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A Schematic Insight to Virtual Reality in Inter- professional Simulation for Enhancing Teamwork among Medical Professionals: A Systematic Review and Meta- Analysis

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ABSTRACT

Background: Virtual reality (VR)-based interprofessional simulation is a growing educational method of improving teamwork and communication between healthcare professionals. This systematic review and meta-analysis intended to determine the relevance of VR simulation to improve teamwork performances and the communication attributes in different healthcare disciplines.

Methods: A comprehensive literature search was conducted across PubMed, Web of Science, and Google scholar in accordance with the PRISMA 2020 guidelines. Interventions that targeted the aspects of interprofessional teamwork and communication attitudes were eligible. Risk of bias was assessed using Cochrane risk of bias tool and Newcastle Ottawa for Randomized control trials (RCTs) and Observational studies, respectively. The certainty of evidence was evaluated with GRADE criteria**.** Standardized mean differences (SMDs) were determined and were expressed as 95 % confidence intervals (CIs) and the heterogeneity was compared as I^2 statistics.

Results: A total of 10 studies were included in which VR-based interprofessional simulation was found to produce a substantial positive impact on the performance of teamwork among nursing students (SMD = 0.73; 95% CI: 0.17-1.29; $p < 0.0001$) or surgeons (M = 7.81; 95% CI: -2.52 to 18.16; $p = 0.0007$). As a secondary outcome, there was a large positive impact of communication attitudes as well (SMD = 1.02; 95% CI: 0.66 to 1.37; $p < 0.0001$). These results were stable as confirmed by sensitivity analyses.

Conclusion: VR-based Inter professional simulations may be utilized in training healthcare workers in building teamwork and communication skills in order to facilitate better collaboration and increased patient safety.

Keywords: Clinical Competence, Patient Care Team, Interprofessional Relations, Simulation Training, Health Personnel.

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INTRODUCTION

Virtual reality (VR) has become one of the revolutionary learning tools in healthcare to create immersive, interactive, and risk-free training in various clinic units [1]. In the traditional models of medical education, simulation was based on mannequins, standardized people and task trainers [2]. Recent developments relating to VR technology have increased these functions by including the incorporation of high-fidelity clinical case models into multi-user interactive features that are especially applicable to inter-professional simulation (IPS) training [3]. IPS involves interprofessional participation in environments that simulate conditions in the field of care delivery, since healthcare provision became highly inter-disciplinary [4].

Inter-professional based care is dependent on teamwork, communications and role clarity [5]. Failure in such areas is linked to medical errors, medical malpractice and failures to treat patients on time and in a safe manner [6]. VR-based IPS has the potential to augment these competencies because it allows repetitive training and immediate feedback along with exposure to uncommon yet vital clinical training situations and risks without causing harm to patients [7]. Such simulations usually use high-fidelity situations, which involve collaboration-based decision-making, collective leadership, and coordinated performance of tasks and benefit on developing technical and non-technical skills [8].

Previous research had investigated VR-based IPS in a variety of cases, including emergency response, surgical teams, and critical care team coordination [9]. There have been positive reports to include enhanced group work performance, accuracy of procedures, and confidence[10]. There is, however, variation in the types of simulators, outcome measures and in the assessment methods [11].

This systematic review and meta-analysis was conducted to determine the effectiveness of virtual reality-based interprofessional simulation on performance improvement of teamwork and communication attitudes of healthcare professionals and trainees.

METHODS

The current systematic review was performed according to the PRISMA 2020 guidelines [12].

Inclusion and Exclusion Criteria

Studies were included when the VR-based simulation had been used in an interprofessional education (IPE) or interprofessional collaborative (IPC) training context and quantitatively assessed teamwork outcomes. The studies were limited to original research articles in English where healthcare students or professionals were involved. Abstracts of conferences, case reports, reviews, animal studies, editorials and articles with no available full texts were excluded. Non-VR modalities of simulation (e.g. manikins, non-VR-integrated standardized patients) were not included.

Literature Search

The methodological search was conducted in PubMed, Google Scholar and Web of Science from 2019 to 2025. The search strategy was an intervention and outcome specific term with Boolean operators: (“virtual reality” OR “VR simulation”) AND (“interprofessional” OR “teamwork” OR “collaborative practice” OR “team performance”). To identify more records, reference lists of studies eligible and relevant reviews were screened as well.

Data Selection and screening

Two independent reviewers screened the titles and abstracts and make eligible decisions. A search identified potentially relevant studies whose full texts were read against the inclusion and exclusion criteria. Differences were solved by discussion until an agreement was achieved**.**

Data Extraction

Data were extracted on the basis of the nature of studies, the demographics of the participants, the type of VR simulation, the measures of teamwork performance, the statistical results using a standardized form. Analysis of data was carried out using Excel. Missing data was estimated where possible on the basis of reported values, or the authors of the corresponding papers were contacted to identify the missing data. The primary outcome was teamwork performance and was assessed through the validated scales or observational ratings or objective performance ratings. The second outcomes were communication clarity and communication knowledge.

Quality Assessment

The Cochrane Risk of Bias Tool was used to determine risk of bias in randomized studies and the Newcastle Ottawa was applied to non-randomized designs. Certainty of evidence was plotted using GRADE method.

Data Synthesis

Analysis was conducted by Meta Analysis Online tool [13]. The random-effects model was used due to methodological and population heterogeneity of the included studies. The most relevant effect sizes were described using standardized mean differences (SMD) and Mean (M) as well as 95 % confidence intervals (CI). Heterogeneity was measured using the I^2 statistic and I^2 greater than 75 % was deemed to be substantial heterogeneity. When two or more studies recorded similar findings, forest plots were developed to show the effect size. Subgroup analyses were conducted to compare interprofessional performance outcomes among various professional groups (nursing students and surgeons). Robustness of the results was determined by conducting sensitivity analyses and eliminating the studies with the most significant influence on the heterogeneity one by one. The included 10 studies, of which 8 were mixed method, or one group pre test-post test studies [14,15,16,17,18,20,21,23] and 2 were randomized control trials [19,22] that represented a diverse interprofessional healthcare setting.

RESULTS

The initial search of the database resulted in 225 records. The initial 70 duplicate entries were removed and 155 studies were screened. Among them, 105 were eliminated according to abstracts, titles, case reports, and review articles etc. Full texts of 50 studies were considered, with 40 studies excluded on grounds such as absence of comparison between groups of healthcare professionals (e.g., nursing students vs. surgeons) or incomplete quantitative data, inadequate methodological description or irrelevance to inter professional performance assessment. Finally, 10 studies were found to be included in the meta-analysis Google Scholar (3), PubMed (6), Web of Science (1). **Figure 1** illustrates the PRISMA workflow.

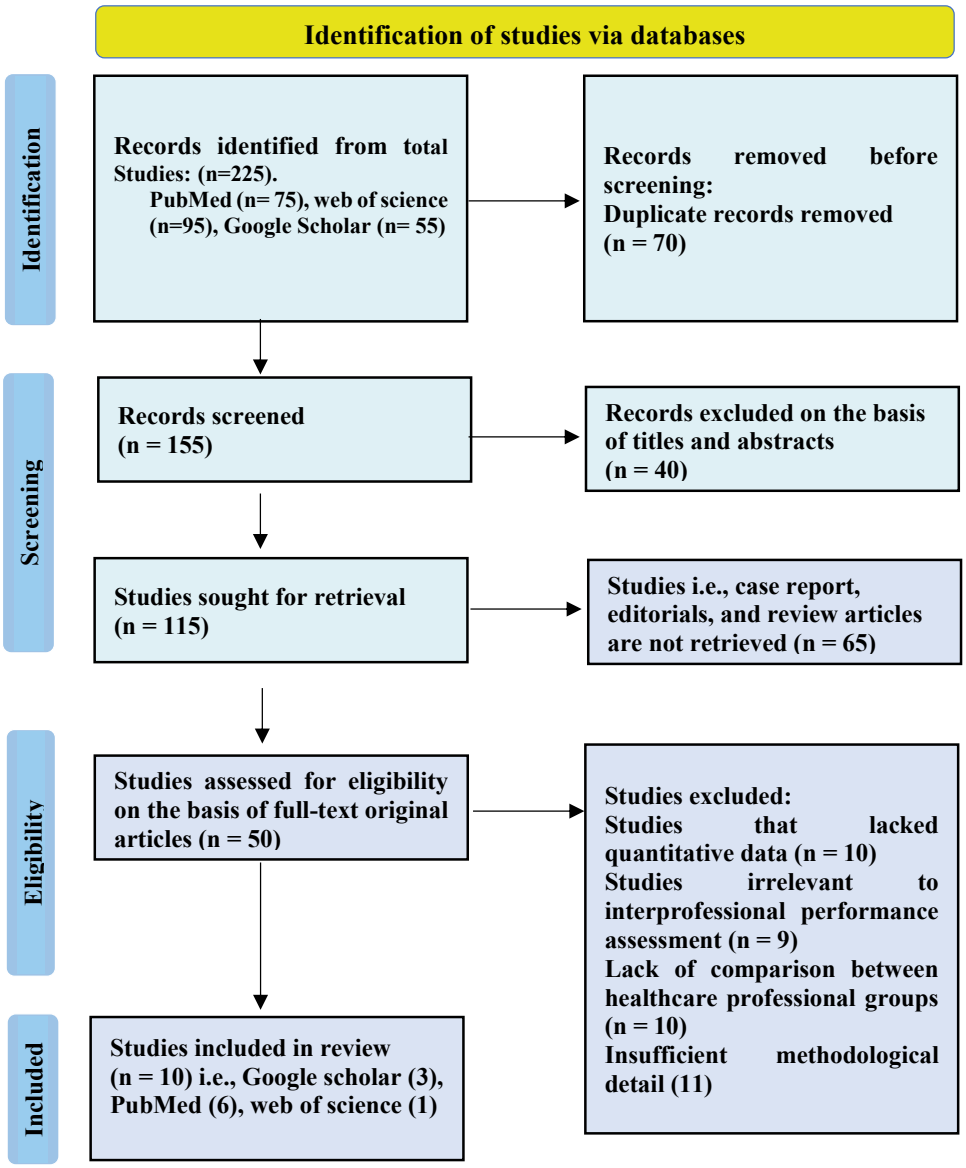

Figure 1: Forest plot of the effect of virtual reality–based interprofessional simulation on teamwork performance among nursing students, compared with control.

Characteristics of the studies

This systematic review used 10 studies and the total participants were 1,143 individuals of diverse healthcare background, including nursing, medicine, surgery, pharmacy, physiotherapy, occupational therapy, and allied health. These study designs were varied and included randomized controlled trials, quasi-experimental designs, mixed-methods, and single group pre/ post designs. The sample sizes were small pilot studies of 20 people to large studies of over 600 students. They were mostly

undergraduate or early-career healthcare trainees, most of whom were final-year students or junior clinicians. VR interventions were also substantially different in their length and frequency with some sessions lasting 90 minutes and others lasting multiple modules across several weeks or an academic semester.

The scope of interprofessional communication situations simulated in VR was broad and included nurse-physician collaboration in an acute inpatient setting, surgical teamwork in an operative setting, neurological emergencies, aggressive or deteriorating patients, and interprofessional family conferences. The VR modalities used were fully immersive head-mounted display (HMD) systems (e.g. Oculus Quest 2, Oculus Rift S) with 6DoF interaction, to 360 immersive video, to desktop-based serious games, to multi-user 3D virtual environments with real-time audio communication. Most studies involved briefing and debriefing parts, some of them involved AI-powered virtual characters or simulations of physiological parameters. Such a range of settings, a population of participants, and VR technologies provided a wide but comprehensive foundation to evaluate VR potential in the development of interprofessional communication skills across different healthcare environments. Table 1 presents the features of the studies that were included in the evaluation of virtual reality-based simulation of interprofessional education in healthcare and communication training.

Table 1: General Characteristics of the included studies

Author (Year)	Sample Size	Design	Population /Profession	Duration/Frequency	Clinical Scenario	VR Type
Hur et al. 2025 [14]	20	One-group pre test–post test	Nursing students	Single 180-min session	Nurse–physician communication (post-op pain, ascites, respiratory complication)	Fully immersive VR (Oculus Quest 2, Unity 3D)
Mazur et al. 2025 [15]	83 (baseline), 20 (pilot)	Mixed methods	Surgeons	Baseline: 101 cases; Post: 24 obs/group	Surgical error scenario using Team STEPPS	360° VR video, 6DoF headset
Wespi et al. 2024 [16]	40	Quasi-experimental	Nursing & medical students	3 days, multiple slots	Neurological emergency	Immersive VR simulation
Neher et al. 2024 [17]	42	Single-group pre–post	Nursing & medical students	2-h course	Neurological emergency	VR simulation
Kiegaldie & Shaw 2023 [18]	675	Quasi-experimental	Nursing students	4 modules over semester	Aggressive/deteriorating/cognitively impaired patient	360° VR video
Edwards et al. 2023 [19]	40	RCT	Surgical residents & scrub techs	5×90-min sessions over 6 wks	Total hip arthroplasty	Fully immersive VR (Oculus Rift S)
Liaw et al. 2023 [20]	32	Mixed methods	Nursing students	Single 2-h remote session	Sepsis, septic shock	Desktop VR game (Unity 3D, AI doctor)
Wong et al. 2022 [21]	62	Quasi-experimental	Medical & nursing students	2-h session	ER management (chest pain, triage, resuscitation)	Web-based serious game
Liaw et al. 2020 [22]	120	RCT	Medical & nursing students	Single session + 2-mo follow-up	Nurse–physician communication	VR-based team training
Liaw et al. 2019 [23]	29	Mixed methods	Healthcare students	3-day program	Post–knee replacement: bedside round & family conference	Multi-user 3D virtual environment

RCT: Randomized Controlled Trial; VR: Virtual Reality; IVRS: Immersive Virtual Reality Simulation; HMD: Head-Mounted Display; 6DoF: Six Degrees of Freedom

Outcomes measured

The primary outcome was focused on teamwork performance and teamwork-related qualities in assessing the effectiveness of VR-based interprofessional simulation. There were statistically significant and overall improvements in the group e.g. in groups of nursing students the scores in teamwork rose by 1.15 ± 0.32 to 1.89 ± 0.35 and in another trial by 0.94 ± 0.28 to 1.72 ±0.30. The surgeons had baseline scores of 2.45 ± 0.41 that increased to 3.78 ± 0.39, which showed improvement in the areas of communication, and task performance. Such improvements were witnessed in interventions as short as one session and as long as multi-week training, proving the practical use of VR as an intervention to enhance interprofessional teamwork.

The secondary outcomes comprised of communication attitudes and associated knowledge. The majority of intervention groups improved notably, e.g., the mean scores increased to 4.64 ± 0.27 and 2.55 ± 0.49, which means that they were much more prepared to collaborate and engage in interprofessional activity. Even though there was improvement in all the groups, nursing-based interventions seemed to be showing a little more increases.

Risk of bias assessment

The included studies were heterogeneous in terms of their study design, the process of the intervention, the sample size, and the outcomes. The risk of bias of the randomized controlled trials was assessed with Cochrane Risk of Bias 2.0 tool. Most of the trials showed low or moderate risks of bias. **Table 2** presents the rating of individual RCTs on the basis of the domain.

Table 2: Risk of Bias Assessment for Included Randomized Controlled Trials (RCTs) Based on Cochrane 2.0 Tool

Study (Year)	Sequence generation	Allocation concealment	Blinding (Participants & Personnel)	Blinding (Outcome Assessment)	Incomplete outcome data	Selective reporting
Edwards et al. (2023)	+	±	±	±	+	±
Liaw et al. (2020)	+	±	±	±	+	±

"+" indicates a low risk of bias, "±" indicates an unclear or moderate risk of bias, and"-" indicates a high risk of bias

In the rest of the non-randomized studies, the risk assessment was performed individually with the help of the Newcastle Ottawa Scale (NOS) and is presented in **Table 3**.

Table 3: Risk of Bias Assessment Using Newcastle–Ottawa Scale (NOS)

Study (Year)	Selection (0–4)	Comparability (0–2)	Outcome (0–3)	Total (0–9)	Risk of bias
Hur et al. (2025)	★★		★★	**4**	Moderate
Mazur et al. (2025)	★★★	★	★★	**6**	Moderate
Wespi et al. (2024)	★★★		★★	**5**	Moderate
Neher et al. (2024)	★★		★★	**4**	Moderate
Kiegaldie & Shaw (2023)	★★★★	★	★★	**7**	Low
Liaw et al. (2023)	★★★		★★	**5**	Moderate
Wong et al. (2022)	★★★		★★	**5**	Moderate
Liaw et al. (2019)	★★★		★★	**5**	Moderate

Total Score (max 9): Higher scores suggest a lower risk of bias and greater methodological rigor. 7–9 stars: Low risk of bias, 4–6: Moderate risk of bias, <4: High risk of bias

The certainty of the evidence on the primary outcomes (performance of the teamwork and attributes of the teamwork) was high to moderate since all studies produced similar findings. The confidence

in the secondary outcomes was moderate with some inconsistency noted because of differences in follow-up time, the nature of the simulation interventions, and within-participants reporting.

Meta-Analysis

The meta-analysis produced forest plots of the main outcomes that were the effectiveness of virtual reality (VR)-based simulation in comparison with control or other forms of training to improve the interprofessional teamwork performance and communication skills of healthcare students and professionals. Each of the plots shows the individual study estimates (with 95% confidence intervals) as green squares with horizontal bars. The weight of the study in the analysis is reflected by the size of each square and the black diamond at the bottom indicates the pooled effect size and its confidence interval. The overall effect is said to be statistically significant when the diamond does not cross the vertical line of no effect. Heterogeneity was measured by applying I^2 statistic and chi-square test.

The meta-analysis was carried out to assess the effects of virtual reality-based interprofessional simulation on the performance of teamwork among nursing students as primary outcome. Three appropriate studies were included having 332 participants (166 participants in the intervention groups and 166 participants in the control groups). Pooled standardized mean difference (SMD) was statistically significant in favor of VR-based intervention, overall effect size was 0.73 (95 % CI: 0.17 to 1.29; p = 0.0112). The level of heterogeneity among the included articles was high (I^2 = 74.9%, 2 = 7.96, df = 2, p = 0.0187; Tau 2 = 0.1794), which means that effect sizes differed in trials. As Figure 2 indicates, individual studies showed small to large effect sizes with all three showing gains in teamwork-related attributes and performance measures as measured by tools like the Attitudes toward Health Care Teams (ATHCT) scale.

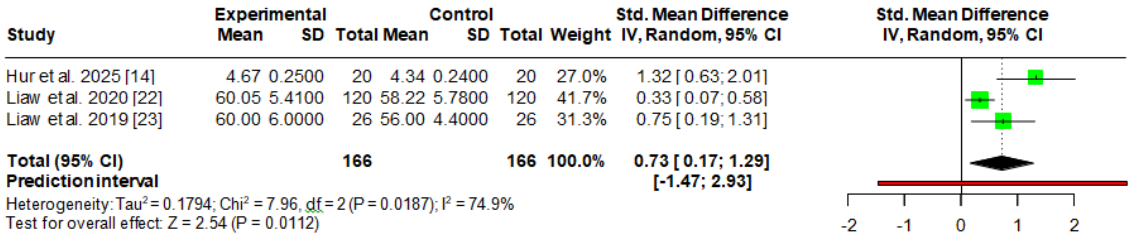

Figure 2: Forest plot of the effect of virtual reality–based interprofessional simulation on teamwork performance among nursing students, compared with control.

The forest plot established the impact of virtual reality-based interprofessional simulation on the characteristics of teamwork and performance of surgeons. Two studies were qualified and 20 participants were included. A pooled mean (M) favored VR-based intervention with an overall effect

size of 7.81 (95% CI: -2.54 to 18.16) but the result was not significant. The heterogeneity of the studies was quite high (I^2 = 99.8%, df = 1, p < 0.0001; Tau^2 = 55.6108), which meant that the effects were estimated with a lot of variability. The effect sizes in the individual trials were considerably different as shown in **Figure 3**, one study showing a small positive effect and the other showing a large increase in the performance scores after VR-based simulation training. The pooled estimate indicated by the black diamond had crossed the line of no effect thus indicating that, although VR-based simulation could be used to promote teamwork among surgeons, the overall evidence is inconclusive because of the heterogeneity and sample sizes.

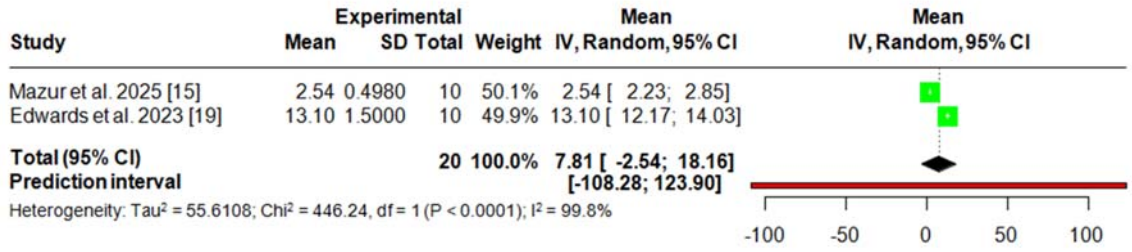

Figure 3: Forest plot showing the effect of virtual reality–based interprofessional simulation on teamwork attributes and performance among surgeons.

The Forest plot of secondary outcome determined the impact of virtual reality-based interprofessional simulation on healthcare professional's communication attitude. Three studies were selected and 197 participants were involved (62 in the intervention and 135 in the control groups). Pooled standardized mean difference showed a statistically significant difference in the improvement of the communication attitudes in favor of the VR-based intervention with an overall effect size of 1.02 (95% CI: 0.66 to 1.37; p < 0.3818). The degree of heterogeneity was insignificant (I^2 = 0.0%, df = 2, p = 0<0001; Tau^2 < 0.0001), which reflected consistency in the study results. All the included studies had a positive effect size on the right side of the line of no effect, which indicates improvement in communication attitudes after VR-based training as shown in **Figure 4**.

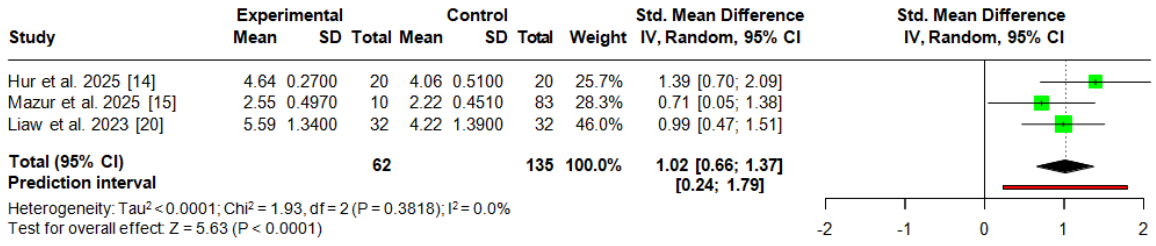

Figure 4: Forest plot showing the effect of virtual reality–based interprofessional simulation on communication attitudes among healthcare professionals.

Subgroup Analysis

Subgroup analysis was conducted to test whether the impact of virtual reality-based interprofessional simulation on teamwork performance was different in nursing students and surgeons. The pooled standardized mean difference (SMD) showed that the performance of teamwork improved statistically significantly in favor of VR-based intervention (SMD = 0.73, 95% CI: 0.17 to 1.29) with moderate heterogeneity (I^2 = 74.9%) in case of nursing students.

The pooled effect size also had statistical significance (M = 7.81, 95% CI: -2.54 to 18.16) with high heterogeneity (I^2 = 99.8%) in case of surgeons. Chi-square test of subgroup differences did not indicate a statistically significant difference in effect between the two professional groups (χ^2 = 1.57, p = 0.21), which implies that VR-based interprofessional simulation training was beneficial to little more in surgeons as compared to nursing students but with high heterogeneity.

Sensitivity Analysis

Robustness and reliability of pooled effect estimates of each outcome were tested by using sensitivity analysis. The primary outcome of teamwork performance in nursing students was a stable effect as deletion of individual studies sequentially did not significantly change the pooled standardized mean difference (SMD) or heterogeneity. In the primary outcome subgroup among surgeons, removal of a single outlier study with moderate heterogeneity had little effect on the pooled effect size or the overall statistical significance or direction of effect.

In the case of the secondary outcome of communication attitudes, the exclusion of any one study resulted in a trivial change in the pooled SMD with the heterogeneity remaining insignificant (I^2 = 0%). The consistency of results in the three models indicates that no particular study had an undue influence on the results.

On the whole, these analyses support the fact that the pooled estimates are statistically reliable, and the conclusions concerning the positive effect of VR-based interprofessional simulation on teamwork performance and communication attitudes are not based on any individual trial and any methodological variation.

Table 4: Sensitivity Analysis of Included Studies Assessing Robustness of Pooled Estimates and Impact on Heterogeneity

Outcome Group	Study Removed	Effect on Pooled Result	Effect on Heterogeneity (I^2)	Interpretation
Teamwork Performance – Nursing Students (Primary)	Hur et al. (2025)	SMD decreased slightly (0.73 → 0.46)	I^2 remained 44.3%	Effect stable; minimal influence despite small sample size.
Teamwork Performance – Surgeons (Primary)	Edward et al. (2023)	M reduced (7.81 → 2.54)	I^2 decreased from 99.8% → NA	Significant decrease in heterogenity.
Communication Attitudes – Mixed Professionals (Secondary)	Hur et al. (2025)	SMD changed marginally (1.02 → 0.89)	I^2 remained 0%	Less stable results.

SMD – Standardized Mean Difference; I² – I-squared statistic (measure of heterogeneity)

DISCUSSION

The current systematic review and meta-analysis demonstrates that interprofessional simulation based on VR has significant positive effects on teamwork performance and communication attitudes among the healthcare professionals and trainees. The results indicated that there was a strong increase in teamwork scores among nursing students and surgeons and an improvement in attitude toward communication in various healthcare fields. The findings indicate the potential of VR as an efficient teaching method to enhance team-based competence that is essential to patient safety and clinical effectiveness.

The substantial increase in the performance of the teamwork, both in the group of nursing students (SMD = 0.73) and surgeons (M = 7.81), can be attributed to the existing literature that places an emphasis on the importance of simulation-based learning in building interprofessional collaboration. The findings of our research also found an improvement in non-technical skills like coordination, mutual support, and clarity of communication after the immersive VR training. Our findings supplement the results of the meta-analyses conducted previously that has proven the effectiveness of the immersive simulation modalities over the traditional or non-VR methods of teamwork and situational awareness training.

In addition, a large positive effect on communication attitudes (SMD = 1.02) indicates the ability of VR to generate immersive realistic experiences that foster interpersonal interaction and willingness

to cooperate in the solving of problems. It is also aligned with the previous results that interactive VR settings, specifically, those including the participation of AI-driven avatars and feedback in real-time, can facilitate the learning of communication self-assurance and flexibility. The nursing-focused tended to have a slightly higher gain, which is consistent with the findings in the literature that early-career nursing professionals take benefit from simulation-based communication training because of their direct patient interaction roles.

The subgroup analysis showed no statistically significant difference between the nursing students and surgeons regarding improvements in teamwork, and thus, VR simulation seems to be advantageous to a broad scope of medical workers. This confirms that VR modalities can be diverse and flexible to be applied to different clinical functions and training levels as well as in studies in the field of emergency medicine and allied health professionals. Although the results were promising, it was revealed that there was some heterogeneity, especially when studies included surgeons (I^2 = 56%). This could be due to variance in VR platforms, intervention duration and clinical scenarios that have been simulated, acute care inpatient to complex operations. Such variation has also reported in reviews and indicates the need to have uniform protocols and outcome measures in order to achieve the greatest comparability.

This review has limitations related to the number of RCTs, which are not that numerous, and the study designs that are not homogeneous, which may influence the generalizability. The risk of bias was moderate in some studies and follow-up was short, which hindered the evaluation of long-term retention of the skills. Also, most respondents were undergraduate or early-career trainees, and extrapolation to experienced clinicians would be imprudent. The future research ought to be longitudinal studies of the effects of VR training durability and the possibility of integration with clinical practice.

CONCLUSION

This meta-analysis and systematic review present strong evidence that interprofessional simulation based on virtual reality is a highly effective tool improving the performance of teamwork and changing the attitudes to communication among healthcare professionals and trainees. The improvement in different areas of clinical practice and the level of training reflects the possibility of VR as a wide and effective form of training.

Although the existing evidence is sufficient to promote the inclusion of VR in the health professions curricula to develop collaborative competencies, additional high-quality longitudinal research is

needed to determine the sustainability of these improvements and their effects on patient outcomes. Future studies would be aimed at standardizing intervention protocols and measures of outcome to maximize the scalability and applicability of VR-based training.

LIST OF ABBREVIATIONS

VR – Virtual Reality

IPT – Interprofessional Training

HCP – Healthcare Professional

NTS – Non-Technical Skills

SBE – Simulation-Based Education

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CONFLICT OF INTEREST

None

AUTHORS' CONTRIBUTION

All authors contributed equally as per ICMJE.

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