Final report to the SRHE: A literature review

A scoping review to investigate the models and measures of learning outcomes used in research on professional skills development in technology-enhanced simulation-based medical education (the MMED-SIM project)

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Introduction: Defining and aligning the objectives for the review and the research questions

Graduates need a range of skills to succeed in the labour market. Higher education institutions should facilitate students' learning of not only subject-specific knowledge, but a range of professional competences (UUK, 2016). These are often called transferable skills, graduate skills, non-technical skills or employability skills. This scoping review focuses particularly on medical education where the development of non-technical skills is now firmly included in the curricula, but the issues it addresses are relevant to the whole higher education sector in the U.K. and elsewhere.

In medical contexts non-technical skills (NTS) are also referred to as non-clinical or 'soft' skills. These refer to decision-making, leadership, communication and teamwork (Gordon, Baker, Catchpole, Darbyshire, & Schocken, 2015) and are considered to be centrally important to medical doctors. This scoping review focuses on research on medical education aimed at advancing non-technical skills.

This is an area of medical education that has been identified as particularly important at the time of the COVID-19 pandemic. The pandemic has necessitated many changes in NHS practice. Staff and trainees have to work in new (and often newly constructed) teams, which are large and multi-professional. Working in unfamiliar environments (such as providing critical care in untypical locations) and with personal protective equipment further adds to the challenge. These changes have particularly highlighted the need for strong non-technical skills, such as effective communication and interprofessional teamwork, to ensure safe high quality clinical care (e.g., Fonseka et al., 2020; Yule & Smink, 2020). At the same time, cancellations in elective treatments and outpatient clinics have drastically limited training opportunities within many specialties. Limitations in access to patients have further reduced opportunities to develop non-technical skills. These restrictions have impacted on other higher education areas too. In teacher education, access to practice with real people is constantly weighed against the risk of virus spread, while communicating with pupils in remote teaching places novel burdens of communication and collaboration.

Technology-enhanced simulations are emerging as a potential key contributor to addressing these Covid-related learning needs (Dieckmann et al., 2020) but they also address many broader medical education challenges. Technology-enhanced simulations are well known in the aviation industry. A range of factors have made them attractive to medical education. The numbers of doctors and health professionals in training mean that new effective ways of learning are needed, including increased utilisation of learning technologies. Concern for patient experience and safety has led to a need to replace apprenticeship-type approaching to learning, and develop new learning environments in which competences can be developed and practised. Simulations enable the complexity of the target practice to be reduced to support novice learners. They offer an opportunity for practising complex real-life expert skills without risk to patients or students (Clark et al., 2017). At the times of a pandemic simulations offer practice opportunities without the need to meet patients. Yule and Smink (2020) further point out the importance of non-technical skills training for rebuilding capacity after the pandemic.

Simulations can take many shapes. They vary from role play and written scenarios, to low-fidelity procedural skills practice, to high fidelity manikins and full-immersion 3D virtual reality environments (Kostusiak et al., 2017; Chernikova et al., 2020). Technology-enhanced simulations are quickly developing and many technology companies are responding to the pandemic by rapid development of new technology-enhanced simulation tools. There is mounting evidence from systematic reviews that simulations are effective in medical education as well as more widely across higher and professional education (Chernikova et al., 2020). This recent evidence also suggests that enhancing simulations through technology further improves their effectiveness. Yet, few simulation tools are well evaluated, which can make them an expensive and risky investment (Kostusiak et al., 2017; Clark et al., 2017). Despite their promise, little is known about the effectiveness of many technology-enhanced simulation-based learning opportunities on the development and transfer of non-technical skills.

Many discussions of research on simulation-based medical education have focused on the quality of the research designs. Randomised controlled trials, used in clinical trials, have been described as a gold standard in research on the effectiveness of educational interventions (Hutchinson & Styles, 2016). However, evaluating the impact of educational interventions also requires the ability to assess the learning outcomes those interventions have achieved. Without adequate outcome measures used cumulatively across studies, rigorous experimental designs alone do not deliver us the evidence we want.

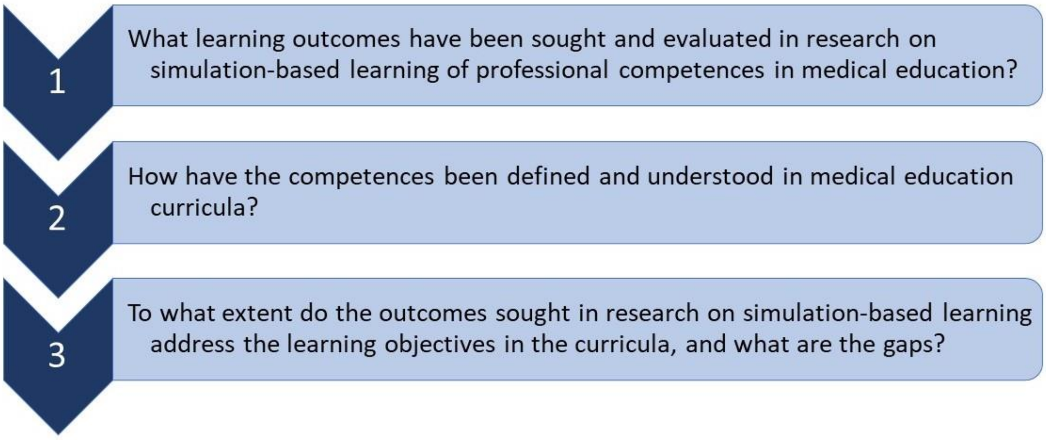
There is a shortage of learning outcome measures for assessing non-technical skills that are based on valid conceptual understandings of the developing skill and reliable operationalisations. A recent BEME Systematic Review (Gordon et al., 2019) found that a consensus on how to assess non-technical skills in medical education is lacking and few conceptually-founded validated assessment instruments exist (cf. Hofmann & Vermunt, 2021). Much research evaluating the effectiveness of learning interventions targeting non-technical professional competences draws on subjective measures of participant satisfaction, or instruments developed just for that study.

This scoping study reviews the literature for robust models and measures evaluating learning of non-technical skills, thus informing the development of a framework for systematically studying the effectiveness of technology-enhanced simulations aimed at supporting the learning of non-technical competences. While the scoping review focuses particularly on medical education, it has potential for wider significance across higher and professional education.

Research questions

This scoping research addresses the gap outlined above by answering three related questions presented in Figure 1.

Figure 1 Review questions



While the goal of this study is to identify new concepts and instruments to facilitate rigorous development and evaluation of technology-enhanced simulations, the decision was made not to exclude research focusing on simulations where technology did not play a central role or was not explicitly mentioned in the abstract. This was for three key reasons.

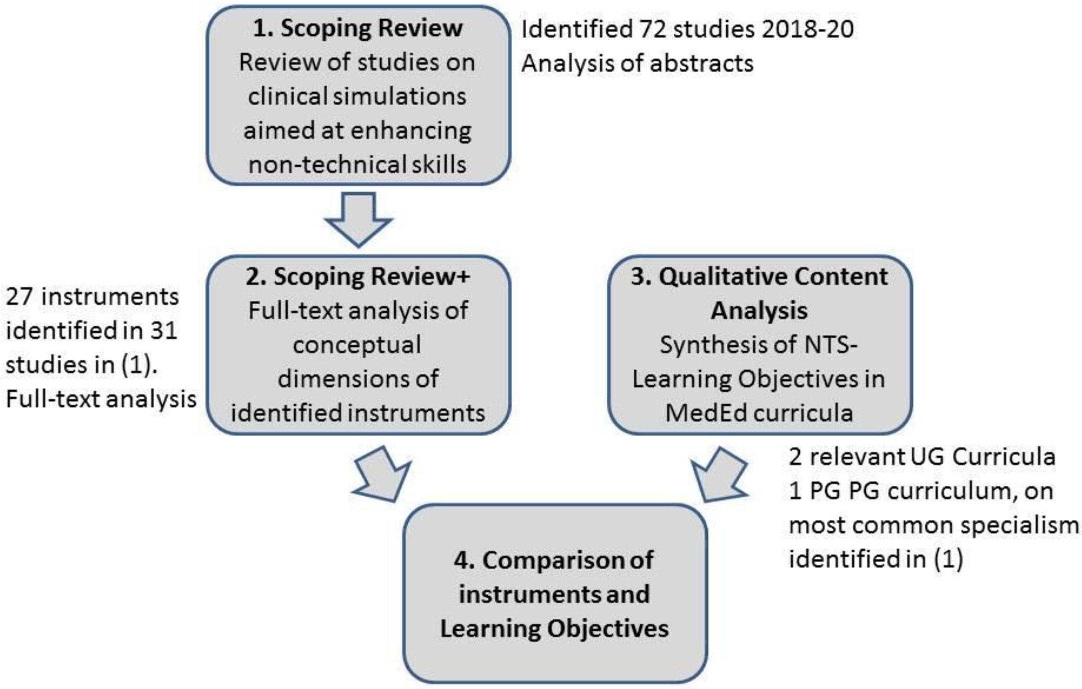
- Initial review found that the simulations were often poorly described in the abstracts; many abstracts which did not mention technology were interpreted by experts on those specific simulations as likely to have used technology. Therefore, excluding these studies would have significantly limited the study's scope, more so than including studies which may not have included technology.
- Besides, although earlier evidence is mixed on the added benefits of technology in simulation-based learning (Cook et al., 2010), the most recent evidence synthesis suggest that technology-use had an added positive effect on learning in simulations (Chernikova et al., 2020). This difference in the evidence may be in part due to the variable quality of evidence in earlier studies on technology-enhanced simulations (May, Park, & Lee, 2009). Acknowledging the weak nature of many evaluations in this field, and to ensure that we do not throw the baby out with the bathwater in terms of identifying robust measures, this scoping review includes both evaluations of technology-enhanced simulations and relevant simulations not using or explicitly naming technology.
- Finally, due to limitations to training brought on by the COVID-19 pandemic, even many simulations currently using role play scenarios, typically with simulated/standardised patients, may now need to increasingly be offered through technology-enhanced provision. If we want to be able to compare technology-enhanced versions of these simulations to previous traditional versions, it is important such future research will utilise the same methods and instruments where possible.

Identifying the best evidence on all outcome constructs and measures in the field was deemed to make the greatest potential contribution for developing and evaluating technology-enhanced simulations in the future.

Overall research design and methodology: Scoping Review plus focused content analysis

Figure 2 presents the design of the study. The overall methodology developed is described in this section.

Figure 2 Review design



Scoping Review is an established, systematic approach to comprehensively 'mapping', synthesising and analysing the extant literature base on a topic of interest (Booth et al., 2016; Levac et al., 2010;). Typical aims of scoping reviews include determining what kinds of methodological approaches have been taken to a topic and what sorts of evidence have therefore been generated, mapping and clarifying key concepts related to a research area, 'feeling out' the boundaries of a field and, on the basis of that, making recommendations for further research (Munn et al., 2018;). Approaches to data analysis and synthesis can be both quantitative and qualitative (O'Brien et al., 2016), and vary from more descriptive to conceptually-informed approaches (Davis, Drey, & Gould, 2009), frequently exploring themes or inter-relationships which emerge across a body of literature (Booth et al., 2016). They therefore serve both as stand-alone reviews in their own right, with their own findings, and as useful, and often necessary, preliminaries to further research (Arksey & O'Malley, 2005). They are carried out and reported systematically, with transparency and replicability as core principles driving the research design and presentation of findings (Arksey & O'Malley, 2005; Munn et al., 2018), and, much like Systematic Reviews and Meta-Analyses, have their own codified methodological and PRISMA reporting guidelines.

Scoping Reviews are oriented toward breadth of analysis, with varying degrees of complementary depth of analysis according to the purpose of the study (Arksey & O'Malley, 2005). As Scoping Reviews do not typically restrict the evidence base according to study design or quality (Levac et al., 2010), they have the advantage of being able to synthesise a wide range of methodological and conceptual approaches into a coherent picture of a field (Arksey & O'Malley, 2005;), thus informing how different areas of the research base relate to one another, and shaping recommendations for future research. They enable researchers, policy makers and practitioners to make better use of the extant literature on a topic by providing an accessible summary and a means to navigate a complex field (Arksey & O'Malley, 2005). Aside from enabling researchers to synthesise a very large body of literature within a (relatively) rapid timeframe (Arksey & O'Malley, 2005), when it is considered that the purpose of academic abstracts is not simply to summarise a published study but also to position it within a pre-existing field (Hyland & Tse, 2005), the outcomes of a Scoping Review therefore go beyond an appraisal of the nature of evidence which exists within a field and provide an indication of how the field characterises itself, how it perceives itself as being interconnected, and what criteria for relevance and significance of research are in operation in the given field.

The synthesis of the curricula drew on the well-established method of qualitative content analysis (Mayring, 1993; for description, see Hofmann & Vermunt, 2021). The study followed the ethical procedures of the Faculty of Education, University of Cambridge. Individual consents were not required as patient-level or personal data were not examined. Throughout the study, efforts were directed towards reporting the search strategy and data analysis clearly and transparently, enhancing reproducibility, data validity, and reliability. Rather than the use of rigid quality assessment criteria, an iterative process was employed that at least in part, was determined by the findings as the study progressed. No conflicts of interest are declared by the authors.

Specifying the foci for the review and search terms

This and the following section focus on the selection of the area of medical education, the refinement of the specific competences to be researched and the identification, selection and refinement of the criteria for the literature search.

As discussed in the original proposal, the recruitment of the Research Associate for the project (SC) influenced the decision over the area to be studied. Since the Research Associate recruited was not a medical specialist (albeit with several years' experience as a hospital physiotherapist) and initial reviews of the literature showed the limited rigorous literature in any one specialist field, it was decided it would not be beneficial to narrow down the scoping review to one medical specialism at this stage of the study. Instead, an initial literature review to identify relevant key competences applicable across specialisms was undertaken.

Based on an initial review of the literature, 4 key non-clinical competences were identified and defined for the subsequent review as: Inter-professional work; Communication; (Holistic) Decision-making and evidence-based reasoning; Clinical leadership. Our earlier research had already identified the absence of robust outcome constructs and measures for clinical leadership development and developed such a construct and measure (Hofmann & Vermunt, 2021). Therefore, this study focused on the first three of those competences which were found to be under-researched in the literature. This process also supported the development of search terms for the scoping review. The full set of search terms is provided in Figure 3.

Following the development of a protocol detailing the search strategy, a literature search was undertaken for each of the areas using these sets of keywords, using three databases: PubMed, Embase and ERIC, for peer-reviewed journal articles. The literature search was conducted in July 2020. Studies were screened based on their titles, keywords, abstracts, and subject headings. Medical subject headings (MeSH) were used for the medical data bases (PubMed and Embase), with a separate set for the educational data base (ERIC). The timeframe contained studies from 2018-2020. The total identified unique papers numbered 225.

Figure 3 Search terms

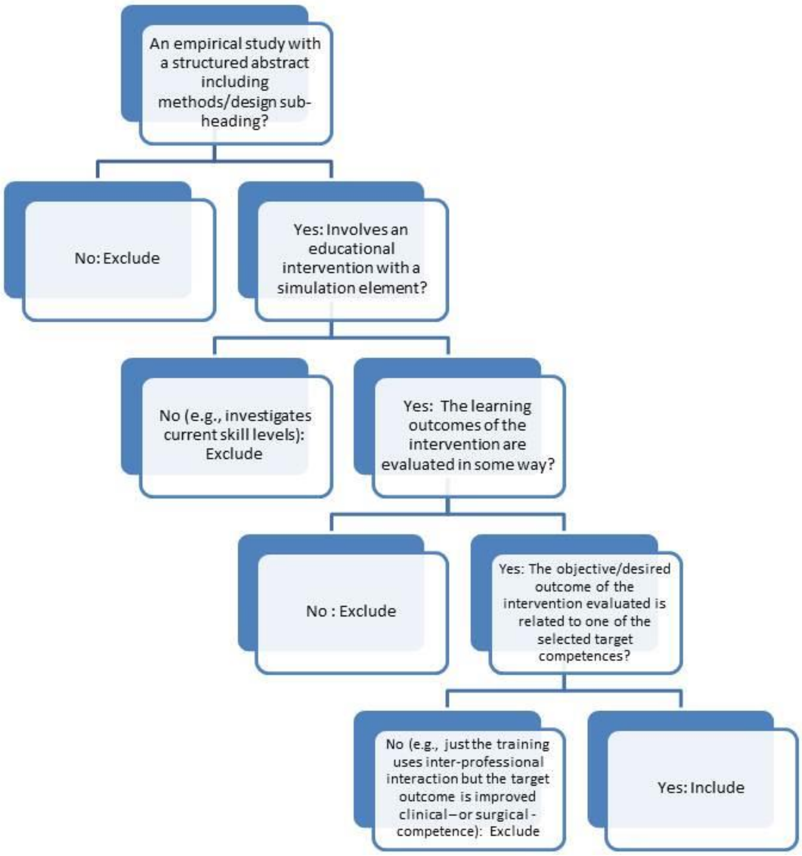
Group	Title or Key words (all: OR)	Medical subject headings	ERIC Subject headings
1 (For ERIC only)	ONLY for Education Data Bases medic* Clinical Doctor Physician nurs*	GROUP 1 SEARCH TERMS NOT USED IN MEDICAL DATA BASES	Medical Education Medical student Nurses Nursing Nursing students Health care [as 2 words] Clinical Teaching (Health Professions)
2	Simulat*	Simulation	Simulation
3	learn*; educat*; train*; develop*; Professional; CPD OR ("continuing professional development"); CME or ("continuing medical education")	Learning; Education; Training; Professional competence	Learning;Training; Professional development NB. "Education" NOT to be used as Subject Heading in ERIC
4A	team* Interprofessional OR Inter-professional Multiprofessional / Multi-professional Collaborat* Non-technical skills OR nontechnical skills Interdisciplinary	Interprofessional relations – Public relations: teamwork = subheading Interdisciplinary communication Cooperative Behavior is subheading of SH 'Cooperation' Team (all) All subheadings except team-sport	Interprofessional relationship Team* Collaboration
4B	Communication (all: skills; strategies; communication ONLY)	Communication barrier Persuasive communication Doctor-Patient Relation	Communicatio*
4C	Reasoning (all: Reasoning ONLY; Clinical reasoning; collaborative reasoning; explicit reasoning) Decision-making / Decision making Problem-solving / Problem solving	Problem solving Decision making Evidence based practice	Problem solving (no hyphen) Decision making Reasoning
5	For the Medical data bases only, the abstract must contain the word "Methods" or "Method(s)"		

Inclusion/exclusion exercise

Based on the initial literature search, inclusion and exclusion criteria were developed to identify the sub-body of papers from the search to be reviewed in our analysis. In an initial pilot inclusion exercise it was observed that these criteria did not fully capture the fact that many papers did not actually contain an evaluation but rather a discussion or description of a simulation. To more effectively exclude such studies, an additional criterion stipulated that the studies had to use the words “method”, “method/s” or “design” *as sub-heading* as part of a structured abstract, serving as a proxy in the medical database findings for identifying empirical studies, as opposed to discussion papers.

Figure 4 illustrates the inclusion/exclusion criteria for the search findings.

Figure 4 Inclusion/exclusion criteria for the search results



The two researchers independently reviewed the dataset according to the full set of inclusion criteria. The resulting inter-rater agreement was 82%, rising to 93% after discussion of discrepancies. The remaining 12 studies (7%) on which no agreement was reached were reviewed by the lead researcher (RH) and a decision made. The final number of papers included in this scoping review was 72.

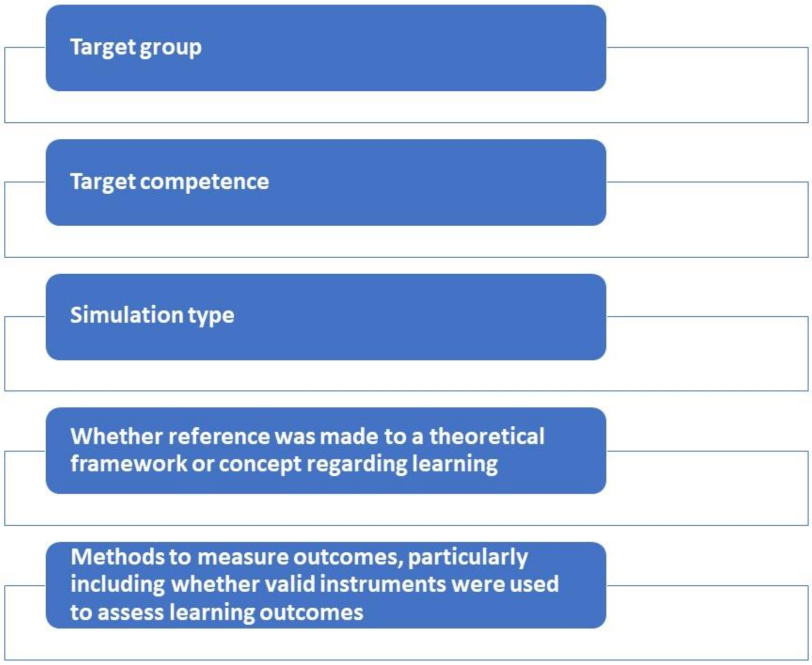
Evidence extraction from the literature

Evidence extraction Round 1 (Abstracts)

In the main scoping review data were extracted from the identified studies' abstracts. All data was coded by two independent coders of the group of three, including the PI (RH), the research associate (SC) and a research assistant (SD). As it was identified (see below) that it was not possible for researchers without clinical knowledge to reliably code the abstracts for simulation type, due to very limited information in the abstracts about the simulations themselves, a further coding round was conducted by RH and 2 external experts with clinical simulation experiences.

Figure 5 lists the data extraction categories.

Figure 5 Data extraction categories



The categories were tested, discussed and refined before full coding. For the **target group**, it was decided to include nurses and other health professionals, since a huge proportion of learning research in clinical settings is in the context of nursing, with a strong methodological tradition for learning research. We did not want to miss the opportunity to learn from this body of research. After a trial round to develop agreement, the papers were independently coded by two researchers. Inter-rater agreement was 85% or over. A third coder coded the discrepant cases. Only one category remained problematic: Simulation type (agreement 81%). It was concluded that information offered in the abstracts was so limited that it was not possible for the non-clinical specialist researchers to reliably code this. Two clinical specialists (a medical registrar and a simulation manager) were brought in to independently code the full set of abstracts for simulation type. Those experts coded the abstracts for simulation types alongside RH. Where at least two coders agreed, the majority decision was accepted. Discrepancies were reviewed by RH and returned to one of the coders until agreement was reached for each abstract.

Evidence extraction Round 2 (Full text)

The full text analysis focused specifically on named instruments identified in Round 1 data extraction. 27 named instruments relating to the target competences were identified in a total of 31 papers in Round 1 coding, with 4 used twice. From each of these 31 papers, the conceptual dimensions of the instrument, where present, were identified and extracted.

Identification and analysis of curriculum documents

The review questions also included a focus on the constructs for the target competences. To examine this, learning objectives in medical education curricula were analysed in the second stage of the study. For undergraduate curricula, the two major U.K. curricula, as also used in our university's clinical school, were selected. As training in the target competences continues to be of significant relevance throughout clinicians' professional development beyond graduation, a postgraduate curriculum was also to be included in the analysis. The most common specialty in the studies identified by the scoping review, Anaesthesia, was selected. The new curriculum document in this specialty was included in the analysis. The curricula analysed are listed in Figure 6.

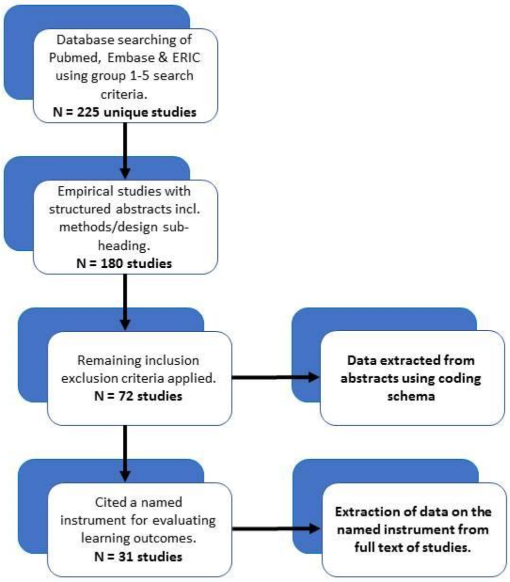
Figure 6 Curricula analysed

A total of 99 learning objectives (LOs) relating to the three target competences was identified across the three curriculum documents. A synthesis grouping similar objectives together resulted in 21 LOs.

Findings for Stage 1: Scoping Review and Scoping Review+ (RQ1)

Figure 7 illustrates the results for the Scoping Review inclusion process.

Figure 7 Inclusion exercise results



We first discuss the findings from our coding of the 72 abstracts. For **target competence**, in our coding, 36% (26) of the studies were identified as focusing on interprofessional competence, 21% (15) on communication and 13% (9) on reasoning/decision-making. However, many studies had a broad focus on a range of non-technical skills and nearly a third (31%) (22) cited only a general NTS focus. Due to this it was decided that the as-identified studies would be examined together.

In terms of **target group**, nearly half of the studies, 43% (31) focused on doctors (including a range of specialties and training levels). Over a third, 38% (27) focused on multiple professional groups while 9 studies (13%) focused on nurses and 5 (7%) on other clinical professionals or an unspecified group. In only 22% (16) of the studies was any reference made in the abstract to a **theoretical framework** regarding learning.

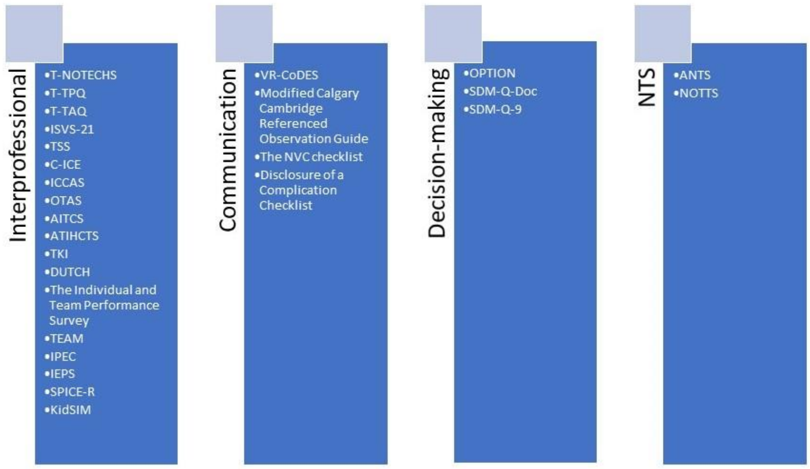
Half – 49% – of the identified studies did not include apparent use of **technology**, although as mentioned before, some of these may also have utilised technology. Using Chernikova et al.'s (2020) categorisation, 35% (27) used simulators while 11% (8) included immersive virtual reality application. Only 2 studies used technology in the form of computer/screen-based technology. In terms of the **type of simulation**, the most common types were roleplay (with other professionals or simulated/standardised patients) or manikins, at 38% (27) each. We did not differentiate between high- and low-fidelity scenarios since this information was rarely available in the abstracts (and, in fact, some of these may actually have been VR-based). 14% (10) of the studies used document-based or written-scenarios (some with screen-based applications). The remaining 11% drew, as described above, on virtual applications.

Under half of the studies, 43% (31) used a **named assessment instrument** related to our target competences. The remainder used a range of data, with half (50%) using structured instruments like questionnaires, a quarter (25%) collecting qualitative data (interviews, focus groups) and a sixth, (17%) observational data (some used several types of data). A total of 27 instruments related to our target competences was used in these studies on altogether 31 times. Interestingly only 4 instruments across all the studies were used more than once (twice each), the rest only once each. Of these, 18 were focused on Interprofessional competences, 4 on Communication, 3 on Decision-making and 2 on non-technical skills generally. These papers were the focus of our full-text analysis.

We note that the studies using named instruments included a mix of target competences (all 3 plus non-specific foci) and target groups (doctors, nurses and mixed). There is not one specific target group or competence that particularly includes studies using named instruments; their use is inconsistent across all the target groups and competences. For this reason, and the prevalence of NTS foci not focused on only one of the three competences, we decided to do our subsequent round of analysis with regard to all of the competences, instead of narrowing down to one, which would have significantly limited our study.

Figure 8 presents the 27 named instruments used in the studies, based on the abstracts, which focused on one or more of the three target competences. Named instruments which related specifically to a clinical/procedural skill have not been included as they are not relevant to our focus. While the table mentions the target competence for the instrument, it was found in the full-text analysis that many of the instruments actually spanned across the competences.

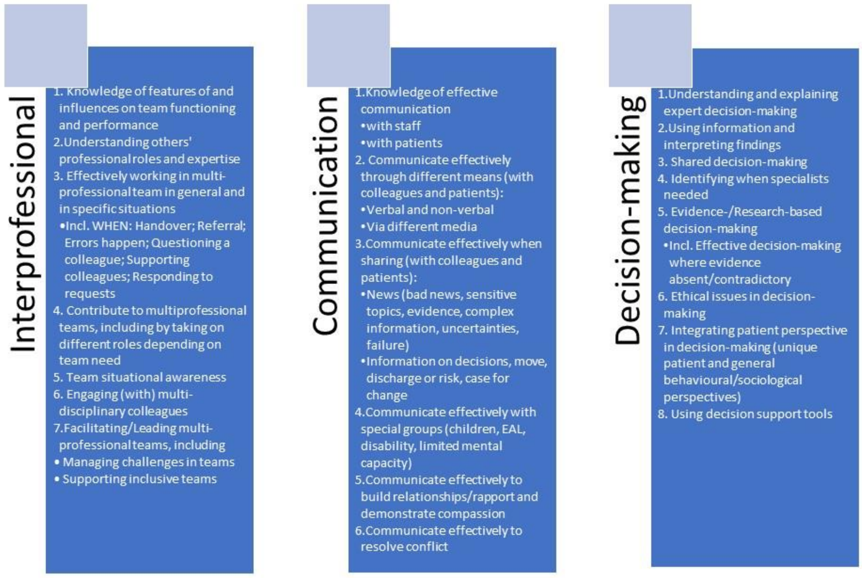
Figure 8 Instruments identified



Findings for Stage 2: Curriculum Review of Learning Objectives (RQ2)

The content analysis of the three curricula identified 99 learning objectives, the generalisation and structured synthesis of which generated 21 objectives, 6, 7 and 8 for each target competence respectively (though some with further specified sub-categories). Figure 9 presents these synthesised categories.

Figure 9 LOs for the three non-technical skills



Integrative Findings for Stages 1 and 2 (RQ3)

Four of the papers using a named instrument did not contain information for the instrument they used and hence these instruments (IPEC, The Individual and Team Performance Survey, SDM-Q-Doc and SDM-Q-9) have not been compared to the learning outcomes. However, these have been recorded here for future research. The remaining papers contained variable levels of information about the conceptual dimensions of their instrument. It is noteworthy that due to this, it is possible that these instruments contain dimensions that we have not accounted for, since these were not mentioned in the papers. This too can be followed up in future research.

The comparison of the conceptual dimensions of the outcome measures discussed in the papers and the synthesised learning objectives from the curricula show significant overlap. However, it is also interesting to note the dimensions from the curriculum learning objectives which are not mentioned as measured outcomes in any of the studies analysed here. Notably, while all other communication-related competences are mentioned in the data (at least in one of the studies' descriptions of the named instruments), no study or instrument (as discussed in the paper) makes reference to the learning objective for communicating effectively with special groups. Also, while most of the competences relating to interprofessional working are also referred to at least once in the discussions of the studies' outcome constructs, none make reference to supporting inclusive teams as a leader.

Discussion and Conclusions: Knowledge gaps and future research topics

A summary of findings

Interprofessional competences were the most commonly identified focus of the three selected target non-technical competences in studies on simulation-based learning. Far fewer studies focus on how simulation-based learning can facilitate the development of decision-making, suggesting a gap in the field. Based on the study abstracts, it appears very rare for studies in this field to make explicit use of theoretical frameworks or concepts regarding learning of non-technical competences or the competences themselves. This suggests another potentially significant gap in the field which is further highlighted by our finding that under half of the studies identified a named instrument in the abstracts to measure the target competences. In terms of identifying methods and instruments for evaluating the impact and effectiveness of technology-enhanced simulation-based learning, our review suggests it is worth including studies on non-technology supported simulations, and studies in the context of nursing education and professional development. 6 of the 27 (22%) unique named instruments identified across the dataset came from studies on nursing (all relevant for medical professionals also), significantly higher than the proportion of the papers studying nurses' learning (13%).

The medical education curricula present a number of clear learning objectives regarding the three target non-technical competences which we synthesised to a set of 6-8 key learning objectives per competence. A comparison of these learning objectives with the dimensions of the named instruments identified in the scoping review suggested that while many are covered by the instruments used in research on simulation-based learning targeting these competences, there are some clear omissions. In terms of communication and interprofessional competences, these relate in particular to inclusive practice as well as effective communication and interprofessional practice in a range of concrete challenging situations. The absence of attention to inclusive practice in the studies is particularly notable in the context of the COVID-19 pandemic, as many discussions and inquiries have sought to better understand any possible differential practice and service provision within the U.K. healthcare system with regard to different groups of patients and staff. Further attention to concrete challenging situations, on the other hand, is a key further focus, if we want to advance and evaluate our understanding of the effectiveness of technology-enhanced simulation-based learning in impacting clinical practice beyond the simulation itself, and not only individual participant reactions and learning.

However, the particular gaps identified related to the development of decision-making: several dimensions identified as important in the curricula are not mentioned in any of the studies' discussions of named instruments. There were notable absences where competences related to: Identifying when specialists needed, Evidence-based reasoning/decision-making, Ethical issues in decision-making and Using decision support tools. All of these were not mentioned, suggesting a clear and important gap in the literature.

Key messages for future research

This study has identified several key messages for future research on technology-enhanced simulation-based learning to support the development of non-technical skills in medical education. The key messages from this study can be summarised as follows:

- Research needs to identify and analyse valid instruments and to use these more consistently across studies to ensure more robust and more relevant outcomes and comparability across studies. Our review has generated a pool of such instruments to start with. Further research would be beneficial on analysing actual instrument constructs and linking their relevance to medical education curricula internationally.

- Further research is needed to identify - or develop and validate - instruments that address the as-identified gaps between LOs and existing research on simulation-based learning. Our study contributes to such work as it has identified where the most important gaps lie.
- Our study shows the need for future research in medical education, and simulation-based learning specifically, to draw more systematically on theoretical frameworks for learning and the target competences for more consistent and robust research, and inform the development of a consistent set of research tools as well as simulations themselves.

More generally we note that learning in many of the studies was discussed and evaluated in terms of participant reactions to, and the immediate outcomes of, the simulation. Very few studies were beginning to evaluate transfer of that learning to practice, or beyond that, on organisational outcomes. This is a key future area of development in this field and requires not only strong study designs, but suitable instruments to evaluate the effectiveness of technology-enhanced simulation-based learning in clinical practice and outcome.

While simulations are a well-established educational method in medical education, they have more recently gained resonance in other fields of professional learning and in higher education (Chernikova et al., 2020). In higher education, simulations offer further opportunities for engaging in real-life problem solving in a way that reduces complexity, and practical and ethical barriers. In professional learning, such as teacher education, in particular, the Covid-19 pandemic has limited access to practice. This is increasing the interest in simulation-based learning beyond medical settings. New approaches to simulations, including those making use of new technologies, are emerging in these fields. This is a novel emerging field and as such, it is important that its development is evidence-based. We wish to generate opportunities for cross-fertilisation between medical education and other fields of professional and higher education, so that fields more recently developing simulation-based learning can benefit from the experience within the clinical sector. The instruments identified in this study concern competence areas which are relevant to a wide range of professions, as higher education in increasingly expected to develop students' 'employability' or non-technical skills.

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