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Development of a Training Program for Meta-Analytical Research: A Novel Approach to Minimizing Errors in Medical Systematic Reviews and Meta-Analyses

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Purpose: The Global Andrology Forum (GAF) has developed an innovative training method to equip novice researchers with the fundamental skills to conduct high-quality systematic reviews and meta-analyses (SRMAs) under the supervision of senior experts. This article aims to describe and evaluate the effectiveness of the GAF training program in enhancing these skills.

Materials and Methods: A six-module training program was designed to cover the key steps in SRMA studies, enabling GAF members to conduct high-quality SRMAs. Initially launched as a synchronous (remote) training program, it was later transitioned into an asynchronous format and implemented on the Moodle platform. Trainees participating in the synchronous training program were asked to evaluate the course using a specially designed questionnaire. Participants' assessments of the asynchronous course were collected at various stages. Data from both training models were statistically analyzed.

Results: Among the trainees who participated in the questionnaire on the original synchronous course (n=101), the majority rated the material and assessments as clear, helpful, and effective in enhancing their knowledge. Additionally, the trainees indicated that the features offered in the training made them feel comfortable and engaged. Of the 29 participants enrolled in the asynchronous program, 22 took part in the assessment. Among them, 12 (54.5%) completed all course requirements, achieving an average score of 83.7%, qualifying them for conducting SRMAs.

Conclusions: The GAF SRMA online training program has proven to be an effective and well-received initiative for equipping researchers with essential skills to conduct high-quality SRMAs. By addressing the diverse needs of trainees through its innovative and flexible design, the program has demonstrated its capacity to enhance knowledge and engagement. The successful implementation of this training program highlights its potential to significantly improve the quality of SRMAs in medical research, thereby contributing to the advancement of evidence-based medical practice on a broader scale.

Keywords: Learning, distance; Meta-analysis; Systematic review; Teaching

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INTRODUCTION

The ever-increasing number of new studies, sometimes with diverse, inconclusive, or inconsistent results, can often lead to confusion in clinical decision-making [1,2]. In this sense, systematic reviews represent a particular type of literature review characterized by a methodical, replicable, and transparent approach [3]. Unlike traditional narrative reviews, systematic reviews employ a rigorous methodology to minimize bias in identifying, selecting, reviewing, and synthesizing primary research studies [4]. Meta-analysis provides pooled estimates of the effect of the data extracted from individual studies in the systematic review [1]. Since the 1970s, the role of meta-analysis in the medical field has become increasingly prominent, with meta-analysis occupying the highest tier in the evidence pyramid hierarchy [5].

Despite their importance and impact on clinical practice and guideline writing, studies have shown that the quality of systematic reviews and meta-analyses (SRMA) is highly variable, with some systematic reviews failing to adhere to systematic methodologies [6,7].

Several issues can jeopardize the quality of an SRMA. Among them, a key challenge in research is the availability and accessibility of resources [8], especially in resource-limited or developing regions. Furthermore, the quality of an SRMA is highly influenced by the expertise and experience of the researchers conducting this type of study. Publishing an SRMA requires meticulous adherence to a series of sequential steps by trained researchers. First and foremost, the SRMA research question must be feasible, interesting, novel, and relevant. This is followed by several steps that must be conducted according to a predefined method to ensure accurate data analysis and the generation of impactful conclusions.

Over the past several decades, thousands of meta-

analyses have been published, yet critical mistakes persist in many studies. Common errors include the failure to conduct systematic database searches and nonadherence to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Additionally, studies often have an insufficient number of sources or inadvertently duplicate studies [8].

Errors during data extraction and analysis are particularly problematic. Examples include using standard errors of the mean (SEMs) instead of standard deviations (SDs), and the incorrect application of statistical methods such as standardized mean difference or mean difference. The inappropriate selection of fixed-effect or random-effects models, often based on flawed considerations of heterogeneity, further undermines the validity of findings and leads to misinterpretation of the results [8].

A recent systematic review identified 139 distinct errors in SRMAs across 50 published studies, highlighting frequent issues in data extraction, statistical analysis, and interpretation [9]. These recurring errors underscore significant gaps in researchers' ability to conduct and interpret SRMAs effectively. This calls for the development of well-structured training programs to equip researchers with the essential skills needed to perform rigorous and validated SRMAs. To conduct SRMAs with minimal errors, the authors need to be well-trained and qualified, to ensure accurate execution at each step. Several scholarly papers outline the essential steps in establishing research objectives, framing the clinical question using a model such as the Population/Intervention/Comparison/Outcome/Study design (PICOS) framework, and conducting a comprehensive literature search [3,10,11]. However, the methodologies of these studies do not allow for definitive conclusions regarding identifying the most appropriate protocol for conducting a high-quality SRMA. In this context, developing a training program to teach researchers how to conduct SRMA studies and assess their learning outcomes properly is essential [12].

The internet and the digital age have enabled instant knowledge sharing, allowing global research teams to exchange ideas quickly, collaborate on large-scale projects, and access shared databases and publications. A unique example is a virtual approach of the Global Andrology Forum (GAF) to enrich the process by gathering expertise and perspectives from diverse researchers without the limitations of time or distance [13,14]. This dynamic online environment helped accelerate the pace, enhance the quality of research publications, and nurture the expertise of the researchers involved. Previous studies have highlighted the advantages of asynchronous online learning [15] and learning management system (LMS) platforms, such as Moodle [16], which optimize learning and engagement [17]. Thus, an online training program for conducting a proper SRMA could play a key role in rapidly disseminating essential knowledge about this type of research.

Various organizations offer different programs for research development. However, these programs face several limitations, such as being costly, not providing advanced training in SRMAs, and often lacking highly qualified trainers. In response to these gaps, the GAF [14,18] has recently developed an effective and replicable online training program for researchers conducting SRMAs (https://www.globalandrologyforum.com/training) [19]. This specialized, free program includes online modules, self-assessment, live feedback, and multiple quizzes, all accompanied by detailed explanations and corrections [12].

In the current study, we present a structured training program developed by GAF experts, which builds on our earlier study [12]. This program is specifically designed to prepare novice researchers to participate effectively in conducting SRMA studies. We also provide data on the program's effectiveness based on participants' evaluations collected through questionnaires, as well as an analysis of the participants' assessment scores.

MATERIALS AND METHODS

1. Course participants

This training course was specifically designed to enable GAF members to participate in the SRMA studies conducted by GAF. The trainees were newly joined members with limited or no prior experience in SRMA studies. Ethical approval for the study was obtained from the GAF Institutional Review Board (IRB) under approval number IR-02-23-120. Participants provided their informed consent to allow the use of their information in this study.

2. Course development

1) The synchronous online training course

The original synchronous online training course was developed after several meetings and discussions among GAF experts with extensive experience conducting SRMAs [12]. The training course material, instructions, and communication were delivered via email and WhatsApp. The course addressed the following five learning outcomes, including the key steps in preparing and publishing an SRMA based on the PICOS model:

A. Gaining a comprehensive understanding of SRMAs and what constitutes a PICOS question.

B. Carrying out literature search utilizing established databases such as Scopus, PubMed, Cochrane, and Embase, employing diverse search strategies and keywords to ensure a thorough exploration of the published literature.

C. Sorting, filtering, and screening the articles and assessing their eligibility based on the inclusion and exclusion criteria.

D. Evaluating the quality of the collected literature based on the available quality of evidence (QoE) methods and protocols.

E. Systematic data collection and entry following established protocols.

A total of 101 trainees completed the synchronous online training from June 2022 until April 2023. Each participant underwent a test examination after completing the course requirements. Participants who achieved a score of 80% or higher were considered qualified and directly involved in the SRMA studies.

2) Synchronous training course evaluation

The original synchronous training course was assessed based on participant feedback. The trainees participated in an online survey to evaluate the quality of the training, which was measured using a specially designed comprehensive survey. The survey focused on various aspects, including the participants age and academic degree, feedback on the training course materials (Table 1), evaluations of the training assessments (Table 2), the perceived usefulness of the training modules, and identifying which parts of the training module requires more focused exercises. Data from the respondents were collected for further statistical analysis. Participants who did not respond to specific questions were excluded from the dataset for those questions.

3) The Moodle-based online training

In November 2023, the new asynchronous training format was adopted and implemented for delivery on the Moodle LMS platform. The training also incorporated live feedback from experienced GAF trainers. At the time of submission, 29 trainees had participated in the GAF SRMA training on Moodle. All participants started at a basic level in meta-analysis studies, with each declaring that they had not previously been involved in or had experience with such studies. Completion of each module assessment was mandatory before progressing to the subsequent module. The different

Table 1. Rating the training course materials clarity, content, improving the trainee knowledge and the training assessment

Rate 1: How would you rate the training materials in terms of clarity of instruction (1=least clear, 5=most clear)
Rate 2: How would you rate the training materials in terms of content? (1=least helpful; 5= most helpful)
Rate 3: To what extent did the training materials add to your knowledge? (1=lowest knowledge, 5=highest knowledge)
Rate 4: How would you rate the training assessment in terms of difficulty? (1=very easy, 5=very difficult)

Table 2. Rating the training course assignment in terms of relevance and deadline given, leadership feedback and support, confidence to undergo SRMA, and recommendation of training course for colleagues

Rate 1: How would you rate the assignment in terms of relevance to the training materials? (1=least relevant, 5=most relevant).
Rate 2: How would you rate the assignment in terms of the deadline given (time allotted to complete the exercises)? (1=least convenient, 5=most convenient).
Rate 3: How would you rate the team leader in terms of his/her feedback and support? (1=very poor, 2=poor, 3=average, 4=good, 5=excellent)
Rate 4: How would you rate the team's co-leaders in terms of their feedback and support? (1=very poor, 2=poor, 3=average, 4=good, 5=excellent).
Rate 5: After completing the training program, are you confident enough to undergo SRMA research? (1=nervous, 5=very confident)
Rate 6: Would you recommend a similar training opportunity (as offered to you by GAF) to a colleague? (on a scale of 0 to 10 where 0=not at all, and 10=definitely).

SRMA: Systematic Review and Meta Analysis, GAF: Global Andrology Forum.

modules were formulated as described below:

① Module 1: Introduction and study resources

This module was designed to provide a comprehensive understanding of various study designs in medical research and to develop fundamental knowledge of SRMA to facilitate the practical completion of the modules. It included understanding and formulating research questions, designing an SRMA, developing the PICOS framework for studies, and creating search strategies.

② Module 2: Literature search

This module clarified how to conduct a search using medical databases, including PubMed, Scopus, Embase, and Cochrane. It included searching for specific topics using designated keywords and utilizing the database features to refine the search results. Participants also learned how to systematically name and save all the collected files according to the guidelines provided in the assignment.

③ Module 3: Sorting, filtering, and screening

This module aimed to enhance participants' skills in data management. It covered downloading records in appropriate formats and sorting and filtering them using Excel. The trainees reviewed the retrieved records based on their titles and abstracts to determine whether they should be included or excluded according to the eligibility criteria.

④ Module 4: Evaluation of the quality of published evidence

This module covers the evaluation of eligibility and the quality of published evidence. It includes examining records to determine their eligibility and quality for inclusion in the following data extraction phase. Additionally, participants learned how to evaluate the quality of articles using various tools, such as the Cambridge Quality Checklist [20] and the The Newcastle-Ottawa Scale (NOS) [21] for observational studies, as well as the Cochrane risk of bias [22], CONSORT [23], and JADAD [24] for clinical trials.

⑤ Module 5: Assessing quality of evidence skills and data extraction

This module focused on evaluating participants' skills acquired in the previous module. Additionally, it covered data collection from eligible articles and data entry, such as entering correct data and correct reporting form (SD or SEM), helping participants avoid mistakes in data extraction, which is the most crucial step in an SRMA project.

⑥ Module 6: Final quiz

The participants received detailed feedback and could refine assignments, with support from a dedicated trainer guiding the program. Participants were guided through a step-by-step process in which a specific exercise cannot be started if the previous one has not been completed satisfactorily.

The trainees' progress and performance were evaluated based on assignments and quizzes designed to assess the learning outcomes of each module. Moreover, a final quiz aimed at assessing the wholeness of the skills acquired was offered at the end of the training. The trainees were allowed three attempts at the assignment and quizzes, with a minimum score of 70% to pass the modules and 80% to pass the final quiz. Participants scoring poorly on the quiz underwent another round of training sessions, and mistakes were clarified by one of the trainers guiding the program. The trainees were re-tested, and only participants who performed above 80% on the final quiz were admitted into the SRMA research groups [12].

4) Course evaluation of the asynchronous course

The effectiveness of the asynchronous course was evaluated based on the trainers' assessments of participants' performance throughout the course and participants' feedback. Performance data for participants who actively engaged in the program were retrieved from a database. The data included scores/grades from module assessments and the number of training sessions attended during the course.

3. Statistical analysis

Statistical analyses were conducted using Python (version 3.12) with the support of libraries such as Pandas (v1.5.3), Matplotlib (v3.7.1), NumPy (v1.23.5), SciPy (v1.11.2), and Scikit-learn (v1.2.2) for data management and statistical analysis. All coding and analysis were performed using the Google Colab platform. To assess the distribution of scalar variables, we utilized visual tools such as histograms and probability plots alongside analytical methods, including the Kolmogorov-Smirnov

and Shapiro-Wilk tests. Variables with a normal distribution are expressed as mean±SD, while non-normally distributed variables are presented as medians with interquartile ranges (IQRs).

The Mann–Whitney U test was used for binary group comparisons. Additionally, multivariate analysis was conducted using Ordinary Least Squares (OLS) regression to explore the relationship between various

Table 3. General characteristics of the respondents (n=101)

Question	Answer option	Number	Percentage (%)
Age (y)	20 to 30	16	15.8
	31 to 40	53	52.5
	41 to 50	25	24.8
	51 to 60	7	6.9
Were you an active researcher or a co-leader during training?	Active researcher	79	78.2
	Co-leader	22	21.7
What is your highest academic degree?	PhD	31	30.7
	Urologist	30	29.7
	MD	13	12.8
	DVM	4	4.0
	FEBU	1	1.0
	MCh (Urology)	4	4.0
	Andrologist	7	6.9
	MS	1	1.0
	MSc	6	5.9
	Others	4	4.0
Did you complete the four training exercises?	No	7	6.9
	Yes	94	93.1
Did you complete your final training exercise assignment?	No	12	11.9
	Yes	89	88.1
How many years of research experience did you have before starting GAF training?	1 to 5 years	45	44.5
	11 to 15 years	12	11.9
	6 to 10 years	26	25.7
	>15 years	4	4.0
	Less than one year	12	11.9
	Medical research with GAF is my first research experience	2	2.0
Before joining the GAF, what kind of study design did you participate in? Select all that apply	Animal research	33	12.7
	Association studies	1	0.4
	Field animal research	1	0.4
	I have no research experience	6	2.3
	Meta-analysis	20	7.7
	Narrative reviews	1	0.4
	Observational studies[a]	77	29.7
	Randomized controlled trials	21	8.1
	Retrospective	67	25.9
	Systematic reviews	32	12.4
How many published articles in peer-reviewed journals did you participate in?	1–5	33	32.7
	6–10	21	20.8
	>10	33	32.7
	None	14	13.8
Have you ever received structured training in conducting SRMA before this GAF training?	No	75	74.3
	Yes	26	25.7

GAF: Global Andrology Forum, SRMA: Systematic Review and Meta Analysis.
[a]Cross-sectional, case-control, or cohort.

parameters and the total training survey score. This method allowed for the simultaneous assessment of multiple factors to identify significant predictors while accounting for potential confounding variables.

RESULTS

1. Original synchronous GAF training

More than half of the respondents (52.5%) were between 31 and 40 years old. The respondent's most common highest academic degrees included PhD (30.7%) and MD (Urologist) (29.7%). Most respondents completed all the training exercises (93.1%), and 88.1% finished the final training exercise assignment. Before the GAF training, most respondents (44.5%) had up to 5 years of research experience, with observational studies being the most utilized study design (29.7%). Only 13.8% of participants declared that they had no published articles in peer-reviewed journals. Before the GAF training, only 26 (25.7%) of the respondents had received structured training in conducting SRMAs (Table 3). Most participants (65.7%) had an h-index (Scopus) of 4 or less (Fig. 1).

The respondents rated GAF training materials (Fig. 2). In terms of course difficulty, 'How would you rate the training assessment difficulty?' This particular question was mostly (82%) given a score of 3 or 4 out of 5 (Fig. 3).

Most of the respondents rated GAF training assignments (Fig. 4) with scores of 4 and 5 (on a scale of 1–5) for all the questions.

Most respondents (~80%) were optimistic when asked if they would recommend similar training opportunities to their colleagues (Fig. 5).

The respondents regarded Module 3 as the most helpful training module (Fig. 6A), while Module 2 was considered the least useful (Fig. 6B).

In response to a question about which modules required more detail and focus, participants were allowed to select (more than one choice if applicable). They identified "assessment of the quality of evidence" and "statistical analysis," with 62 and 61 out of 232 responses, respectively. In contrast, "data extraction" and "research methodology" were considered less prioritized, receiving only 37 and 34 responses, respectively (Fig. 7).

The survey's total training evaluation score was correlated with the respondent's assignment score (r=0.287, p=0.023). The survey's total training evaluation score was also correlated (r=0.399, p<0.001) with the "dedicated time for research" submitted by the respondents in their GAF application forms.

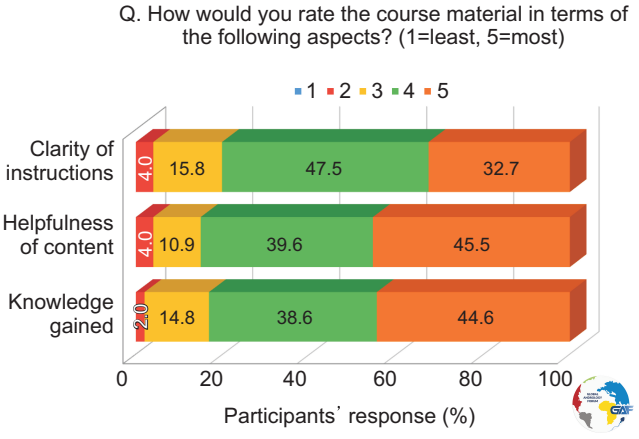


Fig. 2. Rating of the online course material (n=101).

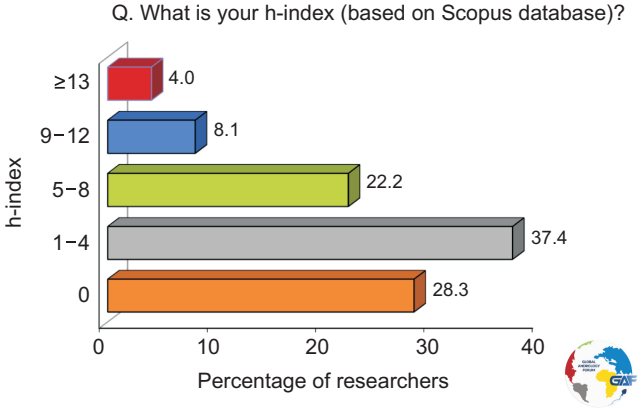


Fig. 1. h-index of participants in the GAF SRMA training (n=101). GAF: Global Andrology Forum, SRMA: Systematic Review and Meta Analysis.

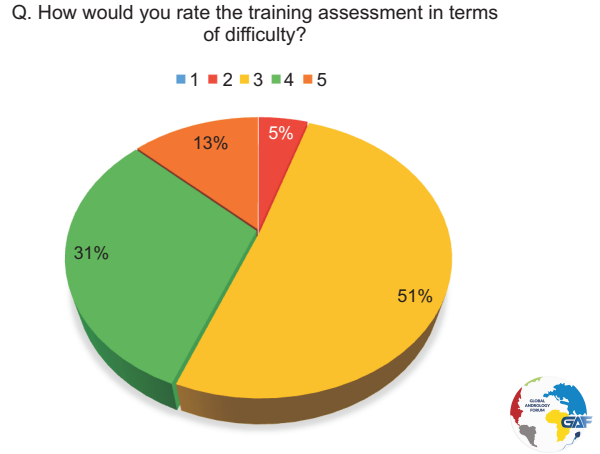


Fig. 3. Rating of the training assessments in terms of difficulty (n=101).

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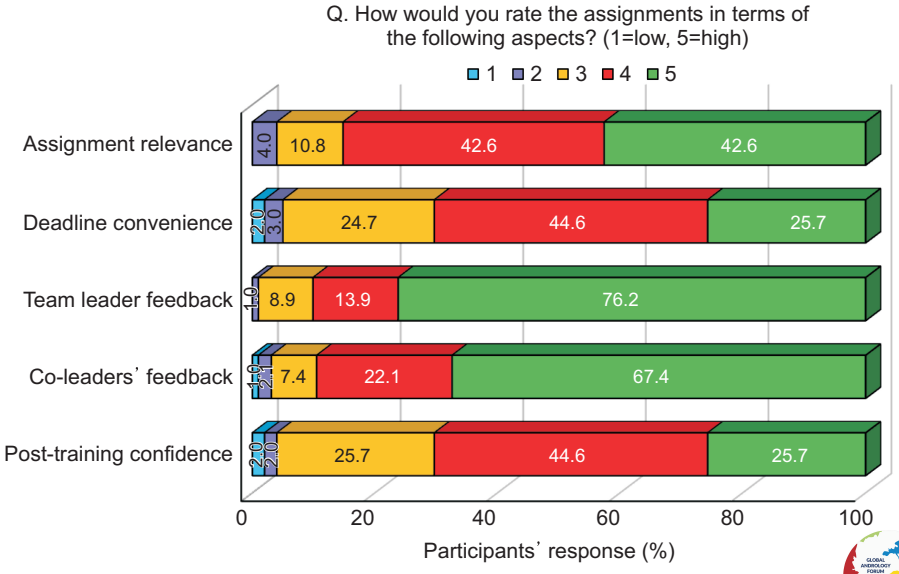


Fig. 4. Ratings of assignment relevance, deadlines, leadership support, and confidence post-training (n=101).

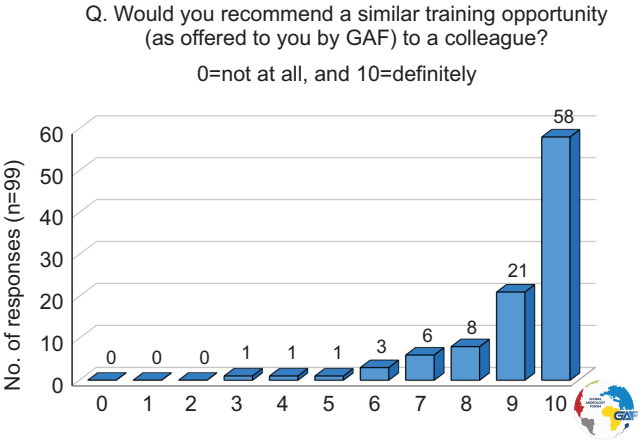


Fig. 5. Recommendation of similar training opportunities to colleagues. GAF: Global Andrology Forum (n=99).

Although not statistically significant (p>0.05), the number of published articles was inversely correlated with the total training evaluation score. There were positive correlations between a higher number of published articles (>5 articles) and lower scores on the following questions: 'To what extent did the training materials add to your knowledge?' (p=0.012). Participants with fewer published articles reported a median (IQR) score of 5.00 (4.00–5.00), while those with more published articles reported a median (IQR) score of 4.00 (4.00–5.00).

Academic degree and country of residence did not significantly affect the responses in this survey (p>0.05). Multivariate analysis identified "hours dedicated to research activities" as the sole predictor of the total training score in the evaluation survey (OR: 1.25, p=0.004).

2. The Moodle-based online training

Since the course was designed to be asynchronous, only 22 members started the assessments. All participants began with no previous experience conducting meta-analysis studies. Among the participants, 12 (54.5%) fully completed all the course requirements, and most of them (92.0%) achieved very satisfactory results (scores >80.0%), with an overall average score of 83.7% across all training module assessments (Fig. 8).

Most of the researchers who completed the course (8/12) passed the test on the first attempt. Two researchers needed to retake the module assessment a second time because they failed to achieve a satisfactory score, and the other two participants needed a third attempt. The average score on the first attempt of the group of researchers who completed the training was 70.8%.

The average best attempt score of each participant (including participants who had not completed all modules yet) from each module, were analyzed to assess the impact on participants' learning progress. The findings revealed that the average best attempt score for each assessment ranged from 79.2% to 90.1% (Fig. 9).

Participants expressed strong satisfaction with the course, praising the clarity and practicality of Modules

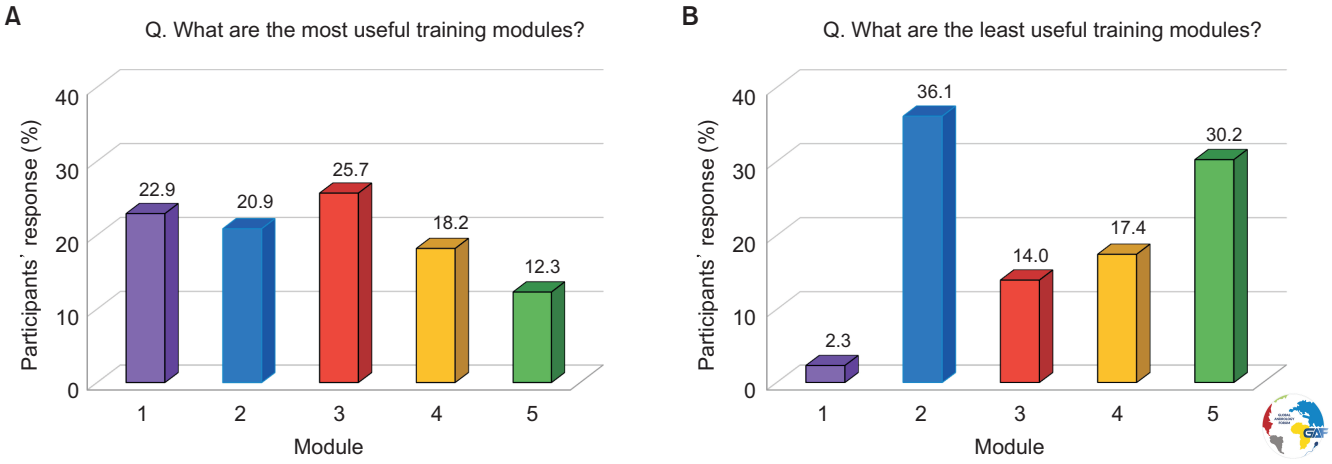


Fig. 6. Evaluation of the most (A) and least (B) useful modules of the training program (n=101).

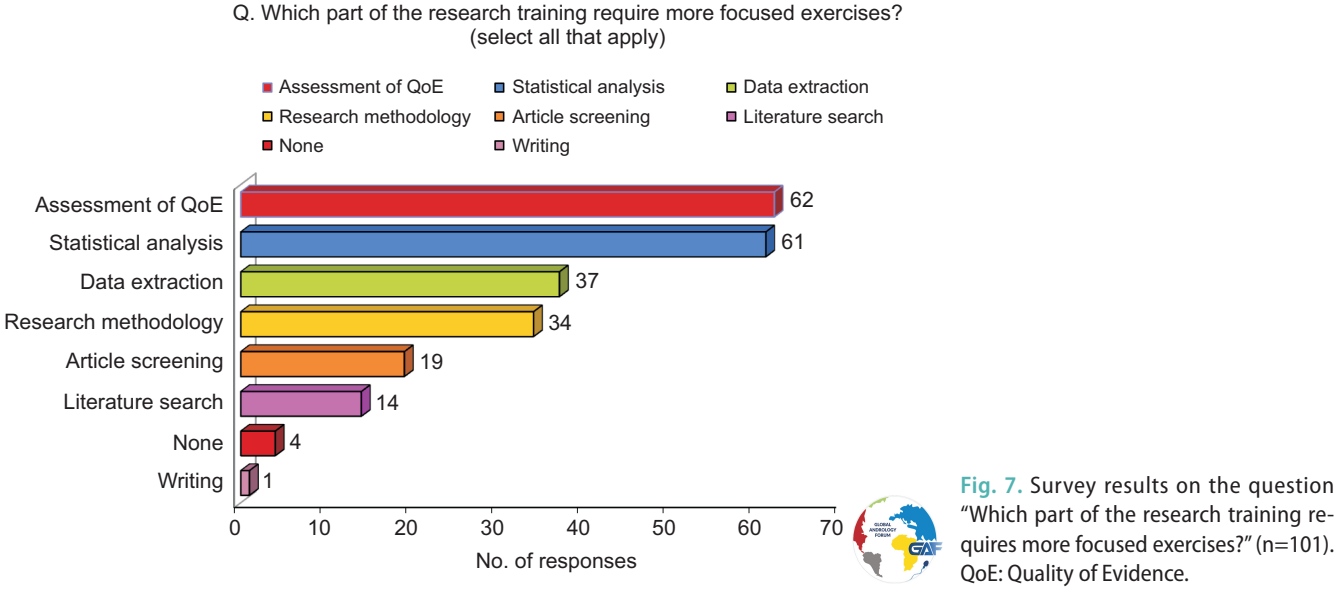


Fig. 7. Survey results on the question "Which part of the research training requires more focused exercises?" (n=101). QoE: Quality of Evidence.

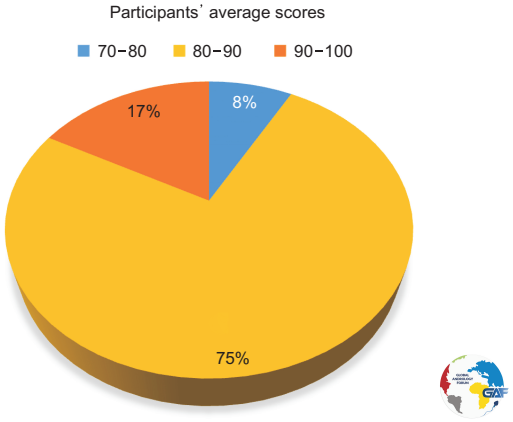


Fig. 8. Participants' average scores on the asynchronous training course (n=22).

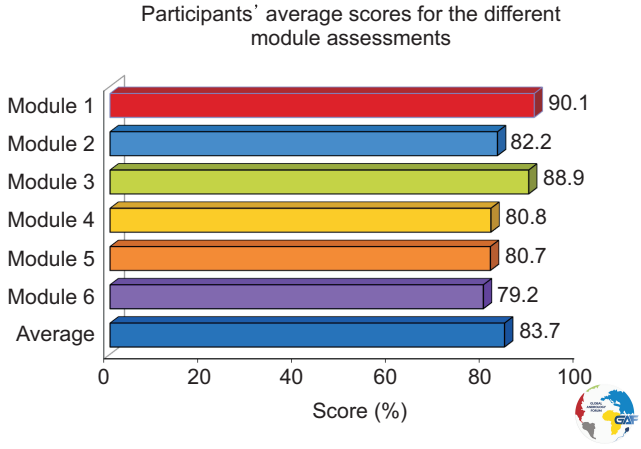


Fig. 9. Participants' average best attempt score for different module assessments in the asynchronous training course (n=22).

1 and 2 and the consistent, effective trainer support. The two-week deadlines were considered manageable, though some suggested reminders. Areas for improvement included clearer guidance in Modules 3 and 4 and more detailed feedback for Module 6 (final quiz). Overall, the course was well-received, with constructive recommendations for refinement.

DISCUSSION

Improving research skills is not a purely cognitive phenomenon. It includes interactions with environments such as laboratories, academic programs, and the more considerable academic discipline, as well as specific behaviors such as training, supervision of research activities, the art of scientific communication, scientific writing, and mentoring of postgraduate students. The need for a dedicated training program to improve researchers' skills has been highlighted in a recent study [12]. The GAF introduced a new training program that adopted a structured, protocol-driven approach to medical research education. This training program was designed to overcome common pitfalls previously identified in conducting meta-analytical studies, such as the inclusion of non-eligible studies and errors in data collection and analysis [25].

The results of the current study indicated that the highest proportion of participants provided top ratings for course clarity, quality of course material, their knowledge improvement, and the comfort of the course exercises. Additionally, regarding the course difficulty, since higher scores on a question about "difficulty" indicate a worse response, the scores mainly of 3 to 4 should be regarded as a positive outcome.

These positive ratings may be attributed to the structured and well-organized nature of the course content, which likely facilitated clear communication of complex concepts. The high-quality course materials explicitly made for this training by senior GAF experts with vast experience in conducting SRMA studies also provided comprehensive and relevant information, supporting the participants' learning. The significant improvement in knowledge could be due to the course's focus on practical, activities reinforcing theoretical concepts. Furthermore, the comfort of the exercises may reflect the user-friendly design and pacing, which allowed participants to engage with the material at a manageable and effective learning pace.

In addition to the course's knowledge content, the trainees expressed high satisfaction with the relevance and timing of the course assignments, the leadership's feedback and support, their confidence in conducting SRMA, and their willingness to recommend the training course to colleagues. The high level of satisfaction with the timing of the assignments may be related to the asynchronous format of the course, which allowed participants to complete the assigned tasks at their own pace, accommodating various schedules and time zones. The relevance of the assignments likely stemmed from their alignment with key skills required for SRMAs, making them directly applicable to the participants' learning goals. Additionally, the consistent feedback and support provided by leadership helped build participants' confidence in mastering SRMA techniques. This positive experience likely contributed to the participants' willingness to recommend the course to colleagues.

Regarding the modules' effectiveness, the survey indicated that 48.6% of participants found Module 1 and Module 3 to be the most useful, while Module 2 was rated as the least useful (31.6%). The lower rating for Module 2 may be attributed to its focus on including technical abilities, search strategies using medical databases, and computer skills. In contrast, Module 3 offered more practical, hands-on experience in tasks such as data collection, sorting, and determining the inclusion or exclusion of retrieved records based on eligibility criteria. This applied learning, often considered the core of conducting an SRMA, is likely to have resonated more with participants, as it directly addressed the critical skills needed for the analysis process and offered immediate, practical value.

Additionally, the participants recommended emphasizing on "assessment of QoE" and data analysis in future courses to enhance their learning experience. This recommendation was expected, as obtaining proficiency in QoE assessment and data analysis requires experience to achieve greater efficiency and precision. This feedback should be taken into consideration to refine and enhance the quality of the lower-rated modules in future courses.

Overall, the survey results indicate that the newly designed course successfully met its objective of overcoming learning constraints and enhancing the knowledge and skills of researchers into conducting high-quality SRMA studies.

The results of the participants' assessments showed significant progress in their skills. The participants who fully completed their assessments achieved an average score of 83.7% despite declaring no prior knowledge of meta-analysis studies. Additionally, since most participants passed the final quiz on the first attempt, it is safe to assume that the success of the program preparing the researchers to conduct SRMA studies.

On the other hand, concerning the subjective perception of the program by researchers undergoing training, the evaluation scores reflecting the quality and consistency of the modules showed consistent and satisfactory results across all modules. Interestingly, hours dedicated to training were significantly associated with a higher achieved total score, highlighting the importance of sustained effort and commitment in mastering the course material, which helps researchers become high-quality professionals capable of conducting robust and accurate SRMAs.

1. Merits of the GAF innovative online training approach

The success of this training course model has contributed to several key advantages in the field of research training, including the following.

1) Overcoming geographic constraints

One of the major advantages of the GAF's innovative online training approach was overcoming geographic constraints to provide high-quality training in research methods to more than 140 researchers from 33 countries over 24 months (Fig. 10).

2) Access to expertise

Sharing knowledge enables the intercultural and cross-border exchange of experiences, which could improve the understanding and skills of researchers [26]. In a cross-sectional survey study utilizing a web-based questionnaire, more than 70% of the respondents agreed or strongly agreed that e-learning was more effective in fostering deep learning than traditional methods. This perceived effectiveness can be attributed to the trainers' calibre, cutting-edge knowledge delivery, and engagement in question-and-answer (Q&A) sessions. The ability to leverage expertise and international audience experience within a concise, short timeframe is a robust endorsement of the virtual landscape for future educational endeavours [27].

3) Real-time interaction and engagement

The GAF online training program used virtual tools to create an engaging and interactive learning space. Participants in these GAF-organized free courses are provided a variety of ways to connect in real-time, such as live Q&A sessions, discussion boards, webinars, and multimedia content. Indeed, this virtual landscape offered diverse engagement activities, including specific interactive multimedia courses, hands-on exercises, and direct communication tools that facilitate real-time interaction between participants and instructors. Practical exercises gave learners the chance to apply their skills directly, helping to strengthen their understanding.

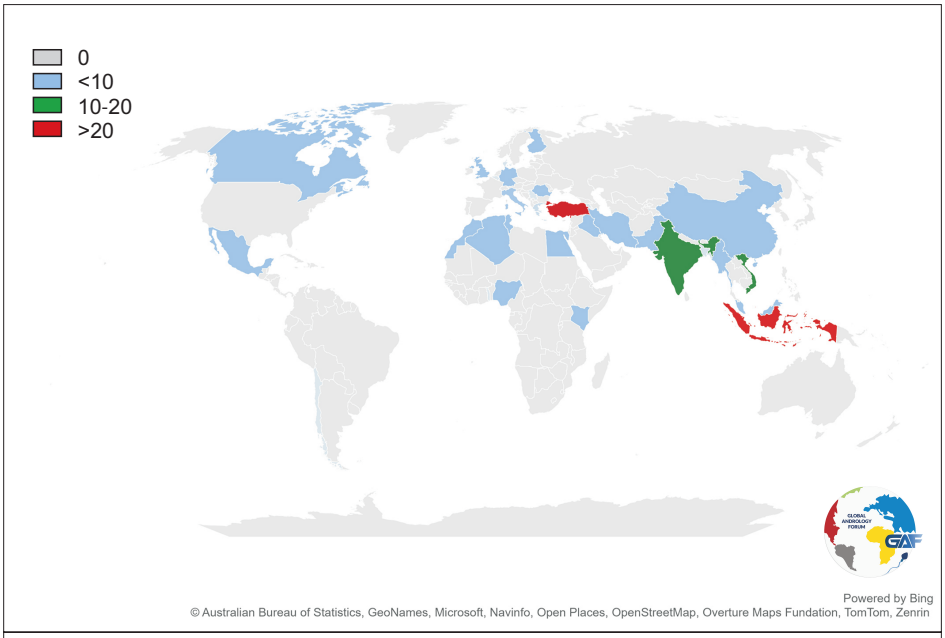
This interactivity setup, which included live Q&A sessions, discussion forums, and webinars, played a crucial role in clarifying doubts, promoting engagement, and supporting deeper learning through a stronger connection to the course content.

4) Flexibility and self-paced learning

The self-learning online training facilitated through the structured online Moodle platform offered trainees an excellent opportunity to learn at their convenience, irrespective of their educational or career stage. With 24/7 access to course materials, participants could determine when to study, progress at their own pace, and decide how much learning to complete within specified timeframes. Notably, this approach increased trainees' self-confidence in self-directed learning, fostering easy interaction with trainers [28] through social and content interactions. This enhanced engagement positively impacted performance and instilled a greater willingness among trainees to undertake new trials.

The iterative approach to various training exercises ensured repeated exposure for researchers, fostering continuous learning since learners can spend more time on challenging topics and move quickly through familiar material, creating a personalized learning experience. The opportunity to review exercises to understand and correct errors contributed to a more robust grasp of concepts. This learning approach shares-similarities with spaced learning, where educational encounters focused on the same material are distributed over intervals. The latter can be defined as a series of "educational encounters (*i.e.*, learning sessions) that are devoted to the same specified material, and distributed over a specified number of study periods separated by

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1. Algeria (3)
2. Armenia (2)
3. Bahrain (1)
4. Bangladesh (2)
5. Barbados (1)
6. Belgium (1)
7. Canada (1)
8. Chile (1)
9. China (1)
10. Denmark (2)
11. Egypt (4)
12. Finland (1)
13. Germany (2)
14. Greece (4)
15. India (16)
16. Indonesia (26)
17. Iran (7)
18. Iraq (2)
19. Italy (9)
20. Kenya (1)
21. Malaysia (2)
22. Mexico (1)
23. Morocco (2)
24. Myanmar (1)
25. Nigeria (4)
26. Pakistan (1)
27. Romania (1)
28. Serbia (1)
29. Togo (1)
30. Tunisia (1)
31. Turkiye (26)
32. UK (2)
33. Vietnam (19)

Fig. 10. Global distribution of trainees participating in the training course (n=149).

an specified interstitial time (the gap between study periods) separated by a specified interstudy interval (duration between consecutive study sessions), with a specified learning outcome after a specified retention interval (time between the final study session and the learning outcome assessment)." This learning method has also been highly effective in health professions education [29]. Learning a large volume of information in a single study session results in 90% of the learned information being lost within a week, with a rapid decline as early as a few hours or days after the study session [30]. Spaced repetition overcomes this limitation, reinforcing learning [30].

5) Multimedia content

Rich multimedia content is vital in research training, significantly enhancing engagement, understanding, and knowledge retention. Various accessible multimedia formats, including video content, infographics, interactive simulations, and animations, contribute to these benefits. Animations, infographics, and 3D models can simplify complex information. Both are important, especially for technical training and scientific research [31].

Video content, for instance, enables instructors to clarify complex study materials, demonstrate processes, and provide step-by-step instructions. It is especially effective for visual and auditory learners [32]. Simulations allow trainees to experiment with various scenarios in a safe and controlled environment. The realistic scenarios allow for retraining and practice until one can master the skill [33].

Overall, the virtual online training provided by GAF encompassed several unique advantages. It overcame geographic barriers, granting researchers worldwide access to high-quality education and fostering inclusivity. Real-time interaction and multimedia content enhanced engagement, while flexible, self-paced learning empowered participants to choose their study hours. This comprehensive approach accommodates various learning styles and caters to a global audience.

2. Challenges in Training program

The training course, while beneficial, encountered some challenges. Limited face-to-face interaction often led to miscommunication, as text-based exchanges lack

the clarity and immediacy of in-person discussions [34] Technical difficulties, including disparities in computational skills, software compatibility issues, and unreliable internet connections, disrupted the learning process [35,36]. Reduced social interaction and delayed responses due to asynchronous communication and time zone differences further delayed engagement and task completion [37]. Self-paced learning demanded high levels of discipline and motivation, which some participants found difficult to sustain, while distractions and multitasking affected focus [38]. Addressing these issues could significantly improve future training.

3. Study limitations, strengths and SWOT analysis

Our analysis has some limitations that warrant consideration. First, the small sample size and the diverse research experience and baseline knowledge levels of participants regarding SRMA steps could have influenced their evaluation of the course modules' "usefulness," introducing potential bias in assessing their effectiveness. While a multivariate analysis was conducted to explore correlations between various parameters and the total training survey score, a subgroup analysis to evaluate the impact of training on specific groups was not feasible.

Additionally, the absence of pre-training assessments precludes a direct comparison of knowledge gained post-training. Furthermore, this study employed a single-arm training intervention without a control group for comparison, such as face-to-face or offline training. Incorporating such a comparative approach in future studies could provide a more objective evaluation of the current training's benefits and help address existing gaps in the medical education literature.

Despite its limitations, this study has several notable strengths. It is the first to comprehensively analyze research training specifically tailored for meta-analytical studies. The training included participants from diverse countries, educational backgrounds, and age groups, reflecting the global and interdisciplinary nature of GAF. A thorough evaluation was conducted, assessing the training quality based on participants' performance and incorporating their feedback to refine future iterations. Additionally, the study explored factors correlating with training outcomes, providing insights that could inform the development of more personalized and targeted training programs. These findings contribute to advancing evidence-based approaches to research education in meta-analysis.

The study's SWOT analysis is summarized below,

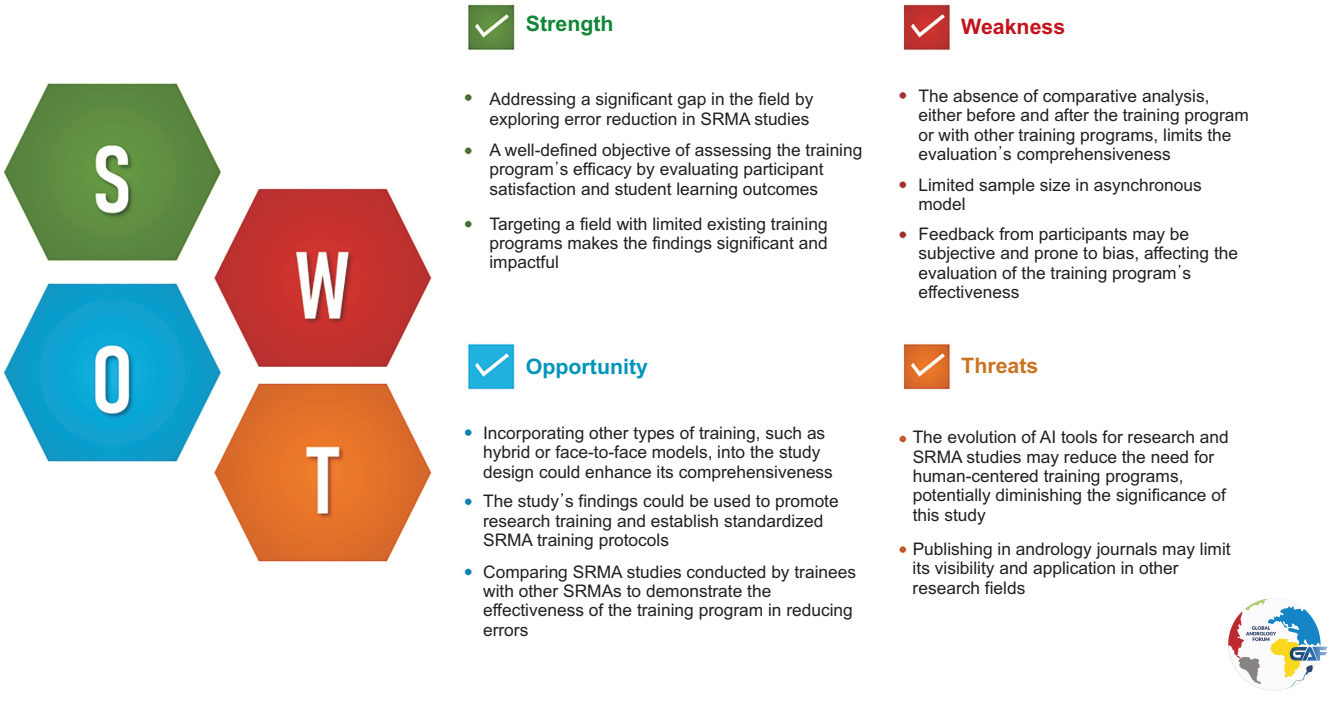


Fig. 11. Strengths (S), weaknesses (W), opportunities (O), and threats (T) analysis of the study. SRMA: Systematic Review and Meta analysis.

highlighting the strengths (S), weaknesses (W), opportunities (O), and threats (T) of our training model (Fig. 11).

CONCLUSIONS

The GAF training program effectively addresses the need for enhanced skills among researchers, equipping them with the tools to conduct high-quality SRMAs. This innovative online training model has successfully overcome geographical and resource constraints, making advanced training in research methodology accessible to medical professionals globally. Participants' positive feedback and improved assessment scores demonstrate a meaningful increase in their knowledge and skills, validating the program's efficacy.

The asynchronous format of the program offers significant advantages, including flexibility for participants to set their study schedules, unlimited time for completion, and continuous feedback and support. The program's strengths include high participant satisfaction, program flexibility, rich multimedia content, and interactive engagement.

The GAF training model fosters inclusivity and accessibility, enabling researchers worldwide to develop a solid understanding and practical skills in meta-analysis. Its scalability ensures that the program can expand to accommodate a larger audience without compromising quality, promoting international research collaboration. Additionally, the adaptable framework of the training model makes it suitable for application across various disciplines, extending its impact beyond the field of andrology.

Conflict of Interest

The authors have nothing to disclose.

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Author Contribution

Conceptualization: AA. Methodology: AP, WZ, HA. Data curation: BS, HA. Writing-Original draft preparation: All authors. Supervision: AA, AP. Validation: AP. Writing-Reviewing and Editing: AA, AP, HA, Raamdan S, AC.

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