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Systematic Review

Research on education of graduates of bonded medical program for rural health in China: A systematic review

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ABSTRACT

Background: The government funded bonded medical program for rural health for graduates of bonded medical program for rural health is an essential strategy to alleviate the shortage of healthcare professionals in rural areas of China and to enhance the quality of the primary care professionals. However, previous studies have lacked a comprehensive analysis of the educational methods, current state, and effectiveness across various institutions.

Objective: This study aims to examine the development, research quality, and future trends in the education of graduates of rural oriented general practice education program from 2010 to 2023, providing insights for future initiatives.

Methods: Literature on the training of graduates of rural oriented general practice education program published between January 1, 2010, and December 31, 2023, was retrieved from seven databases: CNKI, Wanfang, VIP, PubScholar, PubMed, Web of Science, and the Cochrane Library. Two researchers independently screened the literature, extracted data according to inclusion and exclusion criteria, and assessed the quality of studies using the Medical Education Research Study Quality Instrument (MERSQI) and the Newcastle-Ottawa Scale for Education (NOS-E). Descriptive analysis was performed to summarize and interpret the findings.

Results: A total of 37 studies were included, of which 36 were in Chinese and 1 in English. The most common research design was the pre-post test control group (46 %), followed by single-group post-test (22 %) and randomized controlled post-test (22 %). Only 8 % of studies employed a single-group pre-post test design. Of the studies, 97 % focused on undergraduate education, with the primary areas of focus being course adjustments (89 %), teaching method modifications (81 %), and the construction of training models(8 %). Notably, 8 % of training model studies and 19 % of course adjustment studies included courses specifically aimed at rural areas, primary care, or general practice. Outcome evaluations were primarily centered on student feedback (70 %) and improvements in knowledge and skills (86 %), with minimal attention given to behavioral changes (3 %) or benefits to patients and healthcare facilities (3 %). Overall, the quality of the studies was moderate, with a mean MERSQI score of 10.4±2.4 (maximum 14.0). Factors such as sample size, validity of evaluation tools, and outcome indicators contributed to lower scores. The NOS-E score averaged 2.5±1.5 (maximum 5.0), with low scores primarily due to control group comparability and blinding.

Conclusion: Although there has been an increase in research on the education and training of graduates of rural oriented general practice education program, the overall quality of the research remains low. Limitations such as insufficient cross-institutional and cross-regional studies, lack of research focusing on the unique characteristics of targeted training, and limited attention to postgraduate and continuing education remain prevalent. Future research should focus on enhancing multi-institutional cooperation, improving research design quality, establishing a unified evaluation system with a focus on rural and general practice education, and integrating continuous curriculum that includes postgraduate and continuing education.

The shortage and inappropriate distribution of healthcare personnel have long been global public health issues, impacting even developed nations such as those in Europe and North America, with rural areas being particularly affected.[1–6] Research has highlighted that the availability of skilled healthcare professionals is crucial for improving both the capacity and quality of medical services in rural primary care facilities.[7] In response, countries such as Canada,[8] Australia,[9] and the United States,[10] along with developing nations like India[11] and Thailand,[12] have taken significant steps, including focusing on medical education. These efforts have led to the development of specific training

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programs or policies for rural general practitioners(GPs), resulting in positive outcomes in addressing the shortage of doctors in rural areas.

China faces similar challenges. To tackle this issue, in 2010, China launched the "Rural order-oriented Tuition-Waived Medical Education Program" (RTME), aimed at training GPs for township health centers and other lower-level medical institutions.[13] As of 2023, the government had invested over 2.1 billion Chinese Yuan (CNY), training >80,000 medical graduates across over 30 provinces.[14–16] The program continues to be promoted, with plans for gradual expansion in the coming years.[17–19] Consequently, research on this initiative has grown steadily alongside its ongoing implementation.[19]

A review of international studies on similar medical education programs has provided both theoretical and practical support for the training of rural GPs. Key areas of focus include the promotion of selective admissions policies,[10] the establishment of service commitment policies,[8,9,11] the implementation of economic incentives,[10–12] and educational interventions.[8–10,12] These efforts have enhanced the appeal, participation, and overall effectiveness of such programs.[7] Based on these findings, the current state of research on the education of graduates of graduates of bonded medical program for rural health in China, along with relevant experiences, warrants further summary. However, existing reviews on the training of graduates of graduates of bonded medical program for rural health primarily focus on analyzing research trends and hotspots using tools like CiteSpace.[19–21] These reviews mainly offer an overview of the field, with limited in-depth discussion on specific training models and methodologies. While there have been reviews of similar international programs,[22–24] there is a lack of comprehensive analyses on the training models, methods, and effectiveness evaluations at universities. Therefore, this study adopts a systematic review methodology[25] to retrieve and analyze relevant literature, aiming to assess the current status of research on the education of graduates of graduates of bonded medical program for rural health in China. This review will explore the research quality, evaluation methods, and future trends in this field, providing a foundation for promoting the development of China's primary care workforce.

Research methods

Literature search strategy

This study conducted literature searches from February to April 2024 across seven Chinese and English databases: NKI, Wanfang, VIP, PubScholar, PubMed, Web of Science, and the Cochrane Library. The search focused on literature related to the training of graduates of bonded medical program for rural health. The following keyword combinations were used: (1)Keywords related to graduates of bonded medical program for rural health: "定向", "订单式", "免费", oriented, compulsory, rural area, remote area. (2)Keywords related to medical students and general practitioners: "医学生", "全科医生", "医学毕业生", "临床医生", medical graduate, medical students, general practitioners, primary care physicians. (3)Keywords related to education and training: "教育", "教学", "培养", "培训", "课程", education, training. Publications were limited to Chinese and English, with dates ranging from January 1, 2010, to December 31, 2023. The specific search strategies for each database are outlined in Appendix 1. Additionally, references obtained through other means relevant to the topic were also included in this study.

Inclusion and exclusion criteria

Inclusion criteria: (1)Studies examining the implementation and effectiveness evaluation of the rural oriented general practice education program. (2)Programs that include training in medical schools, standardized residency training, and continuing medical education.(3)Empirical research, such as randomized controlled trials and other controlled trials, focusing on inductive methods that validate theories using actual data, in contrast to deductive methods that aim to construct theoretical frameworks. (4)Research conducted within China.

Exclusion Criteria: (1)Studies focusing exclusively on the training of three-year diploma-based graduates. (2)Research that only provides an introduction or descriptive commentary on the training program without specific evaluation indicators, or studies that report only the evaluation indicators without detailing the training programs or curriculum construction. (3)Duplicate publications. (4)Non-research publications, such as government bulletins, work reports, meeting minutes, news articles, or interviews. (5)Reviews, including systematic reviews, meta-analyses, and descriptive reviews. (6)Literature that cannot be accessed in full.

Literature screening, information extraction, and quality control

Zotero 7.0 was used for literature screening and management. The process began with the removal of duplicate studies. Two researchers (H.X. and C.M.) then independently reviewed the titles and abstracts of the articles to exclude those that did not meet the inclusion criteria. Finally, the full texts of the remaining articles were reviewed to determine the final set of included studies, based on the established inclusion and exclusion criteria. If disagreements arose, the researchers first attempted to resolve them through discussion. This discussion was guided by the inclusion and exclusion criteria and the specific content of the studies, aiming to reach a consensus. If this approach did not resolve the issue, a third researcher (D.H.), with more experience, was introduced to provide a decisive opinion.

Before the formal literature screening, a pre-screening was conducted to ensure the reliability and stability of the inclusion and exclusion criteria. After deduplication, 5 % of the remaining studies were randomly selected for independent screening by both researchers (H.X. and C.M.). This included reviewing the titles and abstracts to determine whether the studies met the inclusion and exclusion criteria. The researchers' screening results were then cross-checked for consistency, and the inter-rater agreement was calculated. If the agreement was low (Kappa value < 0.8), the inclusion and exclusion criteria were revised based on feedback from the researchers until an acceptable level of consistency was reached. The specific process for revising the criteria is shown in Appendix 2.

The data extraction form was drafted and tested by two researchers (H.X. and W.J.) using a random sample of 10 included studies. It was then revised through multiple iterations by the research team. The extracted information included the basic details of the studies (title, first author, publication year, journal, research location and institution) and study-specific information (study type, design details, and evaluation methods, including Kirkpatrick's four-level evaluation model). Kirkpatrick's model is widely used in medical education to assess the effectiveness of training, categorizing outcomes into four levels: Level I(Reaction — participant satisfaction and feedback on the course); Level II(Learning—changes in attitudes, knowledge, or skills post-training); Level III(Behavior—changes in participants, actual behaviors after the training); Level IV: Results — organizational or patient outcomes resulting from the training.

Literature quality evaluation

To assess the quality of the included literature, two commonly used evaluation tools in medical education research were employed: the Medical Education Research Study Quality Instrument (MERSQI) and the Newcastle-Ottawa Scale for Education (NOS-E).

The MERSQI evaluates six aspects with ten items: study type, sample (number of institutions, response rate), data type, validity of evaluation tools (structural validity, content validity, criterion validity), data analysis (degree, appropriateness), outcome indicators using the Kirkpatrick grading system. The scores for all items were summed, with a maximum

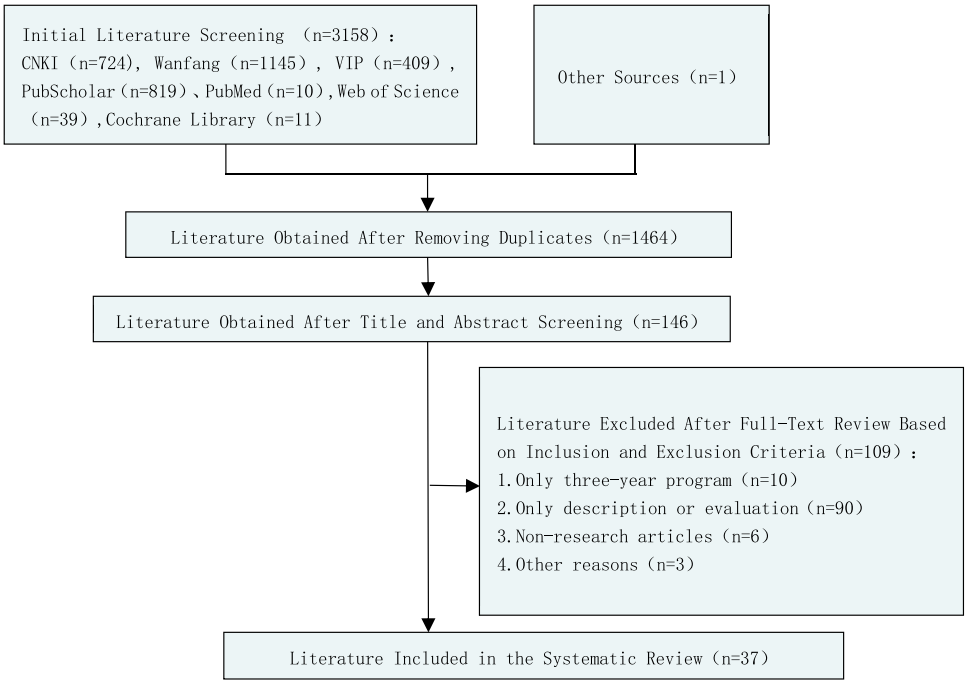

Fig. 1. Literature screening process and results.

total score of 18. The NOS-E evaluates five aspects with six items: sample representativeness, selection of the control group, comparability of the control group, loss to follow-up, blinding. The scores for all items were summed, with a maximum total score of 6. Higher scores on both tools indicate better quality literature. Scores for each individual item and the total score are reported separately.

David A's research[26,27] demonstrates that both tools show good inter-rater reliability. However, each has its own strengths and weaknesses in terms of scope. For instance, MERSQI is suitable for a wide range of non-qualitative studies and provides clear scoring criteria. However, it overlooks blinding and comparability between groups when assessing comparative studies. On the other hand, NOS-E focuses on non-randomized comparative studies, allowing reviewers to integrate more data when making judgments. This is particularly valuable for evaluating comparative studies, but it requires more subjective judgment, increasing the risk of errors. Using both tools offers a more comprehensive assessment of the methodological quality in medical education research.

Statistical methods

A dataset was created using Microsoft Excel 2021 to extract and collect the literature data. In this study, counting data were expressed as frequencies and percentages (n, %), while measurement data were presented as the mean±standard deviation, accompanied by descriptive analysis.

Results

Literature screening process and results

A total of 3158 articles were initially retrieved. After removing duplicates, 1464 articles remained. Following the exclusion of 1427 articles that did not meet the criteria, 37 articles were included in the study, 36 of which were in Chinese and 1 in English. All included studies were conducted in China. The literature screening process is shown in Fig. 1.

Basic information of the included literature and quality scores

Year of publication and journals

From 2011 to 2019, an average of 1–2 studies were published per year. Starting in 2021, the number of studies increased annually, with 10 studies (27 %) published in 2023. Of the 36 studies published in Chinese journals, 7 (19 %) were in core journals. One study was published in an English-language journal and indexed in the Science Citation Index (SCI).

Region and institutions of study implementation

The studies were primarily concentrated in the western region (23 studies, 62 %) according to the classification standard of China's economic regions by the National Bureau of Statistics.[28] Guangxi (8 studies, 22 %) and Chongqing (6 studies, 16 %) had the highest number of studies, followed by the eastern region (6 studies, 16 %) and the central region (5 studies, 14 %). The northeastern region (3 studies, 8 %) conducted all studies exclusively in Jilin. All studies were carried out independently within their respective regions, with the vast majority conducted in single institutions. Only one study involved multiple institutions within the same region.

Literature quality scores

The quality of the included literature was assessed using the MERSQI and NOS-E scales. The MERSQI total score was 10.4±2.4, with a maximum score of 14.0. The main factors contributing to lower scores included the number of sample institutions, the validity of evaluation tools, and outcome indicators. The NOS-E total score was 2.5±1.5, with a maximum score of 5.0. The key factors contributing to lower scores were the comparability of the control group and the use of blinding. Detailed scoring results are provided in Table 1.

Research content of the included literature

Research types

According to the classification of primary care education interventions by Zou Chuan,[29] the included studies employed the following research designs: post-test only in a single group (8 studies, 22 %), pre-test and post-test in a single group (3 studies, 8 %), controlled pre-test and post-test (17 studies, 46 %), randomized controlled post-test (8 studies, 22 %), randomized controlled pre-test and post-test (1 study, 3 %).

Table 1
Quality scores of included literature.

Serial No.	First author	MERSQI Scale / (Full Score)											NOS-E Scale / (Full Score)					
		Research type / 3.0	Number of institutions / 1.5	Response rate / 1.5	Data type / 3.0	Structural validity of evaluation tool / 1.0	Content validity of evaluation tool / 1.0	Criterion validity of evaluation tool / 1.0	Data analysis level / 2.0	Data analysis reasonableness / 1.0	Outcome indicators / 3.0	**Total score / 18.0**	Sample representativeness / 1.0	Control group selection / 1.0	Control group comparability / 2.0	Loss to follow-up / 1.0	Blinding / 1.0	**Total Score / 6.0**
1	Qi	2.0	0.5	0.5	3.0	0	0	0	1.0	0	1.5	**8.5**	0	0	0	1.0	0	**1.0**
2	Pan	2.0	0.5	1.5	3.0	0	0	0	2.0	1.0	1.5	**11.5**	0	0	0	1.0	0	**1.0**
3	Luo	2.0	0.5	0.5	3.0	0	0	0	1.0	1.0	1.5	**9.5**	1.0	0	0	1.0	0	**2.0**
4	Zhang	1.0	0.5	0.5	1.0	0	0	0	1.0	0	1.5	**5.5**	0	0	0	0	0	**0**
5	Liu	1.0	0.5	1.5	1.0	0	0	0	1.0	0	1.0	**6.0**	0	0	0	0	0	**0**
6	Huang	1.0	0.5	0.5	1.0	0	1.0	0	1.0	0	1.5	**6.5**	0	0	0	0	0	**0**
7	Liu	3.0	0.5	1.5	3.0	0	1.0	0	2.0	1.0	1.5	**13.5**	1.0	1.0	1.0	1.0	0	**4.0**
8	Diao	3.0	0.5	1.5	1.0	0	1.0	0	2.0	1.0	3.0	**13.0**	1.0	1.0	2.0	1.0	0	**5.0**
9	Gao	3.0	0.5	0.5	3.0	0	0	0	1.0	0	1.5	**9.5**	0	1.0	1.0	0	0	**2.0**
10	Wang	2.0	0.5	1.5	1.0	0	1.0	0	2.0	1.0	1.5	**10.5**	1.0	1.0	1.0	0	0	**3.0**
11	Pang	2.0	0.5	1.5	3.0	0	0	0	2.0	1.0	1.5	**11.5**	1.0	0	1.0	0	0	**2.0**
12	Shen	3.0	0.5	1.5	3.0	0	0	0	2.0	1.0	1.5	**12.5**	1.0	1.0	2.0	0	0	**4.0**
13	Kong	2.0	0.5	1.5	3.0	0	0	0	2.0	1.0	1.5	**11.5**	1.0	1.0	2.0	0	0	**4.0**
14	Li	1.0	0.5	1.5	1.0	0	1.0	0	1.0	0	1.0	**7.0**	1.0	0	0	0	0	**1.0**
15	Wang	1.0	0.5	1.0	1.0	0	1.0	0	1.0	1.0	1.0	**7.5**	1.0	0	0	0	0	**1.0**
16	Yang	3.0	0.5	1.5	3.0	0	0	0	1.0	1.0	1.5	**11.5**	1.0	1.0	2.0	0	0	**4.0**
17	Shen	2.0	1.5	1.5	3.0	0	1.0	0	2.0	1.0	2.0	**14.0**	1.0	0	2.0	1.0	0	**4.0**
18	Jiang	2.0	0.5	1.5	3.0	0	0	0	2.0	1.0	1.5	**11.5**	1.0	0	2.0	1.0	0	**4.0**
19	Li	3.0	0.5	1.5	3.0	0	0	0	2.0	1.0	1.5	**12.5**	1.0	1.0	1.0	1.0	0	**4.0**
20	Yang	2.0	0.5	1.5	3.0	0	0	0	2.0	1.0	1.5	**11.5**	1.0	1.0	1.0	0	0	**3.0**
21	Zhao	2.0	0.5	1.5	3.0	0	0	0	2.0	1.0	1.5	**11.5**	1.0	0	1.0	1.0	0	**3.0**
22	Cui	2.0	0.5	1.5	3.0	0	0	0	2.0	1.0	1.5	**11.5**	1.0	0	1.0	1.0	0	**3.0**
23	Yang	2.0	0.5	1.5	3.0	0	0	0	2.0	1.0	1.5	**11.5**	1.0	0	1.0	1.0	0	**3.0**
24	Zhang	1.5	0.5	0.5	1.0	0	1.0	0	2.0	1.0	1.5	**9.0**	1.0	0	0	0	0	**1.0**
25	Zhang	3.0	0.5	1.5	3.0	0	0	0	2.0	1.0	1.5	**12.5**	1.0	1.0	2.0	0	0	**4.0**
26	Zhang	1.0	0.5	1.5	1.0	0	0	0	1.0	1.0	1.0	**7.0**	0	0	0	0	0	**0**
27	Zhu	1.5	0.5	1.5	1.0	1.0	1.0	1.0	2.0	1.0	1.5	**12.0**	1.0	0	0	1.0	0	**2.0**
28	Shi	2.0	0.5	1.5	1.0	0	0	0	2.0	1.0	1.5	**9.5**	1.0	0	0	1.0	0	**2.0**
29	Chen	2.0	0.5	1.5	3.0	1.0	1.0	0	2.0	1.0	1.5	**13.5**	1.0	0	2.0	1.0	1.0	**5.0**
30	Deng	1.5	0.5	1.5	1.0	0	1.0	0	2.0	1.0	1.5	**10.0**	1.0	0	0	0	0	**1.0**
31	Hu	2.0	0.5	1.5	3.0	0	0	0	2.0	1.0	1.5	**11.5**	1.0	0	2.0	0	0	**3.0**
32	Huang	2.0	0.5	1.5	3.0	0	0	0	2.0	1.0	1.5	**11.5**	1.0	0	2.0	0	0	**3.0**
33	Jia	2.0	0.5	1.5	3.0	0	0	0	2.0	1.0	1.5	**11.5**	1.0	0	2.0	0	0	**3.0**
34	Lou	3.0	0.5	1.5	3.0	0	0	0	2.0	1.0	1.5	**12.5**	1.0	1.0	2.0	0	0	**4.0**
35	Wu	1.0	0.5	1.5	1.0	0	0	0	1.0	0	1.0	**6.0**	0	0	0	0	0	**0**
36	Yang	1.0	0.5	1.5	1.0	0	1.0	0	1.0	0	1.5	**7.5**	0	0	0	1.0	0	**1.0**
37	Yao	3.0	0.5	1.5	3.0	0	0	0	2.0	1.0	1.5	**12.5**	0	1.0	2.0	1.0	0	**4.0**
Average score		**2.0**	**1.9**		**2.2**	**0.4**			**2.1**		**1.5**	**10.4**	**0.7**	**0.3**	**0.9**	**0.4**	**0**	**2.5**

Education stages

The majority of the studies focused on the undergraduate education stage (36 studies, 97 %). One-fifth of these were conducted during the clinical internship or practicum phase (9 studies, 24 %). Only one study was conducted in the post-graduation education or standardized training phase.

Specific content of the studies

To facilitate information categorization, the research content of the included studies was divided into three categories:

(1) Curriculum adjustment: This category focuses on adjustments to course content, such as additions, deletions, or the introduction of specialized courses targeting rural, primary care, general practice, and their impact on graduates of bonded medical program for rural health.
(2) Teaching method adjustment: This category examines changes in teaching methods, including the addition, deletion, or combination of different approaches, and their impact on graduates of bonded medical program for rural health.
(3) Training model development: This category investigates the impact of new training models specifically designed for graduates of bonded medical program for rural health.

The studies primarily focused on curriculum adjustments (33 studies, 89 %), teaching method adjustments (30 studies, 81 %) and training model development (3 studies, 8 %). All studies on training model development (3 studies, 8 %) and 7 studies on curriculum adjustments (19 %) mentioned the inclusion of specialized courses designed for rural, primary care, or general practice.

Regarding curriculum adjustments, 3/4 focused on theoretical course adjustments (25 studies, 68 %), 1/4 focused on skills course adjustments (8 studies, 22 %). Regarding teaching method adjustments, 3/5 involved single teaching method adjustments (18 studies, 49 %), 2/5 involved mixed teaching method adjustments (12 studies, 32 %), exploring online-assisted teaching (12 studies, 32 %), problem-based Learning (PBL) (8 studies, 22 %), flipped classroom model (7 studies, 19 %), case-Based Learning (CBL) (6 studies, 16 %), role-playing (5 studies, 14 %), team-based learning (TBL) (3 studies, 8 %), micro-lectures (3 studies, 8 %), standardized patients (SP) (2 studies, 5 %), workshops (1 study, 3 %).

Evaluation indicators

The evaluation indicators used in the studies included course evaluation (26 studies, 70 %), course assessment scores (30 studies, 81 %), licensing examination scores (1 study, 3 %), expected compliance rate (2 studies, 5 %), actual compliance rate (1 study, 3 %), patient satisfaction (1 study, 3 %). Most studies assessed Level I (Reaction) (26 studies, 70 %) and Level II (Learning) (33 studies, 89 %) according to Kirkpatrick's evaluation model. Only a few studies evaluated Level III (Behavior) (1 study, 3 %) and Level IV (Results) (1 study, 3 %). Specific details about the included studies can be found in Appendix 3.

Discussion

Since the launch of the bonded medical program for rural health in 2010, China has made significant progress in addressing the shortage of medical personnel in rural areas.[30,31] Studies show that bonded medical program for rural health graduates have performed exceptionally in practice, delivering high-quality medical services to local residents.[32] Furthermore, training bonded medical program for rural health graduates is a crucial part of the broader general practitioner training initiative, which spans multiple stages, including medical school education, post-graduate education, and continuing medical education. This makes it a long-term, large-scale, and multifaceted system requiring extensive coordination.

The educational experiences accumulated over decades of the program's implementation provide valuable insights for innovating training models for primary care professionals. This initiative also plays a pivotal role in promoting the collaborative development of medical education and primary care. The ongoing evolution of the program highlights the need for systematic, long-term efforts to address rural healthcare challenges and to develop a sustainable healthcare workforce capable of meeting the diverse needs of underserved populations. These experiences offer significant references for other countries facing similar challenges in rural healthcare workforce development, providing practical guidance for integrating medical education with service delivery to strengthen rural healthcare systems.

This study reviewed the medical education research on China's five-year system bonded medical program for rural health from 2010 to 2023. While a significant number of studies indicate progress in this field, challenges remain, including the generally low quality of research, insufficient cross-institutional and cross-regional studies, a lack of distinctive features in research content and evaluation indicators related to the directed medical education program, and insufficient attention to post-graduation and continuing education.

The growing focus on bonded medical program for rural health, but poor research quality and lack of multi-institutional and multi-regional collaboration

The number of studies on bonded medical program for rural health has increased annually, reflecting growing interest in this area. This trend aligns with the findings of DONG[21] and ZHANG,[19] who identified the training model for bonded medical program for rural health graduates as a key research focus.

Research institutions are distributed nationwide, though studies are primarily concentrated in China's western regions. This distribution aligns with the program's policy to "train GPs for primary care facilities in central and western regions".[33] Financial support from local governments has facilitated the expansion of these efforts in regions such as Beijing and Zhejiang, which have increasingly focused on this field.

The findings of this study show that most research is conducted within single institutions, with only one study involving multiple institutions in the same region. There is no cross-regional research. This observation is consistent with studies by WEI[20] and DONG,[21] which highlight the limited inter-institutional collaboration that, to some extent, has hindered the development of bonded medical program for rural health and related research.

According to previous studies,[34] higher MERSQI scores indicate better research design and methodological quality, with scores of 14 or above reflecting high-quality studies. In this study, the total MERSQI score for the included literature was 10.4±2.4, with a maximum score of 14.0. This suggests that the overall quality of these studies is relatively low, which is consistent with international experience, as research quality in this field is generally poor.[4,35,36] Two systematic reviews published in Cochrane[35,36] aimed to identify educational measures that could effectively increase the number of health professionals in rural areas. However, only one study was included, and its evidence level was low, indicating that the effectiveness of these educational interventions requires further investigation.

Moreover, the journals in which the included studies were published were of relatively low authority, and there was a lack of inclusion in international English-language journals. This suggests that research in this field is not only of low quality but also lacks international dissemination. Additionally, during the literature screening phase, 90 descriptive studies that did not meet the research objectives were excluded, further indicating that while there is high interest in the field, robust evidence is lacking.

A deeper analysis of the results shows that the main factors contributing to low MERSQI scores include the number of sample institutions, the validity of evaluation tools, and the outcome indicators. Similarly, in the

NOS-E scale, issues like the comparability of the control group and the use of blinding were identified as contributing to lower scores. This highlights the need for well-designed, objective, and controlled intervention studies[29] to improve the quality of evidence in medical education.[37] Such studies will enable better critical assessment of the impact of educational measures on increasing the number of health professionals in rural areas. Moreover, multi-institutional and multi-regional collaboration could effectively facilitate the development of multi-center studies, thus improving the overall quality of research.

Therefore, it is recommended to promote multi-institutional and multi-regional research collaboration, strengthen training for related studies, enhance the design and implementation capabilities of educational research, and encourage the publication of research findings in journals to foster global exchange. Existing academic platforms, such as the "The University Group of General Practice Education in China" initiated by 113 universities,[38] can be leveraged. This alliance regularly hosts academic conferences, facilitates in-depth communication and resource sharing among members, and addresses key issues, hot topics, and challenges in general practice education. Through these efforts, the alliance provides strong academic support for innovative models of primary care professionals training, the development of general practice, educational reform, and the enhancement of primary care workforce building.

Lack of distinctive features in research content and evaluation indicators for the bonded medical program for rural health

In terms of research content, the majority of studies included in this review focus on the impact of course adjustments (89 %) on the academic performance and related outcomes of bonded medical program for rural health graduates. Most of these studies concentrated on adjusting the content and structure of basic medical courses such as systemic anatomy and medical microbiology. Only seven studies (19 %) examined the impact of adding rural, primary care, or general practice courses on bonded medical program for rural health graduates. This focus diverges from the trends observed in similar educational research in other countries.

Studies conducted in countries like Australia,[9] the United States,[10] and India[11] indicate that increasing rural clinical exposure for medical students and residents—through interventions such as adding rural health and general practice courses, assigning family doctors or primary care practitioners as clinical mentors, and organizing training through rural hospitals and family doctor clinics—positively influences the number of healthcare professionals who work and remain in rural areas.[23] In contrast, China lacks research on how specialized courses targeting rural, primary care, or general practice influence the development of bonded medical program for rural health. According to a 2018 study by LI,[39] the absence of such courses addressing rural healthcare needs in the undergraduate curriculum for bonded medical program for rural health may account for this gap.

Moreover, evidence suggests that career education significantly improves the contract fulfillment rate of bonded medical program for rural health graduates.[40] This underscores the need for future research to develop and explore more targeted courses aligned with the program's order-oriented structure. Regarding the development of new training models, studies by LI[39] and SHEN[41] reveal that many universities offering bonded medical program for rural health graduates employ diverse training models, such as "4+1," "3.5+1.5," and "2.5+1+1.5″ systems. However, this review found only three studies (8 %) that explored empirical research on constructing new training models. This suggests a lack of comparative studies examining how different training models affect bonded medical program for rural health graduates' contract fulfillment and retention behaviors. Therefore, future research should focus on developing and evaluating specialized rural-oriented curricula, as well as comparing different training models to assess their impact on the long-term success of bonded medical program for rural health.

Regarding evaluation indicators, researchers should recognize that the training of bonded medical program for rural health shares general similarities with standard medical education but also involves distinctive features.[40] Accordingly, more attention should be given to the impact of specialized courses—particularly those with an order-oriented focus—on key evaluation metrics, such as exam performance, contract fulfillment, retention rates, and job performance. However, in the studies included in this research, the evaluation indicators predominantly addressed the reaction level (70 %) and learning level (89 %) according to Kirkpatrick's model. Few studies explored the behavior level (3 %), which focuses on changes in students' actual behavior, and even fewer examined the results level (3 %), which reflects institutional changes or patient outcomes. Furthermore, there is a noticeable lack of attention to the educational interventions' effects on the project itself or its long-term outcomes.

Although numerous studies in China have investigated the impact of the bonded medical program for rural health on these indicators, the complexity of the program and its associated policies—including educational, incentive, and coercive measures—has hindered the drawing of high-quality, evidence-based conclusions, limiting the generalizability of findings.[42] Nonetheless, several systematic reviews[4,6,23,31] provide evidence that, unlike other interventions, educational measures have played a critical role in addressing the shortage of rural doctors in countries with diverse economic stages, educational systems, and healthcare infrastructures.

Thus, there is a pressing need to strengthen the evaluation of the effectiveness of educational interventions within this program. Additionally, international experiences suggest that the long-term impact of educational measures on the sustainability of rural GPs may not become fully apparent for several years.[43,44] It is essential to draw on previous research,[7,24,45] relying on academic communities to establish standardized evaluation criteria and cross-regional assessment frameworks. For example, the indicator system preliminarily developed by this research team, based on Kirkpatrick's model and outlined in Table 2, can facilitate scientific comparisons. Such efforts would enhance the evidence strength and generalizability of conclusions, contributing Chinese wisdom and strength to addressing this global public health challenge.

Therefore, it is recommended to focus on the development and research of targeted specialty courses for medical students. In the training programs at various stages, adjustments should be made to increase the hours dedicated to general practice courses and related content, as well as extend the practical training time in primary care facilities, such as community clinics. Additionally, career and professional development education should be strengthened to ensure that the theoretical and practical aspects of general practice are integrated throughout the entire process of training students in the bonded medical program for rural health. Furthermore, a unified evaluation framework should be established by leveraging academic platforms that span different regions and institutions, to further validate the effectiveness of various training models and educational measures. This would provide high-quality, evidence-based data to inform the formulation of relevant policies and training programs.

Research primarily focuses on the undergraduate education stage, with insufficient attention to post-graduation and continuing education stages

The studies included in this research predominantly address the undergraduate education stage, with only one focusing on the post-graduation stage. No empirical research on the continuing education of directed medical students was found. This contrasts with international trends, where research is generally more evenly distributed across various stages of education.[22,24] Possible reasons for this gap in China could be that post-graduation and continuing education for bonded medical program for rural health graduates are incorporated into existing educational systems, with directed students often grouped with GPs in educational studies. Additionally, since the bonded medical program for

Table 2
Evaluation indicator system for the effectiveness of medical educational interventions in addressing the shortage of health workers in rural areas.

Kirkpatrick level	Evaluation dimension	Meaning	Evaluation indicators	Common assessment methods
Level I	Reaction	Student satisfaction and evaluation of the course	Course satisfaction evaluation	Questionnaire surveys, interviews
Level II	Learning	Changes in students' attitudes, knowledge, and skills after attending the course (changes in a testing environment)	Changes in knowledge/skills/attitudes before and after training, course/exam scores (medical exams, professional title scores), intention to honor commitment, intention to stay	Theoretical exams, standardized patients, questionnaire scales
Level III	Behavior	Changes in students' actual behavior after training (changes in a real medical environment)	Changes in job competency before and after training, actual fulfillment rates, retention rates, years of retention	Video recording or direct observation, anonymous standardized patients, medical record review
Level IV	Result	Organizational changes or patient benefits brought by the training (direct benefits to the institution/society)	Patient satisfaction, work performance	Patient questionnaires, experimental indicators, institutional statistical reports

rural health has been in place for a relatively short period, the number of graduates currently in the workforce is limited, which may explain why there is little focus on their continuing education needs.

However, it is important to highlight that since 2018, approximately 35,000 directed medical students have been serving in rural primary care facilities.[46] A meta-analysis of retention intentions among directed medical students after completing their service revealed a low retention rate of just 16 %.[47] The availability and quality of continuing education have been identified as key factors influencing retention rates.[43,48] Therefore, investigating the continuing education stage for bonded medical program for rural health graduates holds significant practical and real-world relevance.

Furthermore, general practice was introduced to China relatively recently, and there is still no unified or effective continuing medical education system for GPs.[49] As bonded medical program for rural health graduates represent a highly skilled group of GPs, they could serve as a model population to explore the post-graduation education and continuing education for GPs. This research could offer valuable insights for stabilizing the primary care workforce and innovating training models for healthcare professionals in rural areas.

It is recommended to enhance research on the post-graduation education and continuing education stages for directed medical students, with an emphasis on designing a continuous and integrated teaching approach throughout all stages of training.[50] A comprehensive, dynamic analysis should be conducted to provide systematic findings and evidence-based recommendations to support the development of the primary care workforce. This will ensure that the educational process forms a continuous improvement cycle, thereby maintaining the quality and effectiveness of each training phase. In response, relevant authorities have already begun corresponding initiatives. In January 2023, the National Health Commission's Capacity Building and Continuing Education Center launched the "Bonded Medical Program for Rural Health Graduates' Capacity Enhancement Project",[51] with Hebei, Henan, Guizhou, and Guangxi selected as the first pilot provinces. The project focuses on five key areas: (1)Leveraging the China Continuing Medical Education Network, an online training platform and individual electronic learning records should be established for directed students, forming a continuous support mechanism. (2)Creating communication platforms for interaction among bonded medical program for rural health graduates, administrative staff, and expert groups. (3)A national expert group will provide ongoing guidance, management, and support to directed students. (4)Based on the needs of primary care, outstanding bonded medical program for rural health graduates will be sent to medical institutions affiliated with core expert groups for short-term exchange and learning. (4)National offline activities, such as skills competitions and case presentation contests, will be held irregularly to provide a platform for bonded medical program for rural health graduates to showcase their abilities and engage in interactive communication.

Limitations

Given the limitations of human and material resources, this study focuses solely on the educational training of five-year undergraduate students in China and does not include a comparative study of similar programs internationally. Additionally, there was a lack of in-depth retrieval of grey literature. Despite these constraints, the study provides valuable insights into the research trends and current status in this field and effectively evaluates the quality of the included literature, laying a foundation for future research in this area.

Conclusion

While the education of directed medical students has gained significant attention in recent years, it continues to face multiple challenges. These include generally low research quality, limited cross-institutional and cross-regional collaboration, and a lack of distinctive features in research content and evaluation metrics specific to the bonded medical program for rural health model. Additionally, there is insufficient focus on post-graduation and continuing education stages.

To address these issues, future efforts in the field of primary care education in China should prioritize collaborative research across multiple institutions and international exchanges, improve research design and methodology, and establish a unified evaluation system with distinctive features of the order-directed model. Furthermore, it is essential to strengthen the design of courses with an rural oriented education focus, especially those related to rural areas and primary care. There should also be an emphasis on the continuity of education throughout all stages, including post-graduation and continuing education, with integrated teaching designs. This comprehensive approach will enhance the quality of educational research in this field, providing high-quality evidence to support policy development and the design of training programs.

Declarations

Not applicable.

Authors' contributions

Conceptualization, H.X.; Methodology, H.X.; Data curation, C.M. and W.J.; Formal analysis, C.M., W.J. and Z.C.; Funding acquisition, not applicable; Project administration, not applicable; Resources, not applicable; Supervision, D.H.; Validation, D.H.; Writing–original draft, H.X.; Writing–review and editing, C.M., W.J. and D.H. All authors have read and agreed to the published version of the manuscript.

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Consent for publication

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Appendix

Appendix 1
Search Strategies for Various Chinese and English Databases (Training of Rural-oriented Medical Education students).

Database	Search strategy	Search results
CNKI	SU=('定向'+'订单式'+'免费')*('医学生'+'全科医生'+'医学毕业生'+'临床医生')*('教育'+'教学'+'培养'+'培训'+'课程'), 限定时间范围:2010–01–01至2023–12–31	724
Wanfang	(主题:("定向" or "订单式" or "免费") and ("医学生" or "全科医生" or "医学毕业生" or "临床医生") and ("教育" or "教学" or "培养" or "培训" or "课程")) and 发表时间:2010–2023	1145
VIP	M=("定向" OR "订单式" OR "免费") AND ("医学生" OR "全科医生" OR "医学毕业生" OR "临床医生") AND ("教育" OR "教学" OR "培养" OR "培训" OR "课程"), 限定时间范围:2010至2023	409
PubScholar	TS=('定向' OR '订单式' OR '免费') AND ('医学生' OR '全科医生' OR '医学毕业生' OR '临床医生') AND ('教育' OR '教学' OR '培养' OR '培训' OR '课程') AND PY=(2010–2023)	819
	TS=('oriented' OR 'compulsory') AND ('medical graduate' OR 'medical students' OR'general practitioners' OR 'primary care physicians') AND ('rural area' OR 'remote area')AND ('education' OR 'training') AND PY=(2010–2023)	1
PubMed	(("oriented"[Title/Abstract] OR "compulsory"[Title/Abstract]) AND ("medical graduate"[Title/Abstract] OR "medical students"[Title/Abstract] OR "generalpractitioners"[Title/Abstract] OR "primary care physicians"[Title/Abstract]) AND ("ruralarea"[Title/Abstract] OR "remote area"[Title/Abstract]) AND ("education"[Title/Abstract]OR "training"[Title/Abstract])) AND (2010/1/1:2023/12/31[pdat])	10
Web of Science	(TS=(oriented) OR TS=(compulsory)) AND (TS=(medical graduate) ORTS=(medical students) OR TS=(general practitioners) OR TS=(primary care physicians))AND (TS=(rural area) OR TS=(remote area)) AND (TS=(education) OR TS=(training)) , Year Published:2010/01/01-2023/12/31	39
Cochrane Library	((oriented):ti,ab,kw OR (compulsory):ti,ab,kw (Word variations have been searched)) and ((medical graduate)ti.ab,kw oR (medical students):t,ab,kw OR(general practitioners):t.,ab,kw OR (pimary care physicians) i.ab,kw (Word variations have been searched)) and ((rural area):ti,ab,kw OR (remote area):ti,ab,kw (Wordvariations have been searched)) and ((education):ti,ab,kw OR (training):ti,ab,kw (Wordvariations have been searched)) with Publication Year from 2010 to 2023, in Trials	11

Appendix 2
Consistency evaluation of inclusion and exclusion criteria for literature in the pre-screening stage.

Huang	Chen					
	First Edition Inclusion/Exclusion Criteria[a]			Second Edition Inclusion/Exclusion Criteria[b]		
	+	−	Total	+	−	Total
+	10	5	15	6	1	7
−	3	55	58	0	66	66
Total	13	60	73	6	67	73
Kappa (95 %CI)	0.6475 (0.5408, 0.7542)			0.9157(0.8296,1.0018)		
P	<0.001			<0.001		

Note:

[a] First Edition Inclusion and Exclusion CriteriaInclusion criteria: (1)Studies evaluating the effectiveness of Rural order-oriented Tuition-Waived Medical Education Program(RTME). (2)Training programs include institutional education, standardized residency training, and continuing medical education. (3)Studies conducted within China.Exclusion criteria: (1)Duplicate literature. (2)Non-research literature, including government bulletins, government work reports, meeting minutes, news reports, interviews, etc. (3)Review literature, including systematic reviews, meta-analyses, descriptive reviews, etc.

[b] Second Edition Inclusion and Exclusion CriteriaInclusion criteria: (1)Studies on the implementation process and effectiveness evaluation of RTME. (2)Training programs include institutional education, standardized residency training, and continuing medical education. (3)Study types include randomized controlled trials, other controlled trials, and other empirical studies. (4)Studies conducted within China.Exclusion Criteria: (1)Studies focusing only on three-year specialized RTME. (2)Studies that only describe and introduce the training program or contain theoretical content with no specific evaluation criteria, or studies that report only related evaluation indicators without describing the training program or course construction in detail. (2)Duplicate literature, i.e., the same paper published in different journals, or the same research content reported both in journals and academic theses, or studies included in two or more databases (retain only the one published in authoritative core journals). (3)Non-research literature, including government bulletins, government work reports, meeting minutes, news reports, interviews, etc. (4)Review literature, including systematic reviews, meta-analyses, descriptive reviews, etc. (5)Literature that cannot be accessed in full.

Appendix 3

Basic Information of Included Literature.

No.	First author	Region	Publication year	Study type	Educational stage	Study Content			Evaluation Indicators (Kirkpatrick's Level)*
						Training model construction	Curriculum adjustment	Teaching method adjustment	
1	Qi	Jiangxi	2011	Pre-test-Post-test Control Group	Undergraduate Education	"3.5+1.5″ Model (Increase rural/community health work applicable courses and increase community health service internship duration)	–	–	II
2	Pan	Zhejiang	2012	Pre-test-Post-test Control Group	Undergraduate Education	Wenzhou Medical College Model (Focus on general practice and community knowledge and ability training in later training)	–	–	II
3	Luo	Jilin	2014	Pre-test-Post-test Control Group	Undergraduate Education	–	Biochemistry and Molecular Biology	PBL	II
4	Zhang	Jilin	2015	Single Group Post-test	Undergraduate Education	–	Undergraduate Education	TBL	I, II
5	Liu	Chongqing	2015	Single Group Post-test	Undergraduate Education	–	Basic Clinical Skills	SP + Role-Playing + CBL + Video Recording + Web-Assisted Learning	I
6	Huang	Yunnan	2016	Single Group Post-test	Undergraduate Education	–	Oral Science	PBL	I, II
7	Liu	Jiangxi	2016	Randomized Controlled Post-test	Undergraduate Education/Clinical Stage	–	Respiratory, Digestive, and Cardiovascular Case Studies (Common diseases in rural areas)	CBL	I, II
8	Diao	Beijing	2017	Randomized Controlled Post-test	Undergraduate Education/Clinical Stage	–	Urology Course	Narrative Pedagogy	II, IV
9	Gao	Jilin	2018	Randomized Pre-test-Post-test Control Group	Undergraduate Education	–	English	Web-Assisted Learning	II
10	Wang	Chongqing	2018	Pre-test-Post-test Control Group	Undergraduate Education	–	Internal Medicine, Obstetrics and Gynecology	Extracurricular Self-Directed Collaborative Learning Model	II
11	Pang	Anhui	2019	Pre-test-Post-test Control Group	Undergraduate Education/Clinical Stage	–	Neurology	CBL+TBL	I, II
12	Shen	Guangxi	2019	Randomized Controlled Post-test	Undergraduate Education	–	General Practice Introduction	Web-Assisted Learning + Flipped Classroom	I, II
13	Kong	Guangxi	2020	Pre-test-Post-test Control Group	Undergraduate Education	–	General Practice Introduction	Micro-Lecture + Role-Playing	I, II
14	Li	Guangxi	2020	Single Group Post-test	Undergraduate Education/Clinical Stage	–	Skills Training	–	I
15	Wang	Chongqing	2020	Single Group Post-test	Undergraduate Education	–	Anesthesiology	Web-Assisted Learning	I
16	Yang	Xinjiang	2020	Randomized Controlled Post-test	Undergraduate Education	–	Biochemistry and Molecular Biology	Flipped Classroom	I, II
17	Shen	Guangxi	2021	Pre-test-Post-test Control Group	Undergraduate Education	"3.5+1.5″ Model (Provides more time and opportunities for rural health and primary care training)	–	–	II, III
18	Jiang	Chongqing	2021	Pre-test-Post-test Control Group	Undergraduate Education	–	Biochemistry	Web-Assisted Learning	I, II
19	Li	Xinjiang	2021	Randomized Controlled Post-test	Undergraduate Education/Clinical Stage	–	General Surgery Internship	PBL	I, II
20	Yang	Guangxi	2021	Pre-test-Post-test Control Group	Undergraduate Education	–	Health Management	Web-Assisted Learning	II

(*continued on next page*)

Appendix 3 (*continued*)

No.	First author	Region	Publication year	Study type	Educational stage	Study Content			Evaluation Indicators (Kirkpatrick's Level)*
						Training model construction	Curriculum adjustment	Teaching method adjustment	
21	Zhao	Sichuan	2021	Pre-test-Post-test Control Group	Undergraduate Education	–	Otorhinolaryngology	PBL	I, II
22	Cui	Xinjiang	2022	Pre-test-Post-test Control Group	Undergraduate Education	–	Systemic Anatomy, Medical Immunology, Medical Microbiology, Pathological Anatomy, Embryology	CBL+Web-Assisted Learning	II
23	Yang	Beijing	2022	Pre-test-Post-test Control Group	Undergraduate Education	–	Experimental Diagnostics	PBL	I, II
24	Zhang	Shandong	2022	Single Group Pre-test-Post-test	Undergraduate Education	–	Diagnosis and Treatment of Common and Frequently Occurring Diseases	Flipped Classroom	I, II
25	Zhang	Shaanxi	2022	Randomized Controlled Post-test	Undergraduate Education	–	Medical Genetics	CBL+Micro-Lecture + Role-Playing	I, II
26	Zhang	Guangxi	2022	Single Group Post-test	Undergraduate Education/Clinical Stage	–	Pre-internship Intensive Education	–	I
27	Zhu	Guizhou	2022	Single Group Pre-test-Post-test	Undergraduate Education	–	Community Health Service	–	II
28	Shi	Hebei	2023	Pre-test-Post-test Control Group	Undergraduate Education	–	Adjusted Curriculum to Focus More on Community	–	I, II
29	Chen	Guangxi	2023	Pre-test-Post-test Control Group	Undergraduate Education	–	Step-by-step Communication Skills Course Training	SP+Role-Playing	I, II
30	Deng	Chongqing	2023	Single Group Pre-test-Post-test	Undergraduate Education	–	Anesthesiology, Critical Care Medicine	Web-Assisted Learning	II
31	Hu	Xinjiang	2023	Pre-test-Post-test Control Group	Undergraduate Education	–	Pathology	Web-Assisted Learning+CBL	I, II
32	Huang	Zhejiang	2023	Pre-test-Post-test Control Group	Undergraduate Education/Clinical Stage	–	Neonatal Resuscitation Training	Micro-Lecture + Flipped Classroom + Simulation Teaching	I, II
33	Jia	Hunan	2023	Pre-test-Post-test Control Group	Undergraduate Education	–	Physiology	Web-Assisted Learning + Flipped Classroom	I, II
34	Lou	Anhui	2023	Randomized Controlled Post-test	Undergraduate Education/Clinical Stage	–	Surgical Skills Training	PBL+workshop	I, II
35	Wu	Guangxi	2023	Single Group Post-test	Undergraduate Education	–	Community Health	Web-Assisted Learning + Flipped Classroom + Role-Playing + TBL	I
36	Yang	Yunnan	2023	Single Group Post-test	Postgraduate Education	–	–	PBL	I, II
37	Yao	Chongqing	2023	Randomized Controlled Post-test	Undergraduate Education/Clinical Stage	–	Wound Suturing	Web-Assisted Learning + PBL+ Flipped Classroom	I, II

Note:

* According to Kirkpatrick's Four Levels of Evaluation:Level I: Reaction; Level II: Learning; Level III: Behavior; Level IV: Results

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