The use of interprofessional simulation interventions in medical student education: A scoping review

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Abstract

Introduction: Simulation is commonly used by health and education institutions to facilitate interprofessional learning (IPL). The use of simulation in IPL is resource intensive. Evidence of what works, and with whom, is important to inform practice, policymaking and further research. The aim of this scoping review was to summarise the existing literature on IPL involving medical students, where simulation was the teaching modality. This review examined a variety of simulation-based interventions used to teach IPL to medical students and identified key features and outcomes.

Methods: The databases PubMed, Medline, EMBASE and PsychINFO were searched using the terms related to medical student and simulation combined with interprofessional. Included articles involved medical students alongside a student or practitioner from at least one other health profession taking part in at least one simulation session. Data extraction was performed by two authors using a standardised form.

Results: It emerged that simulations of medical emergencies were the most common format to deliver IPL interventions. Most studies evaluated the success of their IPL intervention using the Readiness for Interprofessional Learning Scale (RIPLS).

Conclusion: All studies were successful in improving student attitudes towards IPL and interprofessional collaboration when these were measured outcomes. Formal team training prior to simulation is effective in improving teamwork skills. IPL interventions with participants from a greater mix of professions have more positive results.

Keywords: interprofessional learning; interprofessional education; medical students; simulation; simulation training

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Introduction

Interprofessional learning (IPL) is currently included in many health curricula, with the aim of improving collaborative behaviours. It is defined by the World Health Organisation (WHO) (2010) as when "students from two or more professions learn about, from and with each other to enable effective collaboration and improve health outcomes" (p. 13). In particular, the aim of IPL is to develop teamwork capabilities and collaborative behaviours.

Many institutions use simulation-based activities to facilitate IPL, with the aim of preparing health professionals for the challenges and pressures they will face in the workplace. Simulation as a teaching modality for IPL enables a broad scope of both complexity and flexibility of learning and is therefore suitable for learners at multiple levels of training and experience (undergraduate, postgraduate and post-qualification) (Poore et al., 2014). A wide variety of simulation interventions have been used in IPL, ranging from high-fidelity simulations involving technologically-advanced mannequins replicating diverse clinical scenarios (Appelbaum et al., 2020; Brown et al., 2016) through to semi-structured interviews with simulated patients, using human actors (Atack et al., 2009; Blackhall, Erickson, et al., 2014; Hess et al., 2016; Lee et al., 2019; Tankimovich et al., 2020). Virtual reality is an emerging branch of simulation, which uses computer generation to mimic clinical scenarios and allows learners to emulate the roles of healthcare practitioners with virtual patients, and it may be more cost effective (Liaw, Ooi, et al., 2020). Accordingly, there are large differences between studies examining broadly different interventions, making comparison challenging.

Learner outcomes are commonly evaluated against the Joint Evaluation Team (JET) model of interprofessional outcomes (Freeth et al., 2007). This model is adopted from the widely recognised outcomes framework of Kirkpatrick (2006) for evaluation of training and has been specifically modified for IPL (Thistlethwaite et al., 2015). Originally designed for business organisations, the Kirkpatrick framework considers four learner outcomes: i) *"reactions"* applicable to their learning needs, ii) *"new learning"* that is effective and sustainable, iii) "*behaviour changes"* that lead to doing something different and iv) "*results"* related to the outcomes of the business. In considering the aims of IPL for improving patient care, the JET model offers more detailed outcome levels. Higher levels in this framework pertain to changes in learners' attitudes, skills and behaviour through to changes in organisational practice and benefits to patients (see Table 1).

IPL implementation is challenging, and barriers are well documented, including timetabling, resources, staff attitudes and skills, professional silos and uniprofessional education programs (Greenstock et al., 2012; Lawlis et al., 2014; Poore et al., 2014). The logistical barriers to synchronising different timetables to bring students together at the same place and time is a significant hurdle. Furthermore, simulation is a resource intensive teaching modality with significant costs in many cases (Lawlis et al., 2014). Despite this,

Table 1

JET Model of Interprofessional Outcomes Accompanied by Examples That Include Medical Students Completing IPL Simulation*

Outcome Levels	Description	IPL example
1. Reaction	Learners' view on the learning experience and its interprofessional nature	Reaction to the IPL team
2a. Modification of attitudes/perceptions	Changes in reciprocal attitudes or perceptions between participant groups.	Perception of another health professional's role
2b. Acquisition of knowledge and skills	Acquisition of knowledge and skills linked to interprofessional collaboration	Improvement in teamwork skills
3. Behavioural change	Identified individuals' transfer of interprofessional learning to their practice setting and changes to professional practice	Nil examples in literature
4a. Change in organisational practice	Wider changes in the organisation and delivery of care	Nil examples in literature
4b. Benefits to patients/clients	Improvements in health or wellbeing of patients/clients	Nil examples in literature

* Freeth et al., 2007

the use of simulation in IPL has increased in medical education (Freeth et al., 2007). Given the barriers to implementation of IPL and the significant resourcing implications, evidence demonstrating efficacy and supporting ongoing program delivery is useful. We need to be aware of gaps in evidence in order to direct further research efforts. The aim of this study was to conduct a scoping review of the current literature on IPL involving medical students, where simulation was the teaching modality. We sought to identify key outcomes assessed, participants and settings for IPL.

Methods

We conducted a scoping review using the steps outlined in the *Joanna Briggs Institute Reviewers' Manual 2017.*

Data sources

On 14 March 2020, we searched the following four major electronic databases: PubMed, Medline, EMBASE and PsychINFO. Search terms consisted of the medical student terms ("medical student" MeSH heading OR "medical" AND "student" in title/abstract)

combined with the simulation terms ("simulation" OR "simulation training" MeSH heading or title/abstract) and interprofessional ("interprofessional" in title/abstract). The reference lists of all identified sources were searched for additional sources. Articles published between 2000 and 2020 were included.

Study selection

Inclusion criteria included (1) primary publication assessing humans, (2) evaluated a simulation intervention, (3) involved medical students alongside a student or practitioner from at least one other health profession (for example, nursing, pharmacy, physiotherapy) and (4) available in full text in English.

Following the application of the English language filter, the title and abstract of these studies were screened independently by two authors for eligibility based on the inclusion criteria. The full text of screened abstracts was then assessed. Disagreements were resolved by discussion until consensus was reached. If there was difficulty in reaching a consensus, a third author reviewed the article in question.

Data extraction

Data extraction was performed independently by two authors using a predefined standardised charting form. Data extracted included: participants (interprofessional groups involved), sample size, type of simulation intervention, format of simulation intervention, duration of intervention sessions, number/frequency of intervention sessions, presence of a control group, presence of blinding, outcomes assessed and method of outcome assessment. Again, disagreements were resolved by discussion until consensus was reached, and a third author reviewed any articles in which there was difficulty in reaching a consensus.

Data charting and collation

Data was organised into tables by type of simulation intervention. Data was characterised according to participants (interprofessional groups involved), format of simulation intervention, outcome assessment method and outcomes measured as described in the Joint Evaluation Team (JET) model of interprofessional outcomes (Freeth et al., 2007). The aim of this structure was to efficiently summarise the literature so as to draw links between the format of the simulation intervention and the specific outcomes measured. An additional aim was to demonstrate the common outcome assessment method types that have been used for different simulation formats.

Ethical considerations

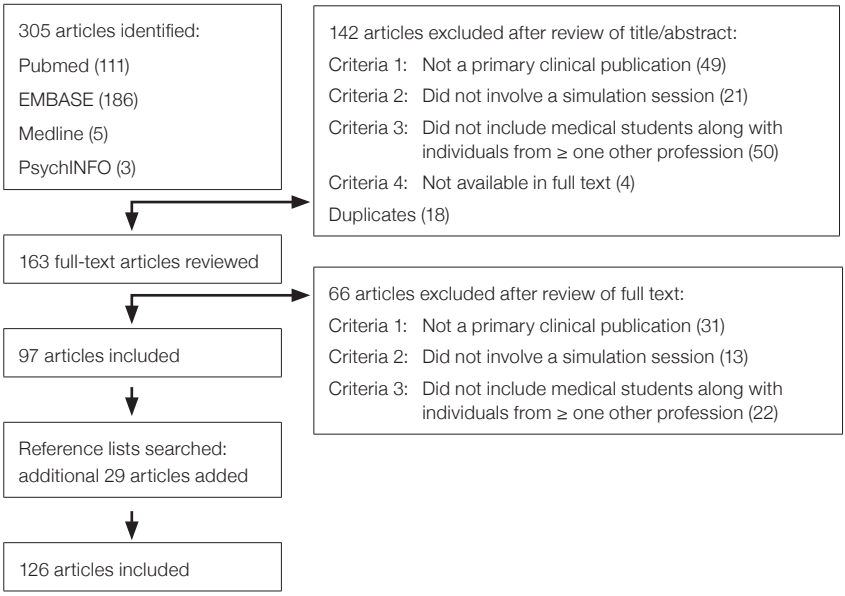
No ethics approval was sought due to the nature of the review.

Results

A total of 126 studies were identified (see Figure 1).

Figure 1

Screening Algorithm



Participants

All studies involved teaching medical students with a student or practitioner from at least one other health profession (126 studies).

The most common health professional student group to be combined with medical students was nursing (109 studies), followed by pharmacy (32 studies). Other professions combined with medical students included physiotherapy, midwifery, physician's assistants, dentistry and paramedics.

Format of simulations

A wide variety of formats were used in simulation interventions. Many studies described their intervention as being a high-fidelity simulation, which involved mannequins that simulate life-like physical signs and display physiological information on monitors (Al-Elq, 2010). Another common format of IPL simulation was creating e-learning tools for students, such as online modules (Berg et al., 2010; Djukic, Adams, et al., 2015; Djukic, Fulmer, et al., 2012; Ellman et al., 2012). Some e-learning tools incorporated virtual reality

Table 2

Participants in Interprofessional Simulation With Medical Students

Two other health professions	55 studies
Three other health professions	24 studies
Four other health professions	8 studies
Five other health professions	4 studies
Six other health professions	1 study
Seven other health professions	2 studies

or telehealth (Liaw, Ooi, et al., 2020; Scott et al., 2020). Frequently, there was a combination of both e-learning tools and high-fidelity simulation within one intervention (Atack et al., 2009; Ellman et al., 2012; Hess et al., 2016; Kearney et al., 2010; J. L. Miller et al., 2014). For example, Atack et al. (2009) offered online modules as preparation for students who were undertaking a high-fidelity disaster simulation. In addition, interventions focusing on communication skills used simulated patients for patient interactions as part of their simulation intervention (Blackhall et al., 2014; C. Cooke et al., 2017; Hess et al., 2016). Some studies included students simply observing discussions with no active participation (Efstathiou & Walker, 2014; Nystrom et al., 2016).

An assortment of frameworks was used in the design of simulation interventions to teach interprofessional teamwork skills. The most common framework was The Team Strategies and Tools to Enhance Performance and Patient Safety (TeamSTEPPS) (Brock et al., 2013; Fewster-Thuente, 2014; Hobgood et al., 2010; Horsley et al., 2016; Liaw, Siau, et al., 2014; Reed et al., 2017; Robertson et al., 2010). TeamSTEPPS is a curriculum designed for interprofessional health teams, focusing on team leadership and communication skills (Brock et al., 2013; Liaw, Siau, et al., 2014; Robertson et al., 2010). Another popular framework was Crisis Resource Management (CRM) skills (Kyrkjebo et al., 2006; Shrader, Kern, et al., 2013; Sigalet, Donnon, Cheng, et al., 2013; Sigalet, Donnon, & Grant, 2015; Smithburger et al., 2013). Initially developed for use in aviation, this framework has been adapted for the healthcare setting and emphasises important non-technical teamwork skills, such as communication, situational awareness and decision making to promote safety and increased efficiency of healthcare teams (Sigalet, Donnon, Cheng, et al., 2103)

Content of simulations

There was a variety of content included in simulation interventions. The two most common themes were emergency scenarios (see Appendix A) and communication skills (see Appendix B). Appendix A (51 studies) includes studies that used an emergency

scenario to develop students' clinical skills in acute care (basic life support, advanced life support and trauma management). Appendix B (32 studies) includes studies that aimed to teach communication skills. The remaining studies encompass a variety of simulation interventions, including simulated ward rounds and simulated procedures. Four studies used a high-fidelity IPL simulation of a hospital ward round to provide a setting for students to practise communicating while participating in the management of a patient (Joyal et al., 2015; Ker et al., 2003; Nikendei et al., 2016; Shrader, McRae, et al., 2011). Four studies used a high-fidelity IPL simulation intervention in the context of teaching procedures related to obstetrics (Gorantla et al., 2019; Kumar, Gilmour, et al., 2014) and general surgery (Paige et al., 2014; Wang et al., 2015) on mannequins.

Outcome assessment methods

Outcomes were most frequently evaluated by collecting data from pre- and post-intervention survey responses or focus group discussions to explore students' experiences of the simulations (See Appendix A and Appendix B). The Readiness for Interprofessional Learning Scale (RIPLS) was the most common assessment tool. It is a self-reported questionnaire undertaken before and after the simulation intervention and is designed to measure changes in attitudes and perceptions towards IPL (Parsell & Bligh, 2002). The KIDSIM team performance questionnaire is also designed to measure students' attitudes towards IPL. Sigalet, Donnon and Grant (2012) designed a study involving medical, nursing and respiratory therapy students participating in an IPL simulated emergency scenario that confirmed the reliability of the KIDSIM questionnaire in assessing attitude changes. Other surveys used as assessment tools included the Communication and Teamwork Skills (CATS) assessment tool (Garbee et al., 2013; Smithburger et al., 2013) and the Attitudes Toward Health Care Teams survey (Wamsley et al., 2012), but these were used less frequently. In terms of focus groups, six studies evaluated the impact of their IPL simulation intervention using a semi-structured format to facilitate discussion and reflection between small groups of participating students (Kumar, Wallace, et al., 2017; Nikendei et al., 2016; Reime, Johnsgaard, Kvam, Aarflot, Breivik, et al., 2016; Reime, Johnsgaard, Kvam, Aarflot, Engeberg, et al., 2017; Rodehorst et al., 2005; Whelan et al., 2008). The aim of the focus groups was to achieve a more detailed understanding of students' attitudes towards the intervention.

Apart from validated survey responses and focus group discussions, several researchers chose to create their own surveys and assessment criteria, using tools such as the Interdisciplinary Education Perception Scale (IEPS) as a framework (Baker et al., 2008; Bottenberg et al., 2013; New et al., 2015; Shrader, Kern, et al., 2013) (See Appendix A and Appendix B). In addition, two studies used student performance in an OSCE to measure the success of the IPL simulation intervention in improving prescribing skills (Ragucci, 2014) and smoking cessation counselling skills (Efstathiou & Walker, 2014). Furthermore,

some studies included control groups so their institution's pre-existing single-profession intervention could be compared with the IPL-based simulation intervention (Saylor et al., 2016; Wamsley et al., 2012). Other studies compared the performance of interprofessional groups to single-profession groups undergoing the same simulation intervention, with the IPL groups outperforming the others (Clay et al., 2017; Scherer et al., 2013).

Outcomes measured

The vast majority of studies measured outcomes immediately following the IPL simulation intervention rather than longitudinal effects and sustainable outcomes of IPL, with 70 studies involving a single workshop or tutorial. The studies examining post-intervention educational outcomes mainly evaluated the effectiveness of their training in terms of learners' reactions to IPL immediately following the simulation intervention (JET Level 1: Reaction). However, some single workshops or tutorials did include a post-test questionnaire aimed at measuring the longitudinal impact of the IPL simulation intervention several months after the session. This demonstrated slight decay in both student knowledge and positive attitudes, but these did not decline completely back to the pre-test level (Kearney et al., 2010; McIlwaine et al., 2007). In addition, some studies used an initial simulation combined with a follow-up simulation, and these showed sustained improvement in performance and confidence with a slight decay compared to the immediate post-test level (Garbee et al., 2013; Nagelkerk et al., 2014; Reime, Johnsgaard, Kvam, Aarflot, Breivik, et al., 2016). For example, Garbee et al. (2013) incorporated two sets of two simulations 6 months apart and found that although some skills were forgotten between the two workshops, skills in communication, cooperation, coordination and situational awareness were rapidly regained in the later workshop between the first simulation and the second.

The most common outcome assessed was students' attitudes towards IPL, with 51 studies citing this as an assessed outcome (see Appendix A and Appendix B). The second most common outcome assessed was self-reported confidence in applying skills learnt from the IPL simulation intervention (21 studies). The third most common outcome was assessment by a supervisor of the teamwork skills performed by the group during the simulation intervention (10 studies).

One common outcome across all simulation interventions, regardless of the study methodology, was that students' preconceived notions or stereotypes of other professions was challenged (JET Level 2a: Modification of attitudes), particularly the hierarchy of decision making between doctors and nurses (S. Cooke et al., 2003; Holthaus et al., 2015; King et al., 2013; Lockeman et al., 2017; Rodehorst et al., 2005; Shanahan & Lewis, 2015; Whelan et al., 2008). Salam et al.'s (2015) finding confirmed that post IPL simulation intervention, medical students strongly agreed that a nurse should be viewed as

a collaborator and colleague rather than as a physician's assistant. Similarly, many studies reported an increased awareness of the roles of other healthcare professionals (Buckley et al., 2012; Flentje et al., 2016; Leithead et al., 2018; Motycka et al., 2018; Nagraj et al., 2018; Partecke et al., 2016; Pitout et al., 2014; Reeves et al., 2017; Rochman et al., 2012; Sehgal et al., 2019; Wen et al., 2019), an increased confidence in participants' teamwork and clinical skills (Atack et al., 2009; Joyal et al., 2015; Kumar, Gilmour, et al., 2014; Liaw, Siau, et al., 2014; Lippe et al., 2020; Luctkar-Flude, Baker, Pulling, et al., 2010; Tofil et al., 2014; Wakefield et al., 2006; Wamsley et al., 2012) and positive attitudes to working in interprofessional teams in the future (Anderson et al., 2017; Brock et al., 2013; Buckley et al., 2012; Dagnone et al., 2008; Efstathiou & Walker, 2014; Kearney et al., 2010; Kumar, Wallace, et al., 2017; A. Miller et al., 2013; Reed et al., 2017; Robertson et al., 2010; Tofil et al., 2014; Wang et al., 2015). Overwhelmingly, student feedback indicated that they found IPL simulation interventions beneficial because of the opportunity to practise clinical (Efstathiou & Walker, 2014; Haber et al., 2017; Kumar, Wallace, et al., 2017) and teamwork skills (Reed et al., 2017; Reising, Carr, Shea, & King, 2011; Shaw-Battista et al., 2015; Stewart et al., 2010; van Schaik et al., 2016; West et al., 2015).

Another common outcome explored in many studies was whether providing student groups with formal team training prior to the IPL simulation intervention led to improved teamwork skills (Jakobsen et al., 2018; Luctkar-Flude, Baker, Medves, et al., 2013; Ragucci et al., 2016; Scherer et al., 2013; Sigalet, Donnon, Cheng, et al., 2013; Sigalet, Donnon, & Grant, 2015; Wang et al., 2015). Luctkar-Flude, Baker, Medves, et al. (2013) found that nursing students who participated in an IPL training module with medical students before commencing the emergency paediatric life support simulation reported increased confidence in their teamwork skills. Similarly, Wang et al. (2015) found that nursing students who participated in an IPL training module with medical students before commencing surgical simulations also reported increased confidence in their procedural skills. In addition, Ragucci et al. (2016) found that IPL groups who attended a half-day workshop on error recognition and disclosure prior to the simulation intervention performed significantly more confidently than groups who did not. Similarly, Jankouskas et al. (2011) found that IPL groups of medical and nursing students who took part in a "Crisis Resource Management Team" training exercise before a basic life support simulation performed better than their peers. However, Sigalet, Donnon, Cheng, et al. (2013) detected that groups were able to significantly improve their teamwork skills by simply repeating the IPL simulation or participating in multiple IPL simulations, independent of prior training. Furthermore, two studies reported that there were no statistically significant differences between groups who did or did not receive training prior to simulation interventions (Hobgood et al., 2010; Luctkar-Flude, Baker, Pulling, et al., 2010), and two other studies reported that the act of participating in an IPL simulation was more significant in increasing

self-reported confidence and satisfaction in teamwork skills than a didactic pre-simulation workshop alone (Wamsley et al., 2012; Wang et al., 2015).

Discussion

This scoping review demonstrates that IPL with simulation is widely used to teach a variety of skills to medical students in conjunction with students from several different health professions, with varied simulation formats tailored to the specific skills and scenarios used in each simulation intervention.

The majority of IPL simulation interventions for medical students have nursing students as the other interprofessional group, suggesting there is scope for interventions designed for students from a broader range of health professions. Interventions with a greater mix of professional groups achieved more positive results (Atack et al., 2009; J. L. Miller et al., 2014). Although this was a smaller number of studies, the finding is in keeping with studies in the business sector, which show that diverse teams make better decisions (Nathan & Lee, 2013). It may be because more diverse professional groups more accurately reflect the workplace.

While a variety of formats were used in IPL simulation interventions, high-fidelity simulations were the most common, despite also being the most costly. The evidence suggests that these scenarios improve students' interprofessional communication and teamwork skills immediately following the simulation intervention. However, these types of simulations in the IPL setting are usually heavily constrained by logistical and cost barriers, particularly regarding the synchronisation of timetables. There was large variation in the topic areas for learning in IPL simulation interventions, the most common topics being emergency medicine clinical skills (basic and advanced life support) and communication skills (see Appendix A and Appendix B).

The most common outcome of IPL simulation interventions was that students' attitudes towards IPL were positive. Students reported a greater understanding of the role of the other health professions, a more positive attitude towards interprofessional teamwork and increased confidence in their teamwork skills. On balance, a greater number of studies found that the student groups who were provided with formal team training prior to the IPL simulation intervention had higher levels of self-reported confidence in teamwork skills and had higher externally-rated team performance scores compared to groups without this extra training. However, some studies did not corroborate this correlation, and this discrepancy may be explained by the wide variety of tasks that are considered a simulation intervention.

The success of IPL simulation interventions was typically evaluated based upon improving the participants' perception of IPL, improving interprofessional teamwork skills, and improving communication skills (see Appendix A and Appendix B). These outcomes were

most frequently evaluated based on subjective student experience, with self-reporting using standardised self-assessment tools completed immediately after the intervention. Therefore, the value of this information is limited in two ways. Firstly, the information is self-reported, and while there is reasonable evidence that students react positively to the opportunity to participate in IPL simulation interventions, there is only limited evidence that such an intervention improves student knowledge and skill in areas such as teamwork and communication. However, for the studies that did measure both self-reported and objective increase in interprofessional skills, these did positively correlate with improved skill level (Atack et al., 2009; Hegg et al., 2020; Krumwiede et al., 2019; Luctkar-Flude, Baker, Pulling, et al., 2010; Ragucci et al., 2016; Reese et al., 2010; Smithburger et al., 2013). Secondly, the vast majority of results were based on immediate post-test results (JET Level 1) rather than longitudinal effects and sustainable outcomes. This review demonstrates a gap in longer-term outcome measures. Whilst educators may intend for positive short-term outcomes in IPL to translate into tangible improvement in interprofessional capabilities within the workplace, evidence is lacking. Studies evaluating higher JET level outcomes would assist by providing evidence of long-term outcomes. However, this research is more difficult to undertake, and confounding from other variables prevents linkage of benefits to a single IPL intervention.

In terms of the limitations of this scoping review, the major difficulty lies in the broad interpretation of what is considered a "simulation intervention". As there is no general consensus on a definition for simulation intervention, this review includes simulation interventions of widely different formats that are not necessarily comparable. While the term simulation intervention neatly applies to interventions involving students practising clinical skills on a mannequin or simulated patient, this review has also included simulation interventions that refer to students participating in online case-based modules, working with virtual reality patients or simply observing discussions with no active participation. While these studies meet the eligibility criteria, they should potentially be considered as a separate category, and in the future, a clear definition for simulation intervention should be sought in order to prevent inappropriate comparisons and conclusions being made. Additionally, the majority of the evidence referred to in this review originates from studies with small sample sizes, and few studies provided sample size calculations. There is also potential for bias in terms of selectively reporting significant outcomes.

Conclusion

This scoping review summarises the existing literature on IPL using simulation for medical student education. The majority of IPL simulation interventions for medical students included nursing students and most commonly involved high-fidelity simulations of emergency scenarios. They also evaluated students' self-reported attitudes before and

immediately post-intervention (JET Level 1). Current evidence suggests that simulation-based interventions are effective in improving medical students' attitudes towards IPL and that formal team training prior to simulation is more effective in improving teamwork skills than simulation alone. IPL interventions with a greater mix of professions have more positive results, in keeping with studies of teams in other non-healthcare settings. Finally, this review highlights the gap in evidence of longer-term outcomes.

Funding and conflicts of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article. No funding was received for this study.

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Appendix A

Summary of IPL Simulations Involving an Emergency Scenario Categorised by Format of Simulation

Author	**Participants** (interprofessional groups involved)	**Format of simulation** (no. and frequency of intervention sessions)	**Outcome assessment method**	**Specific outcomes measured, as classified by the JET model**	**Summary of key outcomes**
Appelbaum et al. (2020)	Medicine; nursing	3 sessions	Pre-post test survey (developed by researcher)	Attitudes: towards teamwork, power distance and psychological safety	Perceived power distance impacted team effectiveness through psychological safety and perceived team cohesion.
Atack et al. (2009)	Medicine; paramedicine; nursing; social worker; pharmacy; respiratory therapist; medical radiation	8-week course, 3-hour weekly modules	Pre-post test survey (RIPLS)	Attitudes: perception of IPL and disaster management competencies	Participants improved their readiness to practise and developed skills related to interprofessional practice.
Baker et al. (2008)	Medicine; nursing	Single session	Survey (IEPS)	Attitude: perception of the interprofessional team	Participants felt they had a better understanding of the roles in the interprofessional team.
Bottenberg et al. (2013)	Medicine; nursing; pharmacy	Single session	Survey (developed by researcher)	Attitude: perception of managing an emergency with an interprofessional team	Participants enjoyed the session, but their attitudes were not significantly altered by the experience.
Buckley et al. (2012)	Medicine; nursing; radiography; ODP; physiotherapy	Single session	Pre-post test survey (developed by researcher)	Attitudes: confidence in IPL, perception of factors contributing to good care, benefits of IPL to future clinical practice and usefulness of video feedback	Participants felt more confident in their team interactions.
Dagnone et al. (2008)	Medicine; nursing	Single session (2–4 mini-sessions combined)	Post-test survey (developed by researcher)	Attitude: perception of value of the simulation	Participants showed positive attitudes towards the sessions.
Flentje et al. (2016)	Medicine; nursing	Single session	Post-test survey (developed by researcher)	Attitude: towards importance of IPL in professional practice	Participants were more aware of other healthcare professionals following the intervention.

ISSN 1442-1100

Author	**Participants** (interprofessional groups involved)	**Format of simulation** (no. and frequency of intervention sessions)	**Outcome assessment method**	**Specific outcomes measured, as classified by the JET model**	**Summary of key outcomes**
Garbee et al. (2013)	Medicine; nursing	Two sessions over 6 months	Survey (CATS, TAS, & Operating Room Teamwork Assessment Scale)	Skill: teamwork	Teamwork skills improved, but there was no statistically significant difference 6 months later.
Hegg et al. (2020)	Medicine; nursing	Single session	Pre-post test survey (developed by researcher)	Knowledge: ABCDE assessment Skills: teamwork and communication	Scores from peer observers were generally lower on all learning outcomes compared to facilitators' scores.
Hobgood et al. (2010)	Medicine; nursing	Single session Format: TeamSTEPPS teaching framework	Survey (developed by researcher) SP evaluation (unspecified)	Attitudes: towards interprofessional teamwork and medical knowledge	Participants' attitudes to teamwork and knowledge scores improved significantly.
Horsley et al. (2016)	Medicine; nursing	Single session (2 mini sessions combined) Format: TeamSTEPPS teaching framework	Checklist (unspecified)	Skill: teamwork	IPL was perceived to be extremely valuable, and participants felt the TeamSTEPPS principles were useful.
Jakobsen et al. (2018)	Medicine; nursing	Single session (4 mini sessions combined) Format: Better & Systematic Team Training course to students (Student-BEST)	Pre-post test survey (developed by researcher)	Attitudes: towards teamwork and communication	Participants reported increased understanding about interprofessional communication, teamwork and leadership.
Jankouskas et al. (2011)	Medicine; nursing	Single session Format: Crisis Resource Management training	Post-test survey Basic Life Support Checklist	Skill: teamwork	No difference in team effectiveness between control group and intervention (crisis resource management training).
Joyal et al. (2015)	Medicine; nursing; pharmacy	Single session	Pre-post test survey (developed by researcher)	Attitude: confidence working in an interprofessional team Knowledge: interprofessional knowledge (unspecified)	Participants reported improved knowledge about other professional roles and greater confidence working in interprofessional teams.

Author	**Participants** (interprofessional groups involved)	**Format of simulation** (no. and frequency of intervention sessions)	**Outcome assessment method**	**Specific outcomes measured, as classified by the JET model**	**Summary of key outcomes**
King et al. (2013)	Medicine; nursing; respiratory therapy	Single session	Survey (developed by researcher)	Attitudes: towards interprofessional teamwork and roles of other professions	Participants reported improved awareness of the importance an interprofessional team.
Kumar, Wallace, et al. (2019)	Medicine; midwifery	Single session	Pre-post test survey (developed by researcher)	Attitudes: confidence working in a team and towards effective communication Knowledge: procedural skills and a systematic approach to obstetric and neonatal emergencies Skill: teamwork	Participants felt that team-based learning could build trust between professions, resulting in better patient care.
Leithead et al. (2018)	Medicine; nursing	Single session	Pre-post test survey (RIPLS)	Attitude: towards IPL Skill: teamwork	Participants had significant improvements in team-based attitudes and RIPLS scores.
Liaw, Siau, et al. (2014)	Medicine; nursing	Single session (2 mini sessions combined) Format: TeamSTEPPS teaching framework	Pre-post test survey (developed by researcher)	Attitude: towards interprofessional collaboration	Participants rated the other profession higher for interprofessional skills, academic ability and being team players.
Liaw, Ooi, et al. (2020)	Medicine; nursing	Single session Format: TeamSTEPPS teaching framework	Pre-post test survey (ATHCT survey & ISVS survey)	Attitude: towards teamwork Skill: communication skills	Computer-based virtual reality was not inferior to live simulations.
Lockeman et al. (2017)	Medicine; nursing	3 sessions	Pre-post test survey (developed by researcher)	Attitude: perception of working in an interprofessional team Knowledge: of IPL	Participants had more positive perceptions of interprofessional practice.
Luctkar-Flude, Baker, Pulling, et al. (2010)	Medicine; nursing	Single session	Post-test survey (developed by researcher)	Attitudes: towards IPL and confidence performing CPR Skill: teamwork	Interprofessional group reported better communication and greater confidence than uniprofessional group (differences not statistically significant).

Author	**Participants** (interprofessional groups involved)	**Format of simulation** (no. and frequency of intervention sessions)	**Outcome assessment method**	**Specific outcomes measured, as classified by the JET model**	**Summary of key outcomes**
Luctkar-Flude, Baker, Medves, et al. (2013)	Medicine; nursing	Single session (2 mini sessions combined)	Post-test survey (developed by researcher) Checklist (unspecified)	Attitude: confidence performing paediatric skills Skill: teamwork	Interprofessional group reported less confidence than uniprofessional group. Interprofessional teams better at role allocation than uniprofessional teams.
Miller, Rambeck, & Snyder (2014)	Medicine; nursing; dentistry; pharmacy; public health; veterinary medicine	Training over semester of 10 hours (3 workshops & 2 simulations) Format: IPEC based framework	Survey (IEPS)	Skills: emergency response and teamwork	Participants demonstrated significant improvement in knowledge, teamwork and emergency response skills. (Some decay at follow-up.)
Nagelkerk et al. (2014)	Medicine; nursing	Single session	Survey (developed by researcher) Observation	Attitude: towards interprofessional teamwork Knowledge: safety knowledge	Participants safety-related knowledge significantly increased, and they felt their interprofessional teamwork skills improved.
Nagraj et al. (2018)	Medicine; paramedic	6 sessions over 2 days	Post-test survey (developed by researcher)	Attitudes: towards teamwork and IPL	Increased knowledge of other professions' role; enhanced mutual respect; improved clinical skills and collaborative practice.
Nystrom et al. (2016)	Medicine; nursing	Single session	Observation Video analysis	The difference in proximate and distant observation of a student simulation by their peers	Proximate: participants took an active role; instructors took more traditional, didactic role. Distant: participants more passive.
Partecke et al. (2016)	Medicine; nursing	Single session (2-day course)	Observation	Attitude: towards IPL	Participants' perceptions and attitudes towards interprofessional collaboration appeared to change positively.
Pitout et al. (2016)	Medicine; physiotherapy; occupational therapy	Single session	Written reflection	Attitude: towards working in an interprofessional team	Participants acknowledged the importance of the interprofessional team and recognised similarities/ differences between roles.
Reed et al. (2016)	Medicine; nursing	Single session Format: TeamSTEPPS teaching framework	Post-test survey (developed by researcher)	Attitude: towards managing an emergency in an interprofessional team	Participants reported that interprofessional collaboration was an integral part of patient care and safety.

Author	**Participants** (interprofessional groups involved)	**Format of simulation** (no. and frequency of intervention sessions)	**Outcome assessment method**	**Specific outcomes measured, as classified by the JET model**	**Summary of key outcomes**
Reese et al. (2010)	Medicine; nursing	Single session	Evaluation rubric	Skill: teamwork in disclosing error	Participants were more comfortable with explicit error disclosure in a team.
Reime, Johnsgaard, Kvam, Aarflot, Breivik, et al. (2016)	Medicine; nursing	2 sessions over 7 weeks	Post-test survey (Delphi performance scale) Focus groups Peer assessment (unspecified)	Attitude: towards managing an emergency in an interprofessional team	Participants reported learning to speak up to ensure safe patient care in an emergency.
Reime, Johnsgaard, Kvam, Aarflot, Engeberg, et al. (2017)	Medicine; nursing	2 sessions over 3 months	Post-test survey (Delphi performance scale) Focus groups Peer assessment (unspecified)	Attitudes: towards interprofessional teamwork and roles of other professions, and confidence in communication	Participants felt participating in different roles and repeated opportunities enhanced realism.
Reising, Carr, Shea, & King (2011)	Medicine; nursing	Single session	Post-test survey (IUSIR)	Attitude: towards interprofessional teamwork	Participants changed how they viewed their own role in the interprofessional team and improved communication.
Reising, Carr, Gindling, et al. (2017)	Medicine; nursing	Single session	Pre-post test survey (IUSIR)	Skills: communication and procedure performance	Improved interprofessional team communication; improved procedural performance; improved patient care in the simulation setting.
Robertson et al. (2010)	Medicine; nursing	Single session Format: TeamSTEPPS teaching framework	Pre-post test survey (developed by researcher)	Attitude: towards IPL	Participants' knowledge of teamwork skills had improved.
Rodehorst et al. (2005)	Medicine; nursing; respiratory therapy; pharmacy	Single session	Focus group interviews	Attitude: towards interprofessional teamwork	Recognised similarities/differences between roles; challenged attitudes about medical hierarchy; improved sense of community and teamwork.
Scherer et al. (2013)	Medicine; nursing	Single session	Pre-post test survey (RIPLS)	Attitude: towards IPL Knowledge: of IPL Skill: teamwork	Participants from the interprofessional group achieved higher RIPLS survey scores than the single profession group.

Author	**Participants** (interprofessional groups involved)	**Format of simulation** (no. and frequency of intervention sessions)	**Outcome assessment method**	**Specific outcomes measured, as classified by the JET model**	**Summary of key outcomes**
Scott et al. (2020)	Medicine; nursing; pharmacy	Single session	Post-test survey (developed by researcher)	Knowledge: of advanced life support Skill: teamwork	Participants reported improved teamwork skills and a better understanding of other professions' roles
Shanahan et al. (2015)	Medicine; nursing	Single session	Pre-post test survey (developed by researcher)	Attitude: towards IPL	Participants increased their understanding of the roles and responsibilities of each profession.
Shaw-Battista et al. (2015)	Medicine; nursing; midwifery	Unspecified	Written evaluation	Attitude: towards IPL	The simulation intervention appeared to improve team-based learning and IPL specific to maternity care.
Shrader, Kern, et al. (2013)	Medicine; pharmacy; physician's assistant	Single session Format: IPEC-based framework	Survey (IEPS, TWS, COS)	Attitudes: perception of IPL and clinical outcome, and teamwork and clinical outcome	Teamwork score was a significant predictor of clinical outcomes scores.
Shrader, McRae et al. (2011)	Medicine; pharmacy; physician's assistant	Single session	Pre-post test survey (IEPS, TWS, COS)	Attitudes: perception of IPL and clinical outcome, and teamwork and clinical outcome	Change in attitude to interprofessional learning—significantly more likely to agree with particular survey statement.
Sigalet, Donnon, Cheng, et al. (2013)	Medicine; nursing; respiratory therapy	2 sessions over 2 weeks	Survey (KIDSIM)	The appropriateness of the KIDSIM scoring tool for the assessment of team performance in IPL	The intervention group scored better than the comparison group for each scenario.
Sigalet, Donnon, & Grant (2012)	Medicine; nursing; respiratory therapy	Single session	Pre-post test survey (ATTITUDES Questionnaire)	Attitude: towards interprofessional teamwork	Significantly increased: relevance of IPL, relevance of simulation, communication, situational awareness, roles and responsibilities.
Sigalet, Donnon, & Grant (2015)	Medicine; nursing; respiratory therapy	2 sessions (time unspecified)	Survey (KIDSIM)	Skill: teamwork	The intervention group scored better than comparison group for each scenario.
Smithburger et al. (2013)	Medicine; pharmacy; nursing; physician's assistant; social work	4 sessions, weekly	Survey (CATS)	Skill: teamwork	The participants' communication and teamwork skills significantly improved.

Author	Participants (interprofessional groups involved)	Format of simulation (no. and frequency of intervention sessions)	Outcome assessment method	Specific outcomes measured, as classified by the JET model	Summary of key outcomes
Stewart et al. (2010)	Medicine; nursing	Single session	Post-test survey (developed by researcher)	Attitudes: perception of knowledge, teamwork and professional identity	Participants reported interprofessional simulation allowed them to practise practical skills and learn from other professions.
Tankimovich et al. (2020)	Medicine; nursing	Single session Format: TeamSTEPPS teaching framework	Pre-post test survey (developed by researcher)	Attitudes: towards IPL and teamwork	Participants reported improved confidence in their teamwork skills and perceived interprofessional team training as beneficial.
Tofil et al. (2014)	Medicine; nursing	4 sessions, fortnightly	Pre-post test survey (developed by researcher)	Attitude: towards teamwork Knowledge: medical knowledge (unspecified)	Participants knowledge scores significantly improved, and they had improved teamwork and communication skills.
Wagner et al. (2011)	Medicine; nursing	Single session	Post-test survey (developed by researcher)	Attitude: perception of working in an interprofessional team	Nursing more confident discussing advanced care directives and better prepared to work in an interprofessional team.
Whelan et al. (2015)	Medicine; nursing; pharmacy	Single session	Pre-post test survey (developed by researcher) Focus groups	Knowledge: of the roles and responsibilities of health professionals	Participants had a greater appreciation of how interprofessional collaboration can lead to better patient care.

Abbreviations:

ATHCT: Attitudes Toward Interprofessional Health Care Team
ISVS: Interprofessional Socialization and Valuing Scale
RIPLS: Readiness for Interprofessional Learning Scale
IEPS: Interdisciplinary Education Perception Scale
CATS: Communication and Teamwork Skills assessment tool
TAS: Teamwork Assessment Scale
TWS: Teamwork Scale
COS: Clinical Outcome Scores
KIDSIM: KIDSIM team performance scale
IUSIR: Indiana University Simulation Integration Rubric

Appendix B

Summary of IPL Simulations Involving Communication Skills Categorised by Format of Simulation

Author	**Participants** (interprofessional groups involved)	**Format of simulation** (no. and frequency of intervention sessions)	**Outcome assessment method**	**Specific outcomes measured, as classified by the JET model**	**Summary of key outcomes**
Anderson et al. (2017)	Medicine; midwifery	Single session	Survey (developed by researcher)	Attitude: perception of confidence of caring for a woman in labour Knowledge: understanding of role of nurses and midwives	Improved understanding of process and others' roles; decreased anxiety; positive interactions; improved confidence working with others.
Berg et al. (2010)	Medicine; nursing	Single session	Survey (developed by researcher) Checklist for SBAR components	Attitude: confidence in using SBAR technique to communicate with an interprofessional team Skill: adherence to SBAR format	Participants reported improved understanding of interprofessional communication but felt they lacked skills to communicate appropriately.
Blackhall et al. (2014)	Medicine; nursing	Unspecified	Survey (developed by researcher, named CBOAT)	Skills: professionalism, communication, shared problem solving and shared decision making	The final CBOAT assessment tool clarified the important collaborative behaviours needed by doctors and nurses.
S. Cooke et al. (2003)	Medicine; nursing	Single session (2-day course)	Pre-post test survey (developed by researcher) Reflective discussion	Attitudes: confidence in breaking bad news to patients and towards interprofessional teams	Participants reported that the experience had challenged their preconceptions of the other profession.
Djukic, Fulmer, et al. (2012)	Medicine; nursing	Single session (plus 2-week online module) Format: TeamSTEPPS teaching framework	Survey (developed by researcher)	Attitude: towards IPL	Medical students appreciated being introduced to the role of nurses and enjoyed the experience overall.
Efstathiou & Walker (2014)	Medicine; nursing; pharmacy; physiotherapy	Single session (3 mini-sessions combined) Format: IPEC based framework	Pre-post test survey (RIPLS)	Attitude: towards interprofessional team communication	Participants felt more confident in their skills and knowledge in dealing with end-of-life communication.

ISSN 1442-1100

Author	**Participants** (interprofessional groups involved)	**Format of simulation** (no. and frequency of intervention sessions)	**Outcome assessment method**	**Specific outcomes measured, as classified by the JET model**	**Summary of key outcomes**
Ellman et al. (2012)	Medicine: nursing; divinity	Single session	Survey (developed by researcher)	Attitude: towards the interprofessional team Knowledge: understanding of end-of-life care issues	Recognised issues beyond own discipline, roles of other professionals and the value of team collaboration.
Fewster-Thuente et al. (2014)	Medicine; nursing	Single session (two mini sessions combined) Format: TeamSTEPPS teaching framework	Pre-post test survey (developed by researcher)	Attitude: towards interprofessional team communication	Participants reported having a better understanding of each other's role.
Hess et al. (2016)	Medicine; pharmacy	Training over semester (5 sessions & 10 online modules)	OSCE prepost intervention (Common Ground Rating OSCE assessment tool)	Skill: patient interviewing skills	Performance in all communication skill domains increased significantly.
Holthaus et al. (2015)	Medicine; nursing; dietetics; physical therapy; respiratory therapy; pharmacy; occupational therapy; social work	Single session	Pre-post test survey (RIPLS)	Attitudes: towards other professions and perception of IPL	Greater understanding of other professions' roles. More comfortable working and communicating as a team.
Kearney et al. (2010)	Medicine; nursing; pharmacy	Single session	Survey (developed by researcher)	Attitudes: towards adverse event disclosure and perception of IPL Knowledge: understanding interprofessional teamwork and patient safety	Positive attitude towards teamwork and interprofessional collaboration. Increased understanding of adverse event reporting.
Ker et al. (2003)	Medicine; nursing	Single session	Survey (developed by researcher)	Skills: collaborative teamwork and effective leadership	Participants enjoyed integrating their learning in a safe environment. Observers noted that collaborative teamwork increased.

Author	**Participants** (interprofessional groups involved)	**Format of simulation** (no. and frequency of intervention sessions)	**Outcome assessment method**	**Specific outcomes measured, as classified by the JET model**	**Summary of key outcomes**
King et al. (2009)	Medicine; nursing; dentistry; laboratory science; nutrition; occupational therapy; pharmacy; physical therapy	2 sessions per week for 5 weeks	Surveillance of program usage data	Usage of the online resources by health students	Use of the online resources dropped each week over the 5 weeks.
Krumwiede et al. (2019)	Medicine; nursing; clinical nutrition; prosthetics/orthotics; physical therapy; physician's assistants; radiation therapy; social work	Single session	Pre-post test survey (developed by researcher)	Attitudes: towards IPL and teamwork Knowledge: error disclosure	More comfortable with disclosing a medical error. Positive attitude towards team roles and responsibilities.
Lee et al. (2019)	Medicine; nursing	Single session	Pre-post test survey (developed by researcher)	Attitude: confidence in assessing sexual assault patients Knowledge: understanding of a sexual assault assessment Skill: communication with sexual assault patients	Confidence in sexual assault assessment rose significantly post intervention.
Liaw, Siau, et al. (2014)	Medicine; nursing	Single session Format: TeamSTEPPS teaching framework	Pre-post test survey (developed by researcher)	Attitudes: perception of IPL and confidence in working in an interprofessional team	Significant improvement in the participants' scores for perceptions of IPL and self-confidence in verbal communication.
Lippe et al. (2020)	Medicine; nursing; social work	Single session	Pre-post test survey (CARES-PC)	The appropriateness of the CARES-PC scoring tool for the assessment of perceived competency in palliative care	The CARES-PC tool demonstrated strong reliability/validity. It captured change in perceived competence.
McIlwaine et al. (2007)	Medicine; social work	Single session	Survey (developed by researcher)	Attitude: towards interprofessional teamwork	Participants awareness of their professional role and knowledge of other health professionals' roles improved.
A. Miller et al. (2013)	Medicine; nursing	Single session	Pre-post test survey (RIPLS)	Attitude: perception of IPL	Participants' attitudes became more positive, but this did not reach statistical significance.

Author	**Participants** (interprofessional groups involved)	**Format of simulation** (no. and frequency of intervention sessions)	**Outcome assessment method**	**Specific outcomes measured, as classified by the JET model**	**Summary of key outcomes**
Motycka et al. (2018)	Medicine; nursing; pharmacy	Single session Format: TeamSTEPPS teaching framework	Pre-post test survey (TTAQ)	Attitude: towards roles of other professions Skill: communication	All participants communication scores increased. The interprofessional teams became more proficient with increased practice.
New et al. (2015)	Medicine; nursing; pharmacy	Single session	Survey (developed by researcher)	Attitude: perception of benefit of intervention for improving interprofessional communication	Participants from all professions indicated that the intervention was helpful and effective.
Ragucci et al. (2016)	Medicine; nursing; pharmacy; physician's assistant	Single session	Survey (developed by researcher) Assessment rubric post intervention	Attitude: confidence in disclosing medical errors to patients Skill: proficiency in disclosing medical errors to patients	Participants with training were more comfortable with explicit error disclosure and more likely to apologise.
Reeves et al. (2017)	Medicine; nursing; physician's assistant	Single session	Post-test survey (developed by researcher)	Attitude: towards teamwork Skill: communication	Increased confidence in applying communication strategies and effectiveness of team function. Enjoyed learning about professional roles.
Rochman et al. (2012)	Medicine; nursing; public health; engineering; business	Single session (3 mini sessions combined)	Survey (developed by researcher)	Knowledge: impact of distractions and interruptions on nurses	Participants developed a more detailed appreciation of the role of the nurse and their challenges.
Saylor et al. (2016)	Medicine; nursing	Single session	Pre-post test survey (developed by researcher)	Attitude: towards interprofessional collaboration Skill: interprofessional competencies	Participants developed a more detailed appreciation of the role of the nurse and their challenges.
Sehgal et al. (2019)	Medicine; pharmacy	Single session (2 mini sessions combined) Format: IPEC based framework	Post intervention reflection	Attitude: towards interprofessional teamwork	Participants recognised their profession's limitations. Participants recognised the importance of interprofessional collaboration.
van Schaik et al. (2016)	Medicine; nursing; pharmacy; dentistry; physical therapy; social work; dietetics	Single session	Survey (developed by researcher)	Attitude: towards usefulness of feedback	Participants found the concept of giving peer feedback challenging but useful.

Author	Participants (interprofessional groups involved)	Format of simulation (no. and frequency of intervention sessions)	Outcome assessment method	Specific outcomes measured, as classified by the JET model	Summary of key outcomes
Wakefield et al. (2006)	Medicine; nursing	Single session	Pre-post test survey (developed by researcher)	Attitude: towards interprofessional teamwork Skill: confidence in breaking bad news	Participants discovered similarities and differences between roles and that differences in roles could lead to interprofessional conflict.
Wakefield et al. (2003)	Medicine; nursing	Single session (2 mini sessions combined)	Pre-post test survey (developed by researcher)	Attitude: towards interprofessional teamwork Skill: confidence in breaking bad news	Participants reported increased confidence in their ability to break bad news to patients.
Wamsley et al. (2012)	Medicine; nursing; dentistry; pharmacy; physical therapy	Single session	Pre-post test survey (ATHCT survey)	Attitude: towards interprofessional teamwork	Greater appreciation for different professional roles. Increased perception of team value and team efficiency.
Wang et al. (2017)	Medicine; nursing	Single session Format: TeamSTEPPS teaching framework	Pre-post test survey (developed by researcher)	Knowledge: understanding of the roles and responsibilities of different professions	Participants felt they learned to operate in interprofessional teams and recognised the importance of collaboration.
Wen et al. (2019)	Medicine; nursing; pharmacy; social work	Single session Format: IPEC based framework	Pre-post test survey (developed by researcher)	Attitudes: towards teamwork and interprofessional communication	Improved confidence in communication. Increased trust in other professions. Increased appreciation for other professions' abilities.

Abbreviations:

RIPLS: Readiness for Interprofessional Learning Scale
IEPS: Interdisciplinary Education Perception Scale
ATHCT: Attitudes Towards Healthcare Teams survey
TTAQ: Teamwork Attitudes Questionnaire