhang Q, Zou L: *Effects of problem-based learning in Chinese radiology education: A systematic review and meta-analysis. Medicine* 2018, 97(9):e0069.
26. Kek B, Buchanan J, Adisesh A: *An Introduction to Occupational Medicine Using a Team-Based Learning Methodology. Journal of occupational and environmental medicine* 2019, 61(2):132–135.
27. Remington TL, Bleske BE, Bartholomew T, Dorsch MP, Guthrie SK, Klein KC, Tingen JM, Wells TD: *Qualitative Analysis of Student Perceptions Comparing Team-based Learning and Traditional Lecture in a Pharmacotherapeutics Course. American journal of pharmaceutical education* 2017, 81(3):55.

28.Volerman A, Poepelman RS: *A pilot study of team-based learning in one-hour pediatrics residency conferences. BMC medical education* 2019, *19*(1):266.

29.Carrasco GA, Behling KC, Lopez OJ: *First year medical student performance on weekly team-based learning exercises in an infectious diseases course: insights from top performers and struggling students. BMC medical education* 2019, *19*(1):185.

30.Kazory A, Zaidi Z: *Team-Based Learning Activities for First-Year Medical Students: Perception of the Learners. Southern Medical Journal* 2018, *111*(9):525–529.

Tables

Characteristics of the included studies							
	Course name	Course type	Sample Size (TBL)	Sample Size (control)	Grade of participant	Intervention	Comparator
	Medical imaging	Theory	40	40	Higher grade	TBL	Traditional
	Medical radiology of cardiovascular system & urinary system	Theory	40	39	Lower grade	TBL	Traditional
[10]	Medical imaging of skeletal system	Theory and Practice	36	36	Lower grade	TBL	Traditional
	Medical imaging	Theory and Practice	177	175	Lower grade	TBL	LBL
	Medical imaging	Theory and Practice	65	66	Lower grade	TBL	Traditional
[9]	Medical image diagnostic	Theory and Practice	20	20	Lower grade	TBL	LBL
	Medical ultrasonic	Theory	20	35	Higher grade	TBL	LBL
[14]	Medical imaging	Theory and Practice	16	16	Higher grade	TBL	LBL
15]	Medical imaging	Theory and Practice	50	50	Higher grade	TBL	LBL
	Computed topography of coronary artery	Theory and Practice	60	60	Higher grade	TBL	CBL
[18]	Computed topography of coronary artery	Theory and Practice	15	15	Higher grade	TBL	CBL
	Computed topography of coronary artery	Theory and Practice	140	140	Higher grade	TBL	CBL

Team-based learning, LBL = lecture-based learning, CBL = case-based

Table 1 Main characteristics extracted from the included studies.

Figures

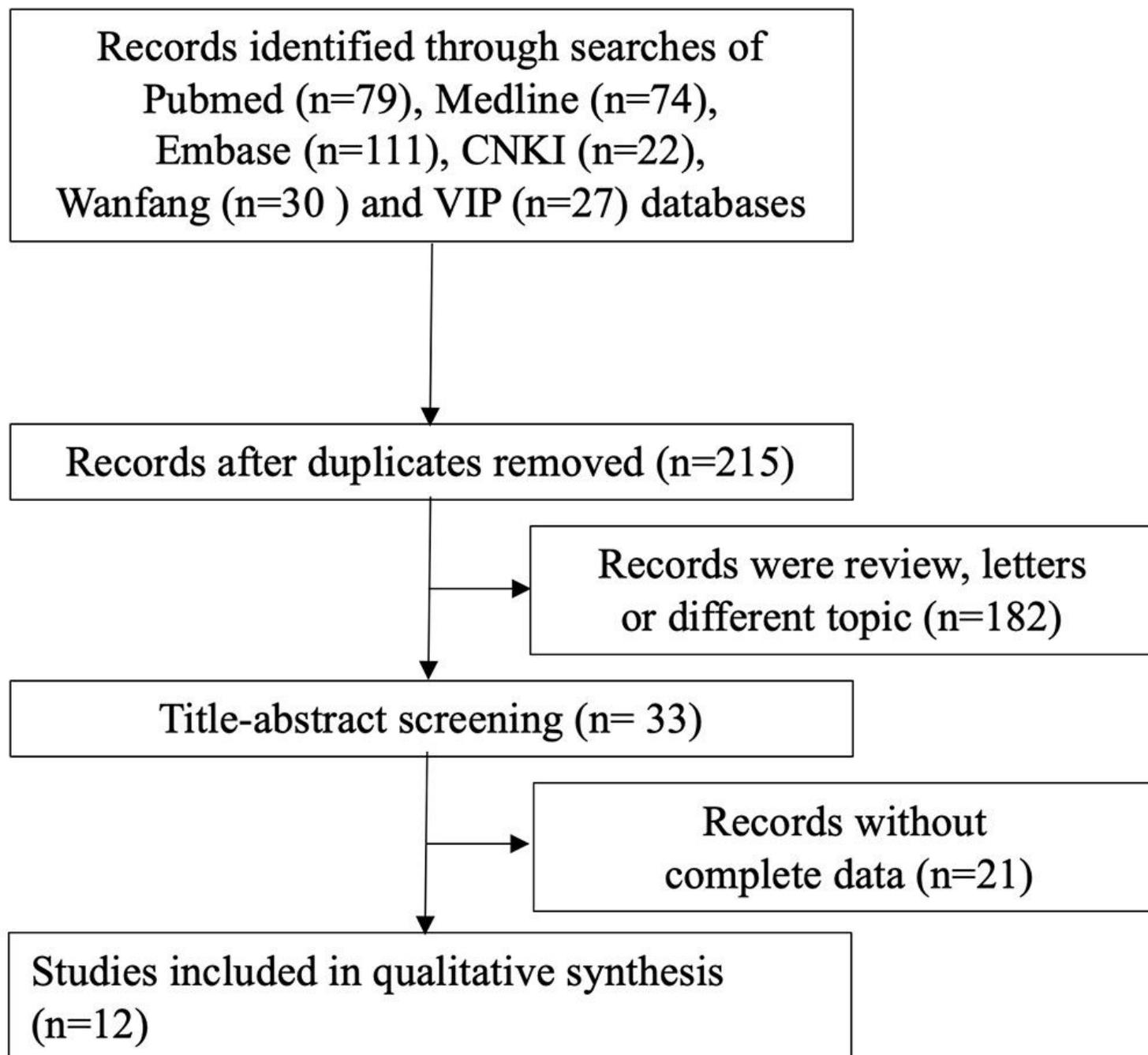


Figure 1

Flowchart of selection process of the included studies.

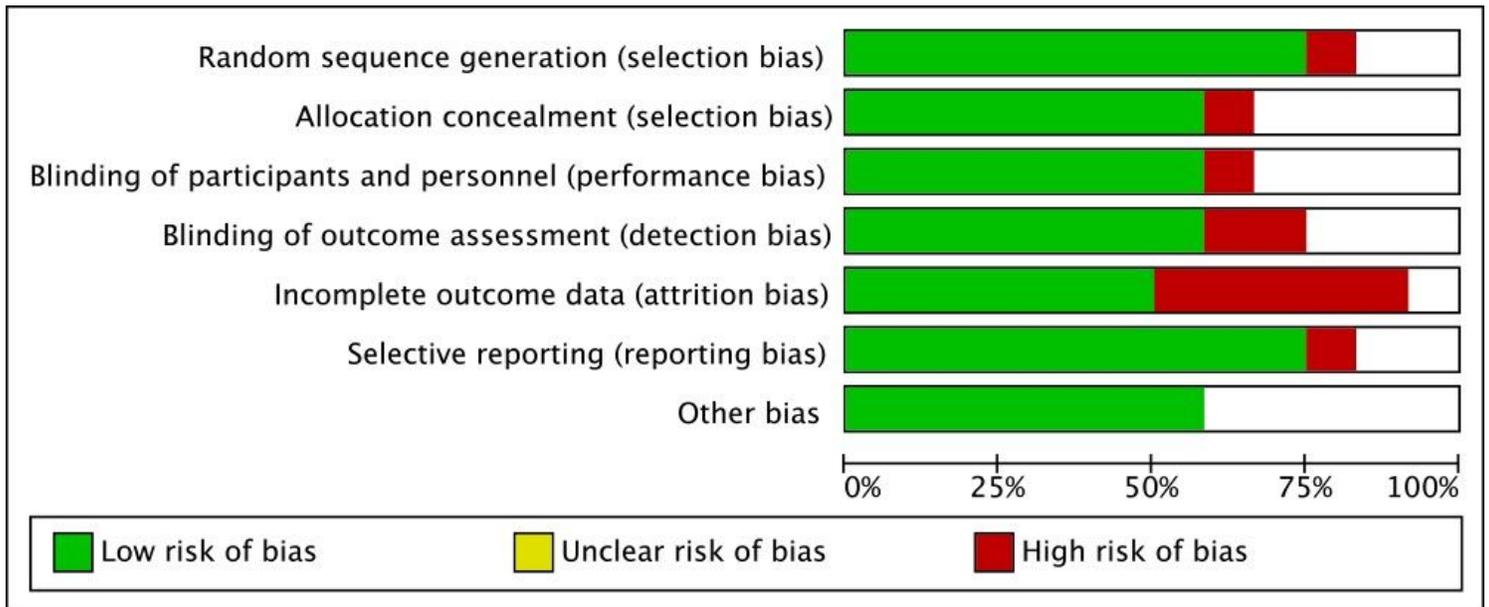


Figure 2

Summary of each methodological quality item presented as percentages across all included studies.

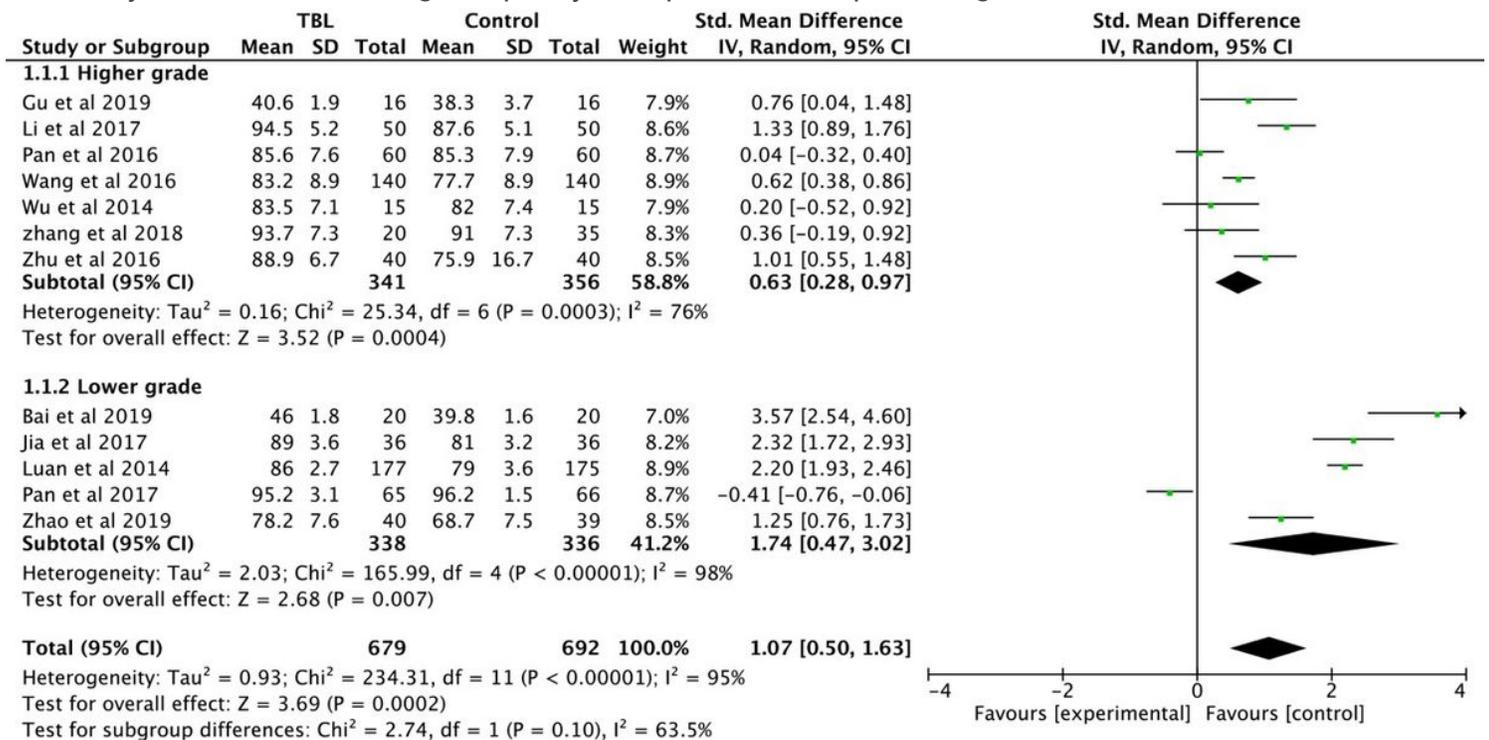


Figure 3

Forest plot for the effects of TBL on knowledge scores compared with the traditional teaching or lecture-based learning. TBL=team-based learning

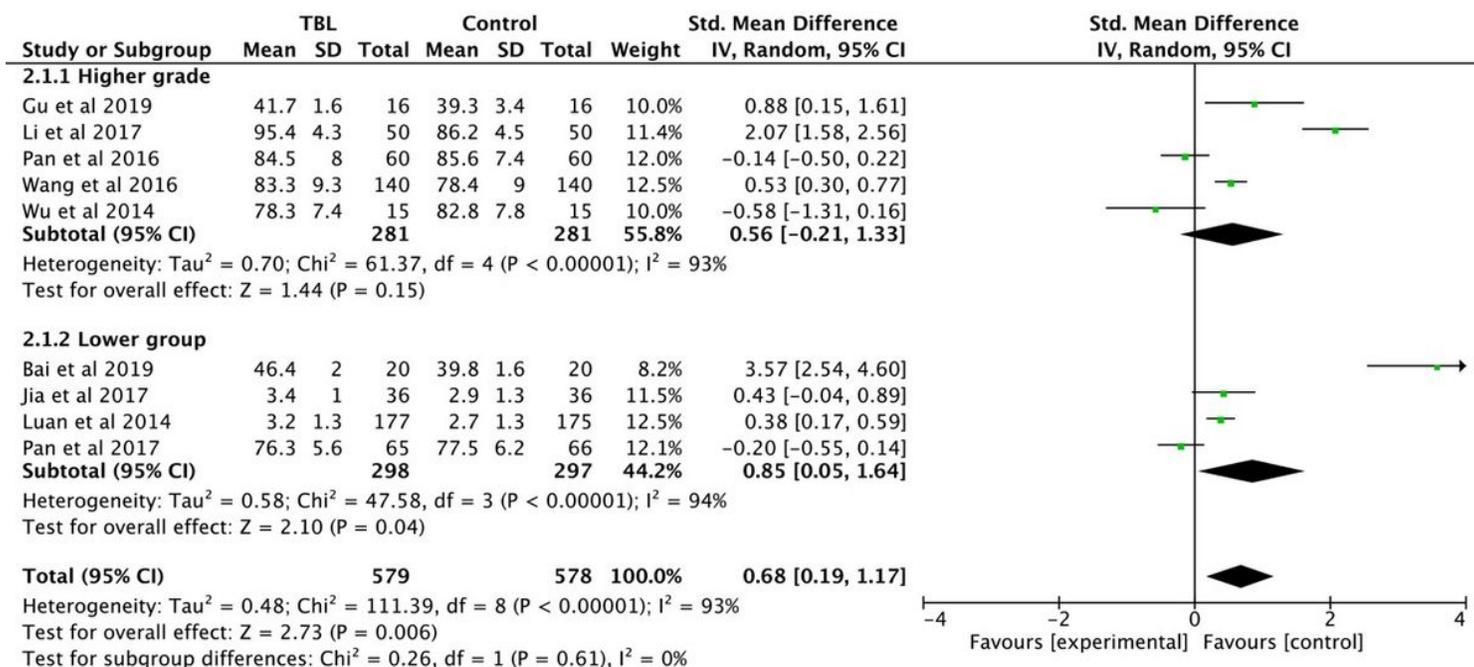


Figure 4

Forest plot for the effects of TBL on skill scores compared with the traditional teaching or lecture-based learning. TBL=team-based learning

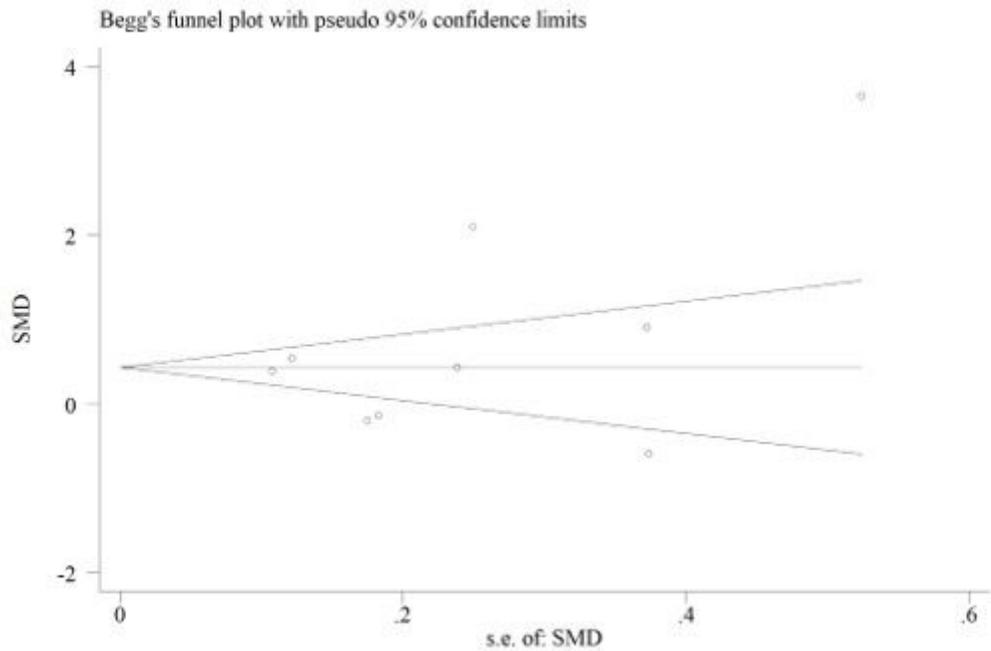
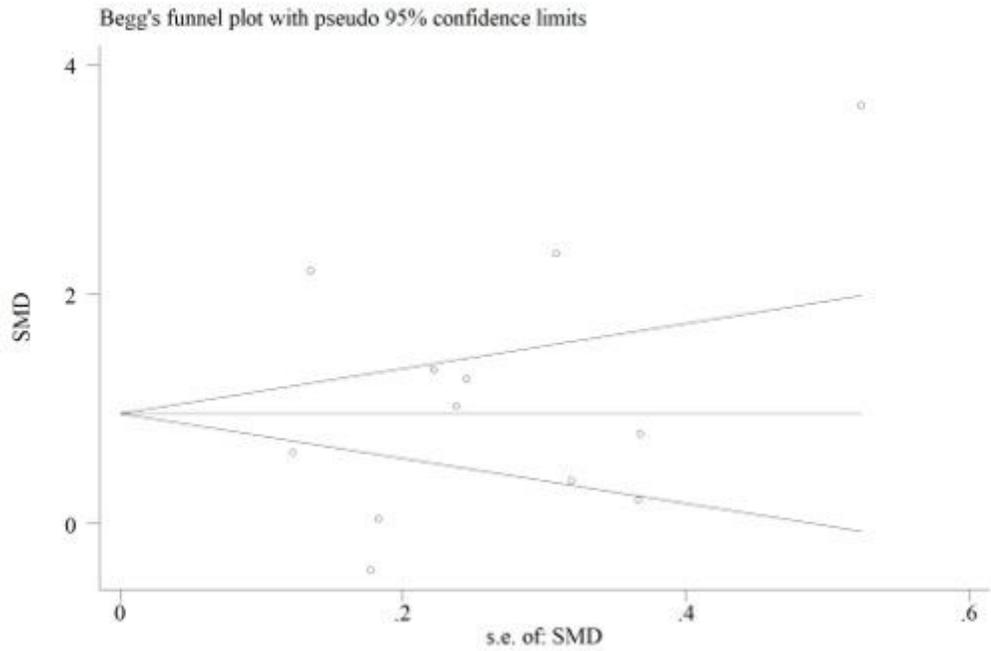


Figure 5

Funnel plot of the included studies for publication bias. (A) Evaluation of knowledge scores, divided into higher-grade subgroup and lower-grade subgroup. (B) Evaluation of skill scores, divided into higher-grade subgroup and lower-grade subgroup.