Team-Based Learning Among Health Care Professionals: A Systematic Review

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Abstract

This systematic review aimed to evaluate the impact of team-based learning among health care professionals over the past four decades. Over 700 articles were evaluated, and 66 papers were included. The results confirm that TBL is effective in improving academic, clinical, and communication skills. TBL enhances learners' engagement, collaborative spirit, and satisfaction. This review adequately summarizes current research in this field.

Introduction And Background

In education, developing and strengthening the skills such as problem-solving, critical thinking, interpersonal communication skills are crucial. Therefore, it is necessary to create an educational environment that links theoretical training with real-life situations. Traditionally, lecture-based teaching was the most common way of disseminating information. A class of students facilitated by a single teacher was the universal method of teaching. Lecture-based learning is widely used as the main learning method globally due to the constraints of teaching resources. However, it was deemed to be more traditional and learner-centered. Instead, many learners described it as passive and less engaging. Therefore, in recent decades, problem-based learning (PBL) and team-based learning (TBL) methods have gained popularity as more engaging and productive learning modalities that improve the theoretical knowledge into practice. Problem-based learning is an instructional method that emphasizes learner-led, group negotiation and interaction. It enhances learning motivation and encourages students to apply knowledge-based materials to problem-solving and integrates them into practice. As a result, medical schools from various countries, including the USA, China, Japan, Korea, India, Skippers, Oman, and Australia, have adopted team-based learning. In the shift towards team-based learning, we conducted this review to evaluate the impact of team-based learning among health care professionals such as practicing physicians, resident physicians, medical students, nursing, pharmacy, and dentistry students in different countries.

Review

Methods

Our systematic review was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Database Search and Screening

We searched PubMed®, Scopus®, EMBASE®, and PubMed Central® till February 17, 2021, to identify the studies using medical search headings (MeSH) and keywords containing "team learning", "cooperative knowledge", "health care workers", "health care professionals" and "medicine." The studies were searched in databases like PubMed®, Scopus®, Embase®, and PubMed Central® using appropriate keywords. Two authors screened the papers, and a third author resolved the conflicts. This was followed by a bibliographic review based on the references of the selected study and bias assessment using the Joanna Briggs Institute (JBI) critical appraisal tool.

The team-based learning model is increasingly being used by different institutions globally. TBL and traditional lecture-based teaching outcomes revealed that TBL participants performed better in academic, clinical, and communication domains. In addition, TBL enhanced learners' engagement, collaborative spirit, and satisfaction. Our study results are similar to the prior meta-analysis and systematic review. Nevertheless, this systematic review remains more comprehensive, up-to-date, and inclusive than the previous studies.

Team-based learning is a pragmatic and superior approach to learning among health care professionals. It has resulted in better academic, clinical, and communication outcomes. This finding spans all the medical and allied professions studied in this systematic review.

Keywords:
- medical education
- problem-based learning
- problem solving
- learning
- health personnel

Categories:
- Internal Medicine
- Medical Education

Introduction

In education, developing and strengthening the skills such as problem-solving, critical thinking, interpersonal communication skills are crucial. Therefore, it is necessary to create an educational environment that links theoretical training with real-life situations. Traditionally, lecture-based teaching was the most common way of disseminating information. A class of students facilitated by a single teacher was the universal method of teaching. Lecture-based learning is widely used as the main learning method globally due to the constraints of teaching resources. However, it was deemed to be more traditional and learner-centered. Instead, many learners described it as passive and less engaging. Therefore, in recent decades, problem-based learning (PBL) and team-based learning (TBL) methods have gained popularity as more engaging and productive learning modalities that improve the theoretical knowledge into practice. Problem-based learning is an instructional method that emphasizes learner-led, group negotiation and interaction. It enhances learning motivation and encourages students to apply knowledge-based materials to problem-solving and integrates them into practice. As a result, medical schools from various countries, including the USA, China, Japan, Korea, India, Skippers, Oman, and Australia, have adopted team-based learning. In the shift towards team-based learning, we conducted this review to evaluate the impact of team-based learning among health care professionals such as practicing physicians, resident physicians, medical students, nursing, pharmacy, and dentistry students in different countries.
other authors then cross-checked.

Data Synthesis

A systematic review of extracted articles was done. Studies with similar outcome measures were grouped and analyzed. Studies or sections of studies with analysis of participants' perceptions about a particular study model were excluded from being subjective. The characteristics of the detailed studies are analyzed and tabulated. Frequency and percentages were used to describe the baseline characteristics of the involved participants and outcomes. Means and standard deviations were used to represent the study outcomes. Meta-analysis was not possible due to heterogeneity in the designs and outcome measures of the different studies.

Assessment of Bias

We used the Joanna Briggs Institute (JBI) critical appraisal tool for the assessment of bias of the included studies (see Tables 1-4) [11].

| Question                                                                 | Carrick et al. [12] | Huang et al. [13] | Yan et al. [14] | Zeng et al. [15] | Das et al. [16] | Athanassaki et al. [17] | Zingone et al. [18] | Liaw et al. [19] | Riddell et al. [20] |
|-------------------------------------------------------------------------|---------------------|-------------------|-----------------|------------------|-----------------|------------------------|---------------------|----------------|---------------------|
| Was proper randomization used for the assignment of participants to treatment groups? | Yes                 | Yes               | Yes             | Yes              | Yes             | Yes                    | Yes                 | Yes            | Yes                 |
| Were allocation to treatment groups concealed?                           | No                  | No                | No              | No               | No              | No                     | No                  | No             | No                  |
| Were treatment groups similar at the baseline?                           | Yes                 | Yes               | Yes             | Yes              | Yes             | No                     | Yes                 | Yes            | Yes                 |
| Were participants blind to treatment assignment?                         | No                  | No                | No              | No               | No              | Yes                    | No                  | No             | No                  |
| Were those delivering treatment blind to treatment assignment?           | No                  | No                | No              | No               | No              | Yes                    | No                  | No             | No                  |
| Were outcomes assessors blind to treatment assignment?                  | No                  | No                | No              | No               | No              | Unclear                | Unclear             | No             | Unclear             |
| Were treatment groups treated identically other than the intervention of interest? | Yes                 | Yes               | Yes             | Yes              | Yes             | Yes                    | Yes                 | Yes            | Yes                 |
| Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analyzed? | Yes                 | Yes               | Yes             | Yes              | Yes             | Yes                    | Yes                 | Yes            | Yes                 |
| Were participants and study staff aware of the groups to which they were randomized? | Yes                 | Yes               | Yes             | Yes              | Yes             | Yes                    | Yes                 | Yes            | Yes                 |
| Were participants and study staff aware of the numeric scores of study groups? | Yes                 | Yes               | Yes             | Yes              | Yes             | Yes                    | Yes                 | Yes            | Yes                 |
| Were appropriate analysis methods used?                                   | Yes                 | Yes               | Yes             | Yes              | Yes             | Yes                    | Yes                 | Yes            | Yes                 |
| Was the trial design appropriate, and any deviations from the standard RCT design (include randomization, parallel or factorial group assignment, intent to treat analysis and analysis of intention to treat) | Yes                 | Yes               | Yes             | Yes              | Yes             | Yes                    | Yes                 | Yes            | Yes                 |

TABLE 1: JBI critical appraisal for randomized controlled trials

JBI - Joanna Briggs Institute; RCT - randomized controlled trials
| Question | Tan et al. | Milzman et al. | Cevik et al. | Burgess et al. | Rezaee et al. | Chandelkar et al. | Garcia et al. | Brandler et al. | Jost et al. | Jafarkhani et al. | Jafari et al. | Hemmati et al. | Halasa et al. | Ghorbani et al. | Boyson-Osborn et al. | Faezi et al. | Jahromi et al. | Table 2: JBI critical appraisal for non-randomized experimental studies | JBI - Joanna Briggs Institute |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Was there a control group? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Were the exposures measured similarly to assign people to both exposed and unexposed groups? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Was the exposure measured validly and reliably? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Were confounding factors identified? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Were strategies to deal with confounding factors stated? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Were the outcomes measured validly and reliably? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Were follow-up complete and differences between groups in terms of actual follow-up adequately described and explored? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Were the two groups similar and recruited from the same population? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Were the follow-up time reported and sufficient to be long enough for outcomes to occur? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Was the outcome of interest measured in each group in the same way? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Were the exposure and comparison groups compared using an appropriate statistical analysis? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| TABLE 2: JBI critical appraisal for non-randomized experimental studies | JBI - Joanna Briggs Institute |

### TABLE 3: JBI critical appraisal for cohort study and retrospective cohort

| Question | Tan et al. | Milzman et al. | Cevik et al. | Burgess et al. | Rezaee et al. | Chandelkar et al. | Garcia et al. | Brandler et al. | Jost et al. | Jafarkhani et al. | Jafari et al. | Hemmati et al. | Halasa et al. | Ghorbani et al. | Boyson-Osborn et al. | Faezi et al. | Jahromi et al. | Table 3: JBI critical appraisal for cohort study and retrospective cohort | JBI - Joanna Briggs Institute |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Was there a control group? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Were the exposures measured similarly to assign people to both exposed and unexposed groups? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Was the exposure measured validly and reliably? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Were confounding factors identified? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Were strategies to deal with confounding factors stated? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Were the outcomes measured validly and reliably? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Were the two groups similar and recruited from the same population? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Were the follow-up time reported and sufficient to be long enough for outcomes to occur? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Was the outcome of interest measured in each group in the same way? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Were the exposure and comparison groups compared using an appropriate statistical analysis? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

TABLE 3: JBI critical appraisal for cohort study and retrospective cohort | JBI - Joanna Briggs Institute |
| Question | Ihm et al. [43] | Balwan et al. [44] | Kelly et al. [45] |
|----------|----------------|------------------|-----------------|
| 1. Were the criteria for inclusion in the sample clearly defined? | Yes | Yes | Unclear |
| 2. Were the study subjects and the setting described in detail? | Yes | Yes | Yes |
| 3. Was the exposure measured validly and reliably? | Yes | Yes | Yes |
| 4. Were objective, standard criteria used for measurement of the condition? | Yes | No | Yes |
| 5. Were confounding factors identified? | Unclear | Unclear | No |
| 6. Were strategies to deal with confounding factors stated? | Unclear | Unclear | No |
| 7. Were the outcomes measured validly and reliably? | Yes | Yes | Yes |
| 8. Was appropriate statistical analysis used? | Yes | Yes | Yes |

**Overall Appraisal**

Include

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**TABLE 4: JBI critical appraisal for cross-sectional studies**

**JBI - Joanna Briggs Institute**

**Results**

We identified a total of 4161 studies after thorough database searching. After the removal of duplicates, we screened the title and abstract of 3399 studies. A total of 2795 studies were excluded, and we assessed the full text of 603 studies, excluding 538 for definite reasons. Thus, we included 35 studies in our final qualitative analysis. The following is summarized in the PRISMA flow diagram (Figure 1). Among included 35 studies, two were from the USA, seven were from Iran, three were from China, two each from India and the United Kingdom, and the rest were from other countries (Table 5). Twenty-eight studies were carried out in medicine faculty, six among nurses and two among physicians. Of those studies, 20 were non-randomized experimental studies, nine were randomized controlled trials (RCTs), then four cohorts, and three were cross-sectional studies.

**FIGURE 1: PRISMA flow diagram**

PRISMA - Preferred Reporting Items for Systematic Reviews and Meta-Analyses

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**TABLE 5: Study characteristics**

| Study | Country | Experimental group (TBL) | Control group | Limitations |
|-------|---------|--------------------------|---------------|-------------|
| 1. Badiyepeymaie et al. 2016 | Iran | Mean score of final exam: Mean +/- SD | No control group | Web quest (N=38): 67.08+/-6.43 | Team-based learning (TBL): 59.08+/-6.43 |
| 2. Balwan et al. 2015 | USA | 1) Survey: both resident and faculty agreed that TBL should be included in future sessions | Lack of generalizability | Average score of Group Readiness Assurance Test (GRAT) was increased by 22% from Individual Readiness Assurance Test (IRAT) | |
| 3. Faezi et al. 2018 | Iran | Classroom engagement survey (CES): Mean +/- SD | Quasi-experimental study | Team-based learning (TBL): 26.7+/-3.70 | Lecture-based (LB): 23.80+/-4.35 |
| 4. Boysen-Osborn et al. 2016 | USA | Correct percentage: a) combined test score flipped classroom/team-based learning: (FC/TBL); (N=95): 95.1% | Students skipped the podcast sessions | b) 50 Multiple choice question (MCQ) score FC/TBL: 90% | c) 50 MCQ score LB: 88% |
| 5. Carrick et al. 2017 | UK | 1) Live classroom scores: Mean +/- SD; Post-test: 86.1 +/-5 | Technical issues | Online classroom scores: Mean +/- SD; Post-test: 86 +/-5.3 | Cost for the training limited the resources |
| 6. Cevik et al. 2019 | UAE | 1) Score percentage - the same topic learned during 2nd year using TBL: 71.4% | Case discussion did not entirely match the traditional didactic learning method | The topic was studied in the first year by didactics (70.3%) | The topic was studied in the second year by didactics and case discussion (75.5%) |
| Year | Methodology | Details |
|------|-------------|---------|
| 2017 | Traditional Lecture | Pre-test: 4.10; Post-test: 13.39 |
| 2017 | Cooperative Flipped Group | Pre-test: 3.56; Post-test: 12.75 |
| 2017 | Individual Flipped Group | Pre-test: 3.24; Post-test: 13.39 |
| 2017 | Control (non-TBL) | Pre-test: 4.3; Post-test: 13.39 |

**Comparison of Methods**

- **Traditional Lecture**
  - Pre-test: 4.10
  - Post-test: 13.39

- **Cooperative Flipped Group**
  - Pre-test: 3.56
  - Post-test: 12.75

- **Individual Flipped Group**
  - Pre-test: 3.24
  - Post-test: 13.39

- **Control (non-TBL)**
  - Pre-test: 4.3
  - Post-test: 13.39

**Academic Performance**

- **Traditional Lecture**
  - Academic performance (mean score from all three examinations): 77.77 ± 4.16
  - Objective Structured Clinical Examination (OSCE): 33.9 ± 4.3 vs 30.4 ± 4.7
  - Overall score: 47.3 ± 6.1

- **Cooperative Flipped Group**
  - Academic performance (mean score from all three examinations): 75.65 ± 7.40
  - IRAT: 63.78 ± 9.30
  - GRAT: 75.65 ± 7.40
  - Final examination scores (FES): 76.77 ± 4.16

- **Individual Flipped Group**
  - Academic performance (mean score from all three examinations): 72.57 ± 6.4
  - IRAT: 62.92 ± 9.03
  - GRAT: 72.57 ± 6.4
  - Final examination scores (FES): 72.57 ± 6.4

**Key Features of TBL**

- **Increased Student Engagement**
  - Improved interaction and collaboration among students
  - Enhanced ability to apply knowledge

- **Improved Critical Thinking**
  - Encourages students to think critically and analyze information
  - Enhanced ability to solve complex problems

- **Increased Retention and Application**
  - Improved recall of material
  - Enhanced ability to apply knowledge in practical scenarios

**Conclusion**

TBL is an effective method for improving academic performance, critical thinking, and engagement among students. It provides a more interactive and collaborative learning environment, leading to better retention and application of knowledge compared to traditional lecture-based methods.


36. Meantime to completion: 19.4 min

35. Mean scores: medical: 4.3 ± 3.4, nursing: 3.5 ± 3.1

34. Critical action (8) in ICU resuscitation scenario:

33. Self-engaged (reading/reading not visibly interacting with others): 28%

32. Engaged with teacher: 58%

31. Engaged with peers: 62%

30. Lecture: 94%, range: 83% to 100%

29. Virtual (Mean ± SD) 22.60 ± 5.31

28. Test scores may be influenced by multiple factors

27. Acceptance of traditional method as a comparator

26. Small sample size

25. Limited sample size

24. Final exam: Clinical reasoning > Factual knowledge

23. IRAT: Factual knowledge > Clinical reasoning

22. TRAT: all teams (except one) scored lower on week 2

21. 2 participants scored lower in Week 2

20. 1 participant: improved by 3 points

19. 3 participants: improved by 2 points

18. 4 participants: no improvement

17. Participants number and score improvement between weeks:

16. IRAT: Score increase from the Week 1 assessment (median = 2) to the Week 2 assessment (median = 3.5), with a median difference in score of 1.5. (n = 18)

15. The National Board of Medical Examiners (NBME) may impact engagement

14. The National Board of Medical Examiners (NBME) may have had a different clinical experience which may impact engagement

13. Small sample size

12. Few questions were straightforward; objectives were resources

11. Acceptance of blended-learning as a comparator group

10. Participants number and score improvement between weeks:

9. Test scores assessing problem solving skills (total marks = 20); Mean ± SD

8. Test III: 78.66

7. Test II: 50.66

6. Test I: 22.66

5. Findings only: Mean ± SD

4. Class of 2004: M=69.6 ± 9.35, N=130

3. Class of 2003: M=70.3 ± 8.18, N=147

2. Lectures only (Mean ± SD)

1. Test: 94% (range: 60% to 100%)

0. Limited generalizability

2022 Joshi et al. Cureus 14(1): e21252. DOI 10.7759/cureus.21252
A survey among internal medicine residents and faculty with a standard 4+1 block supplemented with TBL was performed in Nazarbaev School of Medicine. Residents were divided into two groups. The first group attended the regular lecture and the second group attended the same lecture with flipped content delivered as pre-readings and case-based discussions. Final-year medical students attending the emergency medicine (EM) clerkship were included in the study. To assess the impact of TBL on the learning outcomes of medical students, the lecture-based and TBL-based Educational modules were compared. The results showed that TBL increased the student's understanding of the material and improved their performance in the EM clerkship. The study concluded that TBL is a promising approach to improve the learning process and to enhance student engagement and satisfaction in medical education.

Another study in Iran analyzed the effectiveness of TBL in a rheumatology course. Out of 84 participants, 34.88% were males, and 65.11% were females. The mean age of the participants was 22.15+/-2.0 years. The study compared the traditional lecture method with TBL and found that TBL improved the academic performance in the examinations. The study concluded that TBL is an effective approach to improve the learning process and to enhance student engagement and satisfaction in medical education.

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A pilot study was done in Germany on students joining neurology courses in 2012-13 to determine the usefulness of TBL on clinical reasoning skills. Examination showed better results with TBL in comparison to non-TBL (p=0.046). However, better results were not seen in the TBL group in multiple-choice question examination, questions referring to topics of anatomy. TBL and questions not referring to topics of seminars/TBL with a p-value of 0.15, 0.473, 0.518, respectively [28].

At the most extensive psychiatry program, psychiatry residents in the UK were divided into groups using a line-up method based on prior knowledge in addiction psychiatry by Medhurst et al. There was an equal number of males and females in the study. Group completed the TBL module, which was then followed by a researcher in TBL training. The class engagement survey (scores from 5 to 40) showed a positive response with TBL in comparison to traditional learning (25.2 vs. 22.5; p=0.041). The feedback questionnaire also revealed a positive response with TBL except for examinees to complete pre-class reading and feeling of preparedness for the IVT [27].

A Kuwait study was done to analyze the effectiveness of team-based learning in academic-outcomes in an entry-level doctor of physical therapy. Traditional learning groups and TBL were compared for basic skills and self-directed knowledge. It was a continuous study, so the number of participants varied yearly from 15 to 30. The result showed a slight improvement with TBL but was not statistically significant [41].

A study in Austria was conducted to determine the impact of team-based learning on the education of first-year medical students. The total participant were 98, out of which 51% were females. TBL method resulted superior to the traditional learning method by showing increased final scores and pass percentage. Data were also stratified based on gender, showing a statistically significant large increase in final scores in males compared to females [7].

A Saudi Arabian study was performed taking female final year medical students to study the effectiveness of learning obstetrics and gynecology in a flipped classroom (FC) in comparison to traditional lectures. Eight obstetricians and gynecologists were selected for the flipped-classroom. Half of the topics were assessed using MCQs, and the other half used the objective-structured clinical examination (OSCE). The overall mean score of FC was better than for TL (67.3 vs. 47.2; p<0.001). Sixty percent of the participants showed increased satisfaction with the FC [35].

A modified cross-over study was done among third-year medical undergraduates to analyze the effectiveness of TBL over passive learning in gaining knowledge on neurological localization and emergencency. Out of 49 total students, 55.1% were female, and the mean age was 21.4 years. Mean percentage change in score from baseline pre-test was significantly better in the TBL for both post-tests, taken immediately (p=0.001) and after 60 hours (p<0.001). Another interesting finding was a significant increase in post-test scores after the TBL sessions in a group of weaker students [38].

Emergency medicine residents from post-graduate years one to four were randomized into two groups. A cross-over study was performed with a 40-minute pre-test based lecture and flipped class session (20-minute at-home video and 20-minute case-based discussion). Modules were based on low back pain and headache. The low back pain module did not show a significant difference in scores compared to the didactic module. Hence, the result was contradictory [29].

In the United States, third-year medical students rotating in pediatrics were checked for the effect of TBL in improving scores on exams in comparison to traditional didactic lectures for the blood disorders module. Institutional TBL score was significantly better compared to the national score (73.5 vs. 75.4; p<0.001). Conversely, with a p-value of 0.033 [14].

Medical students from the Medicine School of Chifeng College were divided into TBL (N=98) and TL (N=99) groups for anatomy learning. The male to female population was almost equally distributed in both groups. The average scores out of 100 in the TBL and TL groups were 91.79 vs. 92.5 and 74.6 vs. 76.7, respectively, at the statistically significant level of p<0.01. The study also fostered that the "TBL enhanced communication among peers and teachers" [19].

A total of 113 third-year medical undergraduates in China were divided into TBL (N=65) and lecture-based learning (LBB) (N=48). The two individual terminal tests (ITT I and ITT II) were taken immediately after the class and the other one week after the class. ITT I did not show a significant difference, but ITT II showed a significant difference in TBL vs. LBB (19.15 vs. 17.66; p=0.042). A survey after TBL completion showed that a good percentage of students had increased interest in learning, ability to solve problems, and effective communication skills [15].

In another study done in India, hundred first-year medical students were randomly stratified into two groups to compare the effectiveness of team-based learning compared to traditional lecture-based education in problem-solving skills, student’s perception, and grades in a course. The "function test" was tested with eight short answer problem-solving exercises, after both team-based and lecture-based learning. Scores in tests assessing problem-solving skills were higher in TBL in both high-achievers and low-achievers groups of students (p<0.05), however scores compared after TBL and traditional lecture without stratification did not show a significant difference. Mean differences were analyzed using the two-sample t-test. More than 70% of students perceived that the TBL session was interesting, encouraging, motivating, stress-free, and effective in this study. However, less than 50% of students perceived that TBL should replace all lecture sessions [14].

A study was done by Brandler et al. to analyze the effectiveness of a team-based learning approach among psychology residents. A total of four, two-hour TBL sessions were held, preceded by self-learning of the material and learning objectives of the session. IRAT and GRAT were compared using Wilcoxon matched-pairs signed-rank tests for the first through fourth TBL sessions. Both achievement and communication outcomes showed an overall mean score for TBL was better than for TL (47.3+/-6.1 vs. 42.7+/-5.9; p<0.001). The study also fostered that the TBL enhanced preparedness for the IRAT.

A study was done by Brandler et al. to analyze the effectiveness of a team-based learning approach among psychology residents. A total of four, two-hour TBL sessions were held, preceded by self-learning of the material and learning objectives of the session. IRAT and GRAT were compared using Wilcoxon matched-pairs signed-rank tests for the first through fourth TBL sessions. Both achievement and communication outcomes showed an overall mean score for TBL was better than for TL (47.3+/-6.1 vs. 42.7+/-5.9; p<0.001). The study also fostered that the TBL enhanced preparedness for the IRAT.
In Denmark, a study was done to analyze and compare the impact of quiz-based and conventional teaching methods in a laboratory exercise. A total of 115 third-year medical students volunteered; 56% were males and 44% were females. They were divided into three groups: students doing individual quizzes (9+7), students doing group quizzes (9+9), and controls (6+2). The study revealed that students doing individual quizzes performed better than those doing group quizzes; however, students’ satisfaction was higher during group quizzes. Knukel-Wallén test was used to analyze the differences between the groups [34].

A comparison was made in a study conducted in Australia between team-based learning and problem-based learning to test team collaboration. Twenty-first-year medical students participated in the study. PBL session was a four-week program conducted in a traditional format, and TBL was a two-week session with four teams comprising five students each. Twenty students participated in the study with a follow-up of 95%. The use of small groups, the traditional assessment tools, immediate feedback from an expert clinician, and time efficiency were all aspects of the TBL experience that students found positive. There was an improvement in test scores through the application of team-based learning [35].

Another study in the United States compared team-based learning with the mixed active learning (MAL) method for ambulatory care. Sixty-four students participated in the survey, with 37 in TBL and 27 in a diverse, dynamic learning format (journal club presentation, group-case discussions). TBL was a two-week session with 8-hour session, and MAL was a three-week 4-hour session. No significant difference in cumulative GPA was noted among the two groups (TBL: 3.59 vs. MAL: 3.16, p = 0.05). Students’ performances were compared based on their grade points adjusted for by their prior exam scores. TBL group was assessed based on attendance, RAT, and TRAT, and mixed active learning group was evaluated based on exam scores. TBL group earned 0.35 more quality points than the MAL group [36].

A modified team-based approach was incorporated in training fellows of pediatrics endocrine fellowship. The fellows were divided into two teams with an equitable distribution of years of training in each group. A significant difference was noted in the DAPAP mean scores by years of training (p ≤ 0.05) [37].

An evaluation of the low versus virtual team learning approach was performed in Singapore. A total of 40 participants comprising of equal medicine and nursing students participated. The mean age was 22.17 ± 0.07 (live group: 21.82 ± 0.07; virtual group: 22.59 ± 0.06). Eighty-one (65.5%) were female. Third and fourth-year students’ distribution was homogeneous in both groups. The demographic variation between the two groups was not statistically significant (except age). A paired t-test was applied to examine significant changes between the baseline and post-test performance scores and an independent sample’s t-test to determine differences in the post-test scores between the groups. The team-based simulation and live simulation assessment revealed no significant differences between the virtual and simulation group communication performance post-test scores (p ≥ 0.05). There were significant increases in interpersonal, communication, and technical performance post-test scores from the baseline scores in both groups, with no significant differences over the three time points [19].

An integrated learning approach combining team-based learning with case-based learning was studied in an anesthesia nursing students studying psychiatry. It comprised 26 females out of 41 participants of the age group 20-21 years. There was an increase in the students’ self-directed learning based on their performance on the post-test. The results showed that the students’ self-directed learning increased after the intervention. The mean difference before and after intervention self-management was statistically significant (p = 0.0001). Also, self-directed learning increased with the mean difference after intervention (p = 0.0001) [40].

Third-year medical students studying psychiatry were evaluated for team-based learning in the United States. Males represented 64.95% of participants among 20 total students. Eight of 15 regular traditional learning methods were replaced with team-based learning and the five clinicals. Each cohort rotated every fifth week for one week in one of two ambulatory clinics, including a patient-centered medical home and a hospital-based clinic. Scores were compared using ANOVA with a post hoc Dunnet’s multiple comparison test. Implementation of team-based learning helped in higher scores in the National Board of Medical Examiners Psychiatry test, and students perceived team learning activities to be more effective and enjoyable [42].

Similarly, Baylor College of Medicine conducted a case-control study to compare team learning and lecture-based learning among medical students and physician assistants. Eight sessions, each lasting 10-120 minutes for lecture, and nine sessions each lasting 10-130 minutes for team learning were conducted. The behavior pattern was uniform across first-second-year medical students and physician assistants. The amount of learner-to-learner engagement in PBL and team learning was similar and much more significant than in lectures, where most meetings were of the learner-to-instructor and self-engagement type. Also, learner-to-instructor engagement appeared greater in team learning than in PBL [39].

A case-control study was conducted in the United States comparing individual professional outcomes to collaborative outcomes in medicine and nursing students working together. A 20-minute teaching session on physician and nurse team learning approach, team interaction and patient-focused care, team communication, collaborative skill performance including barriers to successful medical teamwork. In addition, video examples of different types of team interaction on resuscitation cases on cardiac arrest and ICU resuscitation were made available. Defibrillation sessions followed this up. Outcomes were computed, and the means of the two approaches were compared. The collaborative team achieved significant improvement in critical actions gained 6.5 of the eight critical actions in a mean time of 19.6 minutes [41].

Discussion

Our systematic review evaluated the impact of team-based learning among various health care professionals, including medical students, fellows, residents, nurses, dentists, students, attending physicians, and social workers. We found that more than two-thirds of the included studies reported improved academic performance in terms of scores among those enrolled in team-based learning compared to traditional lecture-based knowledge. This finding was consistent with different disciplines of medicine, including neurology, psychology, anatomy, pathology, pediatrics. It was also consistent among the participants with various education levels, including undergraduate medical students, medical residents, fellows, and attending physicians. Our findings of improved academic performance, skills, and knowledge scores were consistent with previous systematic reviews and meta-analyses done by Alberti et al., Chen et al., and Fatmi et al. [9,17,45]. Only two studies showed contradictory findings. Badhik et al. observed no increase in score performance among emergency medicine residents who underwent it traditionally. They flipped the classroom module, and they found that medical students performed better in individual quizzes than group quizzes [39]. Other modalities of team-based learning using online module was similar to traditional face-to-face learning. In the same time, there was no difference in score performance among nursing students between learning with live simulation and virtual module in nursing students [31,39]. Team-based learning has excellent application in medical education because it facilitates learning with a higher teacher-to-student ratio without constraining the health resources. Team-based learning is also being used in clinical practice. Milam et al. found that collaborative learning with medicine and nursing students led to significant improvement in critical actions leading to better patient care [47].

Another crucial facet of team-based learning is the learner’s attitude towards such learning modality compared to traditional learning methods. About twenty studies reported favorable responses of health care professionals towards team-based learning. Multiple studies included in our review highlighted that team-based learning improved the engagement, understanding, and communication skills among health care professionals and medical students. Medical students, residents, nurses, dentists, and physicians gave positive feedback regarding improved interest, motivation, self-directed learning, time efficiency, and greater time allocation in teaching and learning activities when they participated in team-based learning activities. Similar findings of improved communication and self-directed learning were seen in the review done by Alberti et al. [17]. However, Fatmi et al. reported no certain benefit in learner reaction with team-based learning [45]. Constraints can explain this with the inclusion criteria of Fatmi et al., restoring the inclusion to the validated definition of team-based learning above [46]. Team-based learning enhanced problem-solving skills among medical students as per Jeng et al. [11] and few studies reported improvement in individual reassurance test and group reassurance test with team-based learning compared to traditional-
based learning [13,14,15,16,17].

Our systematic review is comprehensive because it included many studies with various designs and encompassed a wide range of health care professionals in several countries. However, there were a few limitations. The heterogeneity in our study is explained by various study designs, study populations, and different modalities of team-based learning. Most of the included studies had a low sample size and were non-randomized. In addition, there were limitations like lack of control group and generalizability.

Conclusions
Team-based learning is instrumental in medical education, enhancing academic performance, communication skills, and clinical outcomes. It also strengthens learner engagement, motivation, and satisfaction as compared to traditional lecture-based learning.

Appendices
Appendix 1: electronic search details

Embase
Search: (team learning OR "collaborative learning" OR "cooperative knowledge") AND (health care workers OR "health care professionals" OR medicine OR "medic"

Hits: 1155

Link: https://www.embase.com/embbase/login.uri?src=Pubmed+Central+HITS+2226

Scopus
Search: ("team learning" OR "collaborative learning" OR "cooperative knowledge") AND (health care workers OR "health care professionals" OR Medicine)

Hits: 610

Link: https://www.scopus.com/results/results.uri?src=Pubmed+Central+HITS+370

Pubmed
Search: ("team learning" OR "collaborative learning" OR "cooperative knowledge") AND (health care workers OR "health care professionals" OR Medicine)

Hits: 2226

Pubmed Central
Search: ("team learning" OR "collaborative learning" OR "cooperative knowledge") AND (health care workers OR "health care professionals" OR Medicine)

Details: (All Fields) OR ("collaborative learning" [All Fields] OR "cooperative knowledge" [All Fields]) AND (health care workers [All Fields] OR "health care professionals" [All Fields] OR "Medicine" [All Fields])

Additional Information
Disclosures
Conflicts of interest: In compliance with the COIEM uniform disclosure form, all authors declare the following: Payment/serve/stick info: All authors have declared that no financial support was received from any organization for the submitted work. Financial relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. Other relationships: All authors have declared that they are no other relationships or activities that could appear to have influenced the submitted work.

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