

Assessment Tools for Non-Technical Skills in Multidisciplinary Healthcare Team Simulation-Based Education: A Scoping Review

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In recent years, the importance of training healthcare professionals in non-technical skills (NTS) using effective methods to prevent clinical errors in health care has been increasingly recognised. Healthcare professionals are frequently taught NTS through simulation. The aim of our scoping review was to examine the validation evidence for tools used to assess NTS in multidisciplinary teams in simulation-based clinical education. A literature search was conducted in the PubMed and Web of Science databases using predefined inclusion and exclusion criteria. A total of ten studies were included in the final analysis. Seven different assessment tools were identified, with the Team Emergency Assessment Measure (TEAM) and the Non-Technical Skills for Trauma (T-NOTECHS) used more than once. The most frequently assessed NTS within each tool were communication skills, situation awareness, teamwork/cooperation, and leadership skills. While many of the examined assessment tools undergo validation for scoring and generalisation inference, there is a scarcity of tools validated for extrapolation inference such as factor analysis.

Keywords: simulation-based education, multidisciplinary teams, team training, assessment tools, non-technical skills.

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Introduction

Non-technical skills (NTS) are defined as cognitive, social and personal skills that complement technical skills and contribute to a safe and efficient execution of tasks (Flin et al., 2010). Failures in NTS have been shown to increase the risk of serious adverse events in the workplace (Uramatsu et al., 2017). Clinical

errors that occur in the performance of healthcare activities have a significant impact on patient safety, and increase mortality and morbidity, as well as financial costs to healthcare systems (Anderson & Abrahamson, 2017; Kavanagh et al., 2017), with poor communication and teamwork being the leading causes of clinical errors (Müller et al., 2018). Traditionally, nursing students are trained in environments that focus on the acquisition of clinical knowledge and the development of technical skills, while NTS are not commonly emphasised (Pires et al., 2017), leading to errors in patient care (Asensi-Vicente et al., 2018).

Compared to conventional methods, simulation-based learning has been shown to be a more effective strategy for obtaining NTS in a safe and controlled environment (Chernikova et al., 2020; Lynch, 2020). Research shows that simulation helps healthcare professionals to improve teamwork, communication and critical decision-making in complex patient care (Schmidt et al., 2024; Tofil et al., 2014). Integrating simulation into healthcare education and training programmes offers several advantages. First, simulation provides a structured and standardised platform for healthcare professionals to learn and apply NTS in realistic settings (Lee et al., 2024). This hands-on approach allows for immediate feedback and reflection, which are essential for continuous improvement and skills development. Moreover, simulation encourages interdisciplinary collaboration by bringing together healthcare professionals from different disciplines to work as a cohesive team. Such a collaborative environment mirrors the real-world clinical setting where effective teamwork is essential for high-quality patient care (Babiker et al., 2014; Rosen et al., 2018). Through simulation, healthcare professionals can learn to manage team dynamics, enhance their leadership skills and adapt to different healthcare scenarios (Schram et al., 2024; Schram et al., 2021). Due to its positive impact on patient-centred care, multidisciplinary teamwork in healthcare, involving physicians, nurses, and other professionals, has received considerable research attention (Baek et al., 2023; Gantayet-Mathur et al., 2022).

Assessing the effectiveness of simulation-based training in teaching NTS requires valid and reliable assessment tools (Gourbault et al., 2022). Such tools must provide accurate measurement of individual and team competencies in different simulation scenarios (Hofmann et al., 2021). Validity in this context means ensuring that the assessment tools used assess the intended NTS comprehensively and reliably (Flin et al., 2003). It is essential that crew resource management training and assessment tools are specifically tailored to address the identified NTS required in a given profession (Hamilton et al., 2019). The aim of this scoping review was therefore to examine the validation

evidence for tools used to assess NTS in multidisciplinary teams in simulation-based clinical education.

Materials and Methods

For the purposes of the study, a scoping literature review was conducted to compile relevant studies. A thematic analysis was then conducted to examine and categorise the main themes.

Method of Review

The literature search was conducted in the PubMed and Web of Science databases. We used the following search terms: 'interprofessional', 'interdisciplinary', 'multiprofessional', 'multidisciplinary', 'team', 'non-technical skills', 'assessment tool', 'evaluation tool', 'medical education', 'nursing education', 'nursing student', 'medical student', 'healthcare', 'high fidelity simulation', 'patient simulation' and 'simulation training'. We combined these search terms using the Boolean operators 'OR' and 'AND', which produced the final results. The search was conducted in June 2024 and was limited to original, peer-reviewed scientific articles in English that were indexed between 1 January 2013 and 31 December 2023. These articles involved interprofessional healthcare teams composed of professionals or students from different healthcare professions (e.g. nurses, gynaecologists, respiratory therapists).

Review Results

Figure 1 shows the literature search and selection process according to the PRISMA methodology (Page et al., 2021). The initial search retrieved 138 records. Prior to screening, 31 duplicates were removed, 107 records were screened by title and abstract and 39 by full text. Finally, 10 articles were included in the detailed literature analysis.

The literature was selected on the basis of a rigorous assessment of the relevance and quality of the articles in question. The quality of the articles was assessed using critical appraisal tools developed by the Joanna Briggs Institute (JBI): the JBI Checklist for Quasi-Experimental Studies and the JBI Checklist for Cohort Studies. The articles were initially assessed by two researchers. In the event of disagreement, the third and fourth authors were consulted to resolve the differences. Each article was assigned a grade on a four-point scale: inadequate, sufficient (C), good (B) and excellent (A). Following the assessment of article quality, six studies were categorised as good quality and four as excellent quality.

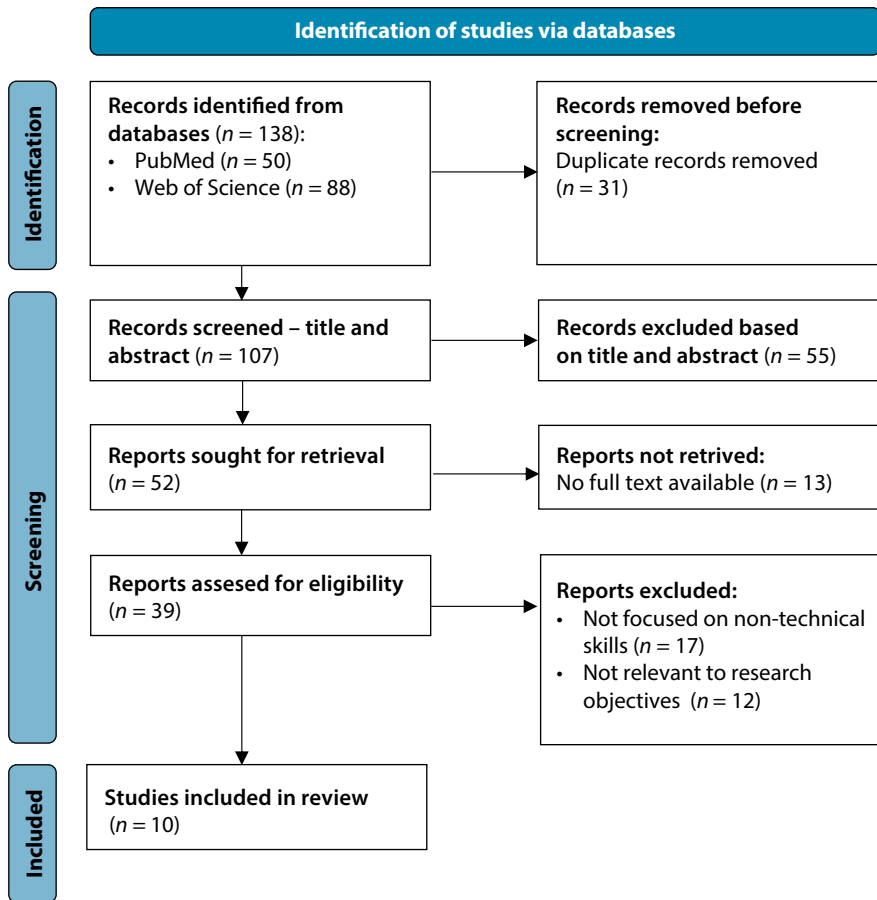


Figure 1 The Literature Search and Study Selection Process, Presented Using the PRISMA Statement Flow Diagram (Page et al., 2021).

Results

The analysis included ten studies addressing tools for the assessment of NTS in multidisciplinary teams in simulation-based clinical education. Nine studies (Alegret et al., 2023; Calhoun et al., 2014; Carpini et al., 2021; Cooper & Cant, 2014; Couto et al., 2015; Freytag et al., 2019; Phitayakorn et al., 2014; Repo et al., 2019; Zhang et al., 2015) used a single assessment tool, and one study (Briggs et al., 2015) used two different assessment tools for the assessment of teamwork NTS. Table 1 shows the primary characteristics of the studies included in the final analysis, with a focus on the objective of the research, the target population, the location where the simulation was performed, and the simulation modality involved in the study.

A total of seven different NTS assessment tools were identified in the studies. The Team Emergency Assessment Measure (TEAM) tool was used in four studies analysed, while the Non-Technical Skills for Trauma (T-NOTECHS) tool was used in two studies. Other tools were employed in a single study only. All the mentioned tools were used in a multitude of clinical scenarios, all of which focused on the management of critically ill patients, whether adults or children, in high-risk environments such as the emergency department or operating room. In these scenarios, the healthcare teams consisted primarily of physicians, particularly surgeons, paediatricians and anaesthesiologists, as well as nurses. However, some scenarios also included multidisciplinary teams consisting of respiratory therapists, paramedics, pharmacists, and students from various healthcare disciplines, reflecting the diverse and collaborative nature of real-world clinical care. The scenarios were conducted in either a simulation laboratory or a real clinical setting (in-situ simulation). The most commonly used simulation modality was the high-fidelity simulator.

Table 2 lists the NTS skills in the seven assessment tools evaluated. The most frequently assessed NTS, as determined by the frequency count, were communication ($n=6$), situation awareness ($n=5$), cooperation/teamwork ($n=5$), and leadership ($n=4$). While all tools assess three to five NTS domains, the number of items in each tool varies considerably, ranging from four items (Non-Technical Skills for Surgeons – NOTSS) to 46 items (Team Performance During Simulated Crises Instrument – TPDSCI). Each study reported validation evidence for its quantitative assessment strategy, either within the same article or by citing a related article that included this information. Seven studies used previously established NTS assessment tools, and the remaining three studies utilised newly developed or modified assessment strategies. Most of the assessment tools included had been validated in terms of scoring and generalisation. A smaller number of tools had been validated for extrapolation inference, such as factor analysis. Internal consistency was reported for four assessment tools. The reported rater agreement and internal consistency scores were all above 0.7 (acceptable), with most scores above 0.8 (good) in the case of the TEAM tool. All tools demonstrated satisfactory inter-rater reliability, as indicated by intra-class correlation or kappa coefficients. However, only two tools (Team Performance Observation Tool – TPOT and TEAM) were subjected to a test-retest reliability assessment. Factor analysis was conducted for TEAM (Freytag et al., 2019) and T-NOTECHS (Repo et al., 2019), revealing a robust construct validity in both cases. There were also other validation parameters for the included assessment strategies, such as content validity using the content validity index (CVI), unidimensional validity or face validity.

Table 1 Key Information from Studies Addressing Tools to Assess Teamwork and Non-technical Skills in Simulation-based Multidisciplinary Clinical Education

Author, year/country	NTS tool	Objectives	Target population	Simulation location/ simulation modality	Medical field
(Galhoun et al., 2014)/ USA	TPDSD	The objective was to assess team performance during simulated crises, quantifying team self-insight, and analysing session content using a video review to understand the impact of hierarchy errors on communication and team dynamics.	Paediatric Emergency Department team (physicians and nurses), a total of 5 sessions conducted.	Sim lab/HFS	Paediatric emergency
(Cooper & Cant, 2014)/ Australia and UK	TEAM	The objective was to assess the validity and reliability of the TEAM in measuring NTS in medical emergency teams.	Medical emergency teams (population sample size included 97 HCPs).	Sim lab/SP	Emergency
(Phitayakorn et al., 2014)/USA	OTAS	The study aimed to determine the feasibility of assessing OR professionals' teamwork in high-fidelity OR simulations.	The study involved five OR teams (anaesthesiology residents, general surgery residents, and OR nurses or surgical technicians).	In-situ/HFS	OR management
(Briggs et al., 2015)/ USA	NOTSS and T-NOTECHS	The study sought to investigate the deterioration of NTS over the course of simulated trauma scenarios and assess the correlation between cognitive NTS scores and critical task performance.	20 teams (surgical residents, emergency medicine residents, emergency department nurses, and emergency services assistants).	Sim lab/HFS	Emergency
(Couto et al., 2015)/ USA	TEAM	The objective was to establish baseline teamwork behaviours among paediatric emergency medicine providers during actual and simulated emergencies, and to evaluate differences in teamwork behaviours among in-situ simulations, in-centre simulations, and actual emergencies.	HCPs who work in ED (physicians, nurses, respiratory therapists, paramedics, patient care assistants, and pharmacists).	Sim lab and in-situ/HFS	Paediatric emergency care
(Zhang et al., 2015)/ USA	TPOT	The research objectives were to decrease the subjectivity of the TPOT by establishing scenario-specific targeted behavioural markers (TBMs) and determine the psychometric properties of the TPOT with the use of TBMs.	47 students in the Doctor of Physical Therapy programme and 25 senior-level students in the Bachelor of Science in Nursing programme.	Sim lab/HFS	Emergency – trauma care

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Author, year/country	NTS tool	Objectives	Target population	Simulation location/ simulation modality	Medical field
(Freytag et al., 2019)/ Germany	TEAM	The objective was to compare novice and expert ratings using the TEAM in simulated emergencies to determine if raters with limited experience can provide reliable data on teamwork behaviour.	HCPs working in emergency department (physicians, psychologists).	In-situ/SP and HFS	Emergency
(Repo et al., 2019)/ Finland	T–NOTECHS	The research aimed to assess the translatability of the T–NOTECHS into a non–Anglo–Saxon language and investigate its psychometric properties for simulated multi–professional trauma team resuscitations.	193 multi–professional participants: anaesthesiologists, surgeons, paediatricians, emergency medicine residents, nurses, and nurse students.	In-situ/HFS	Emergency – trauma care
(Carpini et al., 2021)/ Australia	TEAM	The objectives were to validate the TEAM in obstetric and gynaecologic resuscitation teams through simulations, and to assess the teams' NTS and communication abilities.	Multidisciplinary teams (population sample size 452), who had undergone simulations of obstetric and gynaecologic emergencies.	Sim lab/HFS	Obstetrics and gynaecology
(Alegret et al., 2023)/ Spain	CATS	The study aimed to evaluate teamwork acquisition of NTS through clinical simulation cases by participants in a CRM polytrauma course.	12 trauma team groups (anaesthesiologist, general surgeon, traumatologist, registered nurses, nursing assistant, and stretcher bearer), totalling to 84 HCPs.	In-situ/HFS	OR management

Legend CATS – Communication and Teamwork Skills; HCPs – healthcare professionals; HFS – high-fidelity simulator; NOTSS – Non-Technical Skills for Surgeons; NTS – non-technical skills; OR – operating room; OTAS – Observational Teamwork Assessment for Surgery; Sim lab – simulation laboratory; SP – standardised patient; TEAM – Team Emergency Assessment Measure; T–NOTECHS – Trauma Non-TECHNICAL Skills; TPDSCL – Team Performance During Simulated Crises Instrument; TPOT – Team Performance Observation Tool.

Table 2 Non-technical Skills Assessment Tools

NTS tool	Assessment skills	No. of items/ response scale	Article in which tool is discussed	Reliability	Validity
CATS	Four domains: situation awareness; coordination; communication; cooperation.	21 items 3–point scale	(Alegret et al., 2023)	Inter-rater (ICC 0.80)	/
NOTSS	Four domains: situation awareness; decision making; communication; teamwork.	4 items 4–point scale	(Briggs et al., 2015)	Inter-rater (k 0.83)	/

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NTS tool	Assessment skills	No. of items/ response scale	Article in which tool is discussed	Reliability	Validity
OTAS	Five domains: communication; cooperation/ back up behaviour; coordination; leadership; team monitoring/situation awareness.	15 items 7-point scale	(Phitayakorn et al., 2014)	Inter-rater (ICC 0.42 – 0.90)	/
TEAM	Three domains: leadership; teamwork; task management.	11 items 5-point scale	(Couto et al., 2015) (original citation Cooper et al., 2010) (Freytag et al., 2019) (Cooper & Cant, 2014) (Carpini et al., 2021)	Internal consistency (Cronbach α – 0.89) Inter-rater (k 0.55) Test–retest (k 0.53) Inter-rater (ICC 0.66) Internal consistency (Cronbach α – 0.97) Inter-rater (k 0.55) Internal consistency (Cronbach α – 0.97) Inter-rater (ICC 0.98)	Content (CVI 0.96) Concurrent Construct (59% and 65% variance) Uni-dimensional Construct (83% variance) Construct (ND) Convergent
T-NOTECHS	Five domains: communication; situation awareness; cooperation; leadership; assessment/ decision-making.	5 items 5-point scale	(Repo et al., 2019)	Internal consistency (Cronbach α – 0.70) Inter-rater (ICC 0.54)	Construct (56.8% variance)
TPDSCI	Five domains: medical knowledge; clinical skill; communication skills; professionalism; systems- based practice.	46 items 3-point scale	(Briggs et al., 2015) (Calhoun et al., 2014) (original citation Calhoun et al., 2011)	Inter-rater (k 0.40) Internal consistency (Cronbach α – 0.72) Inter-rater (ICC 0.82)	/
TPOT	Five domains: team structure; leadership; situation monitoring; mutual support; communication.	25 items 5-point scale	(Zhang et al., 2015)	Internal consistency (Cronbach (α – 0.92) Test–retest (k 0.71) Inter-rater (k 0.73))	Face

Legend CATS – Communication and Teamwork Skills; CVI – content validity index; ICC – intraclass correlation; k – kappa; ND – not defined; NOTSS – Non-Technical Skills for Surgeons; NTS – non-technical skills; OTAS – Observational Teamwork Assessment for Surgery; TEAM – Team Emergency Assessment Measure; T-NOTECHS – Non-technical skills scale for trauma; TPDSCI – The Team Performance During Simulated Crises Instrument; TPOT – Team Performance Observation Tool.

Discussion

We conducted a systematic literature review to examine validation evidence for the tools used to assess NTS in multidisciplinary, simulation-based clinical education. Based on this review, we identified seven assessment tools that are suitable for evaluating NTS in simulated environments, particularly for multidisciplinary healthcare teams, as these skills are crucial for their effectiveness. Similar to technical skills, mastering NTS involves more than just acquiring knowledge or reaching a certain competency level – it requires the ongoing and accurate application of these skills in clinical practice (Garbee et al., 2021).

The tools examined in this study were designed to identify the key elements of NTS that are crucial for safe and efficient clinical care, and to evaluate these skills through simulation-based scenarios. The results of our literature review demonstrate that the seven tools we identified are mainly built around four NTS domains: communication, situation awareness, teamwork and leadership, which is also consistent with the findings of Gawronski et al. (2022). In their literature review, Garbee et al. (2021) identified two additional domains frequently categorised as NTS tools: decision making and task management, which are often included within ‘leadership’, ‘teamwork’ or ‘situation awareness’ (Gawronski et al., 2022). In addition, Garbee et al. (2021) show that the six NTS domains in the ten tools studied have overlaps and convergences that are consistent with recognised frameworks for teamwork in different industries. They also emphasise that the inclusion of additional tools to assess multidisciplinary teams in systematic reviews would not lead to the emergence of new related NTS domains.

The results of our review of the psychometric properties of various tools, including validity and reliability, suggest that the TEAM tool is a suitable option for assessing NTS in multidisciplinary teams in simulation-based clinical education. The TEAM tool was employed in four of the studies analysed. The tool comprises three domains (leadership, teamwork, and task management) and 11 items. The TEAM was studied in medical emergency and obstetric/gynaecologic settings (Gawronski et al., 2022). Originally designed to evaluate teamwork performance in both real and simulated emergency scenarios (Cooper et al., 2010), the tool has undergone extensive psychometric testing, including measures such as Cronbach’s α , ICC, CVI, and Cohen’s κ (von Wendt & Niemi-Murola, 2018). Its face validity and content validity have been reviewed by an international panel of resuscitation experts, demonstrating strong internal consistency and moderate-to-high inter-rater reliability (Cooper & Cant, 2014; Gawronski et al., 2022). However, although the tool is reliable

and feasible, it lacks validation for real and simulated paediatric and clinical events (Couto et al., 2015).

Another tool that also produced positive results in terms of psychometric properties was the T-NOTECHS tool. The T-NOTECHS was developed to teach and assess the teamwork skills in multidisciplinary trauma resuscitation teams (Pires et al., 2017). The tool is divided into five domains: leadership, cooperation and resource management, communication and interaction, assessment and decision-making, and situation awareness/coping with stress (Briggs et al., 2015). The T-NOTECHS shows good construct validity and moderate internal consistency and inter-rater agreement (Repo et al., 2019). It has good sensitivity with adequate content validity, face validity and feasibility, but further evidence is needed to support its reliability in real-time settings (Stevenson et al., 2022).

Other tools included in this review require further investigation to fully assess their quality before they can be recommended for use in multidisciplinary simulation training. Five NTS tools received a generally positive rating for their inter-rater reliability and internal consistency, with at least moderate quality evidence, but further testing is needed to assess their construct validity. Importantly, none of the tools in this review were deemed unsuitable for multidisciplinary simulation training, as there was no strong evidence of inadequacies in their psychometric properties.

In our literature review, we focused exclusively on tools used to assess NTS in multidisciplinary teams. Higham et al. (2019) state that it is crucial that each assessment tool be customised for the specific medical speciality and stage of training. Given the distinctive characteristics of different medical specialities, individual disciplines have sought to develop more targeted tools to assess more specific NTS. In health care, over 70 different assessment tools for NTS have been developed over the years, posing challenges for educators when selecting the most suitable one. Moreover, there is increasing recognition of the need for multidisciplinary simulation-based training to foster collaboration between healthcare professionals, as it enhances teamwork and communication as the fundamental skills for optimal patient care (Elen-du et al., 2024). In order to facilitate this, it is essential to have tools that assess broader NTS that are vital for effective interprofessional collaboration.

The increasing use of digital simulation technologies, encompassing virtual reality (VR), augmented reality (AR), and artificial intelligence-driven training tools, has led to substantial advancements in the field of healthcare simulation-based education. These technologies offer an immersive and interactive learning environment, enabling multidisciplinary healthcare teams

to develop and assess NTS in a controlled and reproducible manner (Lee et al., 2024). Furthermore, the accessibility of digital simulations has been enhanced by the emergence of cloud-based platforms and remote learning tools, enabling training to extend beyond traditional physical simulation centres (Chernikova et al., 2020). However, the integration of these technologies into standardised digital education frameworks remains a challenge. According to the European Framework for the Digital Competence of Educators (DigCompEdu), effective use of digital tools in education requires structured implementation, including alignment with competency-based learning outcomes and faculty training (Redecker & Punie, 2017). Ensuring that digital simulation aligns with such frameworks will support its broader adoption and enhance its impact on healthcare education.

There are several limitations to our systematic review. Firstly, our literature search was conducted using only two research databases. While these databases are comprehensive and encompass a wide range of studies, it would be unrealistic to assume that our search captured all relevant studies. Secondly, our review was purely exploratory in nature and no standardised quality assessment instrument was used for the evaluation of the measurement properties of the identified NTS tools. We would therefore recommend that future studies adopt a more rigorous methodological approach and use a validated instrument specifically designed to assess the quality of measurement tools.

Conclusion

Among the plethora of tools designed to assess NTS, the TEAM tool is a particularly noteworthy recommendation for use in multidisciplinary, simulation-based clinical education. Nevertheless, further evidence is required to support the validity and reliability of other NTS tools. Further research is required to confirm the efficacy of these tools for consistent use in multidisciplinary simulation training.

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Orodja za ocenjevanje netehničnih veščin pri izobraževanju multidisciplinarnega zdravstvenega tima na podlagi simulacij: pregled obsega literature

V zadnjih letih se vse bolj priznava pomen usposabljanja zdravstvenih delavcev na področju netehničnih veščin z uporabo učinkovitih metod za preprečevanje kliničnih napak v zdravstveni praksi. Simulacije se pogosto uporabljajo kot učna metoda za učenje netehničnih veščin (NTV) zdravstvenih delavcev. Namen pregleda je bil raziskati validiranost ocenjevalnih orodij, ki se uporabljajo za ocenjevanje NTV multidisciplinarnega tima na podlagi simulacij. Iskanje literature je potekalo v podatkovnih zbirkah PubMed in Web of Science na podlagi vnaprej določenih vključitvenih in izključitvenih kriterijev. V končno analizo je bilo vključenih deset raziskav. Identificiranih je bilo sedem različnih orodij za ocenjevanje, pri čemer sta bili večkrat uporabljena orodji za ocenjevanje TEAM (iz angl. *Team Emergency Assessment Measure*) in T-NOTECHS (iz angl. *Non-Technical Skills for Trauma*). Najpogostejše ocenjene NTV znotraj vsakega orodja so bile komunikacija, prepoznavanje situacije, timsko delo/sodelovanje in vodenje. Številna ocenjevalna orodja so validirana za ocenjevanje in posplo-