Medical Students' Non-Technical Skills (Medi-StuNTS): preliminary work developing a behavioural marker system for the non-technical skills of medical students in acute care

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ABSTRACT

Introduction Good non-technical skills (NTS) are critical to the delivery of high-quality patient care. It is increasingly recognised that training in such skills should be incorporated into primary medical training curricula. This study aimed to develop an NTS behavioural marker system (BMS), specifically applicable to medical students, for use within simulated acute care scenarios.

Methods The methodology used to develop other BMS was adopted and modified. Following ethical approval, 16 final year medical students participated in acute care simulated scenarios. Semistructured interviews were performed to gauge the understanding of NTS. A panel meeting of subject matter experts was convened to translate key NTS into skill elements and observable behaviours. A second expert panel was consulted to refine aspects of the BMS. Further refinement and initial face validity was undertaken by a third panel of experts using the prototype BMS to observe prerecorded simulation scenarios.

Results Five categories of NTS were identified: situation awareness, teamwork and communication, decision-making and prioritisation, self-awareness, and escalating care. Observable behaviours in each category describe good and poor performance. Escalating care was identified as a unique component that incorporated behaviours related to each of the other four skill categories. A 5-point rating scale was developed to enable both peer-to-peer and tutor-to–student feedback.

Conclusion The Medi-StuNTS (Medical Students' Non-Technical Skills) system is the first BMS for the NTS of medical students. It reinforces the importance of escalating care effectively. It provides an exciting opportunity to provide feedback to medical students and may ultimately aid their preparedness for professional practice.

INTRODUCTION

Non-technical skills (NTS) are defined as 'the cognitive, social and personal resource skills that complement technical skills, and contribute to safe and efficient task performance'.[1]

NTS came to the fore in healthcare with the Institute of Medicine's publication *To err is human*.[2] High-level NTS are critical to the delivery of safe and effective patient care, particularly in acute medicine.[3 4] Recent work has demonstrated the positive impact that improved NTS (of either teams or individuals) can have on patient outcomes and rates of error.[5–7] Additionally, an increase in major complications and patient death has been associated with theatre teams who demonstrate weaker NTS.[8] NTS training for clinicians expected to manage acutely unwell patients needs to be targeted at individuals and transferable to a range of potential settings.

NTS training in high-risk industries such as aviation is well-established.[9] NTS taxonomies and behavioural marker systems (BMS) have been developed, validated and integrated into the training of pilots known as crew resource management (CRM) training.[9] CRM is a set of training procedures focused on leadership, communication and decision-making in the cockpit. Since the global adoption of CRM in the 1990s, several other industries have recognised the importance of providing specific training in NTS. NTS taxonomies describe the critical NTS required in a given context. Use of a BMS is a technique that allows NTS to be recognised and reviewed through observed behaviours. BMS developed for individuals have a tri-hierarchical structure[9]:

1. Broad skill categories
2. Subcategories, often referred to as skill elements
3. Observable behaviours

The inclusion of observable behaviours allows raters to score each element and category according to a predefined scale, and to explicitly link behaviours with performance. Medical specialties and allied professions, including anaesthesiology, surgery, obstetrics and gynaecology, emergency medicine and surgical scrub practitioners, have adopted NTS BMS within their training.[10–15] More recently, a BMS has been developed for newly qualified doctors, known in the UK as Foundation doctors (Foundation non-technical skills—FoNTS).[16] The research underpinning the BMS listed above has demonstrated the importance of each BMS being specific to the context of work, the level of training and the clinical experience of the individuals for whom it has been designed.[1 17] While there are some similarities between the different BMS in relation to the broad skill categories, the skill elements and observed behaviours are often different. These differences may initially appear subtle, but are crucial to recognise if the BMS is to be used for training or assessment (as is the case for the surgical BMS: non-technical skills for surgeons—NOTSS).[18]

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It is increasingly recognised that training in NTS should be incorporated into primary medical training, as identified by the Health Select Committee Report (2009)[19] and other bodies.[20 21] Furthermore, the General Medical Council (GMC), the statutory body charged with regulating doctors working in the UK, is now endorsing 'simulated training environments with behavioural debriefing as entirely appropriate for the teaching of non-technical skills'.[22] NTS training courses for students have been described, including integration with Immediate Life Support training.[23] Pager simulations and simulated ward rounds have been trialled as ways of observing and assessing medical students' NTS.[24–27] In Australia, large-scale mass casualty simulation has been used to facilitate student appreciation and development of NTS, particularly teamwork.[28] Although there have been multiple attempts to assess and improve medical students' NTS, there has been little attempt to define the NTS that are specifically relevant to medical students managing acutely unwell patients. Furthermore, many of these educational strategies describe team performance, rather than individual performance.[28] The disadvantage of this approach is that NTS competence may differ significantly between team members, even of a similar clinical level, and the training needs of individuals are therefore unlikely to be identified. The use of FoNTS (designed for newly qualified doctors) as a BMS for the NTS of medical students seems initially appealing. However, recognition of the fundamental difference between medical students and qualified doctors, both in terms of clinical exposure and maturation of clinical identity formation, make it unlikely to be entirely suitable. Medical students in New Zealand undertake a 'pre-intern' year in their final year, prior to transitioning to a newly qualified doctor.[29] Evidence gleaned in that context suggests that medical students are true novices in the professional skills required for clinical practice, such as decision-making, prioritising workload and taking responsibility for the immediate assessment and management of the unwell patient.[29–32] A medical student has little or no experience of NTS as applied to clinical practice and requires cues to enable safe and effective performance.[33] There is, therefore, a necessity to define the key NTS required for medical students and develop a bespoke tool for teaching, understanding and facilitating discussion around these in simulated training environments.

The aims of this study were twofold:

1. To identify the NTS specifically relevant to medical students.
2. To use these NTS to develop a BMS, specifically applicable to medical students, for use within simulated acute care scenarios.

METHODS

Development of a BMS

The methodology used in this study was influenced by previous NTS research in healthcare and other industries.[9–12 14 16] The two main stages advised by Flin *et al* in the development of a BMS are (1) identification of the required skills and (2) designing and refining the marker system itself.[1] An overview of the stages involved in the development of this particular BMS is shown in figure 1, to accompany the detailed descriptions given below.

Skills identification

Following appropriate ethical approval from the University of Edinburgh College of Medicine and Veterinary Medicine Education Research Ethics Committee, 16 final year University of Edinburgh medical students participated in high fidelity simulation. The simulation involved a Laerdal SimMan 3 G patient simulator in a realistic ward setting, with equipment used in the health board where the medical students were on placement. The acute care simulation was a voluntary session as part of their placement at the Western General Hospital in Edinburgh. A total of four scenarios were designed by the researchers (ALH, JK, MAM): anaphylaxis, exacerbation of asthma, venous thromboembolism and sepsis. All scenarios had predefined clinical and non-clinical learning outcomes that aligned with the overarching learning outcomes for the students' acute and general medicine placement. Three students participated in each scenario with six to nine students observing via live videolink. Scenarios lasted for 20 min. To support the educational value of the simulations, each scenario was followed by a 45 min facilitated debriefing including both participating and observing students. The debrief was undertaken by one of the researchers (ALH, JK, MAM) or a trained faculty member.

Following the simulation session, the students were invited to participate in individual semistructured interviews, conducted by one of two researchers (JK or MAM). The same researcher did not debrief and interview any student. A critical incident technique using semistructured interviews is often used in NTS research to identify appropriate skills.[9 10 16] However, the project team felt that it was unlikely that medical students had sufficient exposure to critical incidents to use this technique in a meaningful way. A reflective, semistructured interview approach was adopted whereby students were asked about their recognition and knowledge of NTS in the acute care simulated environment, as well as other situations they may have encountered during their primary medical training. The semistructured nature of the interviews meant that a standardised set of questions (informed by existing literature on the NTS of medical students) was used to explore medical students' knowledge of NTS in acute care, with interviewers seeking clarification and examples when necessary.[34 35]

Each interview was transcribed verbatim. Meaningful phrases were independently coded by three researchers (ALH, JK, MAM) using a priori categories of NTS identified from the literature, as detailed in the left-hand column of table 1.[16 36] Discussions of coding differences between researchers (ALH, JK, MAM) led to refinement of the descriptions of each NTS category. A further miscellaneous category containing quotes from the transcripts was provided for expert panel review. The researchers (ALH, JK, MAM) felt that these quotes did not appropriately fit into any of the aforementioned a priori categories.

Designing the prototype marker system

Designing the tri-hierarchical BMS was a three-step process: defining the broad skills categories, identifying appropriate skill elements and describing observable behaviours.

A panel of six subject matter experts was convened to design a prototype BMS. The panel included clinicians from different medical specialties (acute medicine, anaesthesiology and nephrology) and individuals with experience in medical education, simulation training and the development of BMS used for other healthcare groups. The research supervisor (VRT) was a member of the expert panel; none of the researchers were panel members. A single 2½-hour focus group with the panel was hosted, with further correspondence via email. The panel meeting was recorded and documents annotated to justify and track categorisations and refinements. The prototype BMS was designed and refined as detailed below, using the design criteria defined in box 1.

First, 10 NTS categories and additional miscellaneous quotes were presented to the panel. These categories were rationalised

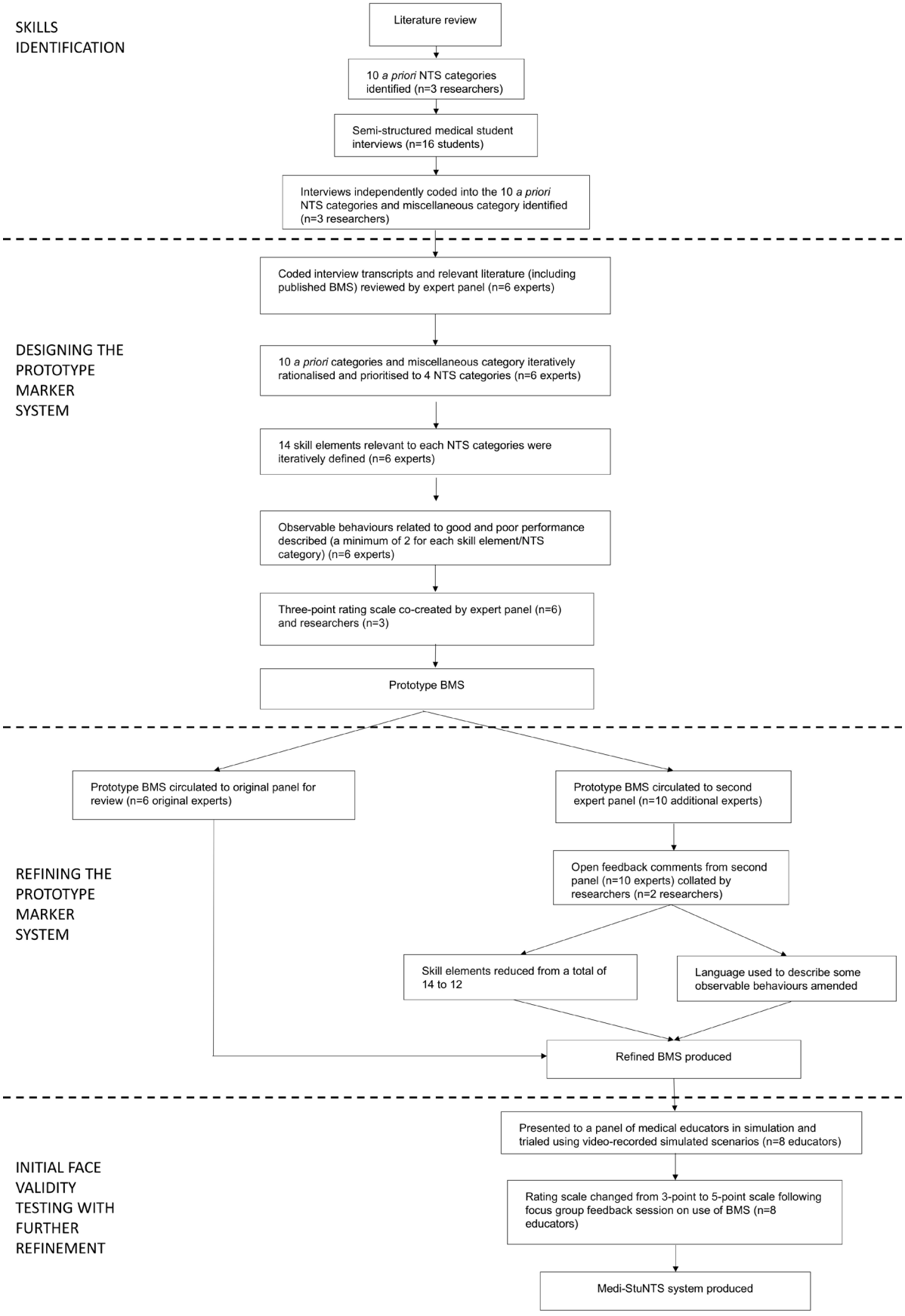

Figure 1 Flow chart illustrating methodology. BMS, behavioural marker system; Medi-StuNTS, Medical Students' Non-Technical Skills; NTS, non-technical skills.

Table 1 Exemplar quotes relating to each a priori category and the decision-making processes of the expert panel leading to the categories included in the prototype BMS

A priori category from the literature	Exemplar quote (student number)	Panel discussion notes The panel agreed that…	Included in prototype BMS as a…
INCLUDED IN THE FINAL BMS			
Communication	'…we talked about closed loop communication which is quite good, makes sure things were done because often things were just left in the open…' (S1)	Similar to previous BMS, this was deemed to be a crucial skill category. Its explicit inclusion as a category would enhance recognition and knowledge of desired behaviours and better prepare medical students to communicate effectively with colleagues and patients.	Skill category: teamwork and communication
Teamwork	'Teamwork's huge, and that's involving, like, having a role, knowing your role, communicating what you're achieving, what you're finding, communicating any problems you might have, delegating' (S6) 'Designating team roles…was really important as it just allowed things to get done a lot faster' (S1)	As communication was felt to be an integral part of teamworking, the two categories were combined.	Skill category: teamwork and communication
Situation awareness	'the recall kind of moments… they're really good for communication because it means that everyone stops, gets up to date with everything… there were a few points where I had no idea what's going on, and then when we did the recall, it kind of helped me to be like, ok, right, so this is what's happening and this is what we need to do and it just brings everything together…' (S14)	This is a key category for any NTS BMS as an awareness of what is happening and what it means is a prerequisite of safe patient care.	Skill category: situation awareness
Decision-making	'…making sure that you don't crumble under pressure … the pressured environment can mean that you change your decisions in a way that perhaps you shouldn't…' (S2)	Decisions to initiate management are intimately linked to the assessment of an unwell patient, and how the various components of the assessment are prioritised. Decision-making was, therefore, combined with prioritisation.	Skill category: decision-making and prioritisation
Coping with stress	'Keep calm under pressure. If you do find yourself quite pressured … take a moment, take a breath … equally tell colleagues if you think they're stressed or out of their depth … say … we'll go back to the beginning and start again.' (S9)	Although included in Flin *et al's* work on NTS,[1] there are insufficient skill elements applicable to medical students to form a broad skill category. Instead, coping with stress forms a skill element in the novel category of self-awareness.	Skill element in self-awareness category
Role awareness/awareness of limitations	'… delegation was done very well, everyone had a clear role, there weren't many points when people were like 'what am I meant to be doing?' (S7)	This is an important but challenging skill for medical students. Medical students' awareness of their role is linked to coping with stress and patient safety considerations. These skills were incorporated into the self-awareness category.	Skill element in self-awareness category
Miscellaneous	'Just to be confident that if something was wrong then you can say it and not just think that someone else will notice it.' (S5) '… accepting help and flagging up problems with the patients, and reiterating that problem if someone hadn't heard or hadn't taken it on board.' (S9)	Themes emerging from iterative review of the miscellaneous quotes related to the novel self-awareness category, particularly speaking up.	Skill category: self-awareness
Task management	'they deal with scenarios that you are going to deal with on the ward and you're dealing with it in real time … you don't actually have to do it so you don't appreciate how long things take …' (S2)	Referring to task management as a single entity could result in medical students failing to recognise the importance of prioritising other aspects of patient care. It should therefore be incorporated into the same category as prioritisation.	Skill category: decision-making and prioritisation
NOT INCLUDED IN THE FINAL BMS			
Leadership	'… when somebody stays at the end of the bed and says 'Right, let's stop, what's happened so far? What have we still got to do? What are we trying to do?' That shows good leadership and also lets everyone in the team know what's happening and allows them to feedback …they get the opportunity to discuss things and hopefully have a better outcome.' (S4)	In the simulated acute care environment, medical students are all of the same level of clinical experience and this skill is therefore less relevant than in other BMS. Instead, behaviours relating to followership are described in the teamwork and communication category.	N/A (not included)
Knowing your environment	"often you are being called to an environment you are not that particularly aware of, you don't necessarily know the other members of the team …' (S15)	Medical students are orientated to the simulated environment for which this BMS is designed.	N/A (not included)
Accepting responsibility	'Whereas now when you're dealing with scenarios you're taking leadership, you're taking ownership of your own investigations, interventions, management, history, examination, everything. And you're coming to a decision based on that. So it really makes you make those decisions to assess patients and what you're actually going to do …' (S9)	This is an important concept, but difficult to observe in medical students as they are not yet practising clinicians. In a simulated environment it may be, at times, difficult to replicate the true sense of clinical responsibility.	N/A (not included)

BMS, behavioural marker system; NTS, non-technical skills.

Box 1 Design criteria for the behavioural marker system (BMS)

The researchers and expert panel defined the design criteria as follows:

- To develop a BMS that would provide feedback on medical students' non-technical skills demonstrated during simulated acute care scenarios.
- The BMS should be straightforward enough to use with minimal training, that is, a focused discussion on using the system prior to a simulated scenario.
- The language of the BMS should use clear and consistent definitions and enable feedback, including peer-to-peer feedback, during facilitated debriefing.

and prioritised by the panel on the basis of the interview transcripts and literature, both of which had been summarised and categorised prior to the panel meeting. Second, through a similar iterative process using the interview transcripts, the panel defined the skill elements relevant to each of the skill categories that had been deemed highest priority during the first stage of the meeting. The third step, to define observable behaviours, was undertaken via email. The agreed skill categories and elements were emailed to the expert panel. The panel was asked to provide observable behaviours for each skill element to indicate good and poor performance of medical students in an acute care context. A minimum of two experts were allocated to each skill category.

During the final part of the process, the observable behaviours generated by the panel were collated by the researchers (ALH and JK). Through an iterative process, these behaviours were reviewed and refined by the expert panel (again via email) and researchers (ALH and JK) to produce a prototype BMS. The BMS was then circulated to the panel for review and comment.

Refining the prototype marker system

The prototype BMS, including the rating form, was circulated to a second panel of 10 different subject matter experts. This second expert panel included clinicians from different medical specialities (surgery, medicine, anaesthesia), individuals involved in medical education at three other Scottish medical schools and individuals with experience using BMS in other contexts. Members of this expert panel had not been involved in the design process of the BMS. Open comments were invited from all 10 members of the second panel, and these comments were used to further refine the BMS. The panel was asked to review the BMS specifically with regards to the content of the skill categories, choice of skill elements and observability of behaviours.

Initial face validity testing

The prototype BMS, including the rating form, was presented to a third panel of eight subject matter experts. This panel included physicians, medical educators and individuals involved in simulation at another Scottish medical school. This panel were given an hour long didactic lecture on the development and use of the BMS. The panel were shown pre-recorded simulated scenarios and asked to use the prototype BMS to rate the NTS behaviours of an individual medical students. Following this, written and focus group feedback were obtained by two researchers (ALH and JK).

RESULTS

Skills identification

Sixteen semistructured interviews were conducted between January and February 2016, each lasting between 5 and 20 min. From the 16 semistructured interviews conducted, it was clear that final year medical students had an awareness and understanding of some of the key NTS that contributed to the a priori categories, for example, teamwork, communication, leadership.

As stated above, the interview transcripts were coded into 10 NTS categories identified from the literature with an additional miscellaneous category containing data that did not appear to fit into one of the a priori categories. Table 1 details the 11 coding categories and provides exemplar verbatim quotes from the interview transcripts.

Designing the prototype marker system

Through the iterative process described above, the initial 11 NTS categories were reduced to four broad skill categories:

1. Situation awareness,
2. Teamwork and communication,
3. Decision-making and prioritisation,
4. Self-awareness (a novel category that was identified by the panel from the interview transcript coding—see table 1).

Table 1 describes the key decision-making processes by the panel that led to the final NTS categories being identified. A total of 14 skill elements were derived in relation to the four initial skill categories. Observable behaviours indicative of good and poor performance by medical students were generated by the panel as described above, with two or three behaviours associated with each skill element. This is shown in figure 2.

The theme of 'escalating care' of the unwell patient was noted by the expert panel during iterative review of the transcripts and existing literature. Escalation of care of an acutely unwell patient is an important process that junior staff should be able to perform safely and efficiently. The theme of escalating care did not fit into any of the a priori skill categories as the panel felt that many of the skill elements required for effective escalation of care traversed several skill categories. In order to acknowledge the importance and complexity of escalating care, the panel decided to add a fifth skill category describing observable behaviours relating to this process that corresponded to each of the other four skill categories contained within the BMS.

Refining the prototype marker system

As described above, initial face validity of the BMS was evaluated by a second panel of subject matter experts. The second expert panel agreed that there was an appropriate number of skill categories. However, the panel felt that more than three skill elements per category made the BMS too complicated, and two skill elements were therefore removed (one from teamwork and communication and one from decision-making and prioritisation). The name of one other skill element in the situation awareness category was amended to focus on the skills of planning and preparing. Overall, the panel felt that there were no significant omissions from the BMS. Following feedback from the second expert panel, some behaviours were modified to ensure that they were truly observable. Examples of the changes made at this stage are given in table 2.

Initial face validity testing

The panel felt that the BMS was easy to use following a brief introduction. The main feedback from members of the panel was in regard to the rating scale. A number of different scale formats

Figure 2 - Medi-StuNTS – Behavioural Marker System

	RATING DESCRIPTORS - It is recognised that not all skill elements will be observed during a single session. A 'not observed' rating is therefore available.			
1. Excellent performance. A positive example for others	2. Good performance. Overall a positive example, but some room for improvement.	3. Acceptable performance. Improvement is desirable.	4. Marginal performance. May impact upon patient safety, improvement required.	5. Poor performance. Threatens patient safety. Improvement is required.

	Skill Element	Positive Behaviours	Negative Behaviours
SITUATION AWARENESS	**Gathering information** - Seeking information about patient's condition, background & wishes from any available sources.	• Collates information from a structured clinical assessment to inform clinical situation. • Uses patient notes to aid clinical assessment. • Seeks information relating to previously expressed wishes.	• Misses important clinical information by using unstructured approach. • Take lengthy history despite a need for urgency. • Fails to seek additional info from other sources
	Recognising & understanding information - Collating information to develop an overall picture of the patient's current situation.	• Uses repeated structured assessments to identify significant change in patient's clinical condition. • Takes "time out" to summarise key findings & reflect on their significance. • Communicates clinical information in a structured format.	• Unstructured re-assessment results in failure to identify clinical change. • Does not respond or responds late to changes in patient condition. • Misinterprets significance of clinical information or trends.
	Planning, preparing & anticipating - Anticipating consequences of actions, & predicting potential outcomes.	• Verbalises expected course of clinical condition & anticipated effects of interventions. • Sources relevant equipment. • Appraises effectiveness of management plan.	• Waits for deterioration or problem to arise before taking action. • Emergency equipment is not available when required due to a lack of forward planning.
DECISION MAKING & PRIORITISATION	**Prioritising** - Deciding priorities of assessment, investigation & management.	• Uses a structured approach to prioritise clinical assessment. • Co-ordinates completion of tasks based on urgency & importance.	• Carries out review/ tasks in unstructured way. • Allows less important tasks to prevent/delay essential ones. • Fixates on individual tasks at the expense of overall patient management.
	Recognising & dealing with uncertainty - Considering differential diagnoses & acknowledging diagnostic uncertainty.	• Communicates multiple potential differential diagnoses. • Identifies a working diagnosis; communicates that this may change as other information becomes available. • Seeks evidence to confirm or refute working diagnosis.	• Remains fixed on single diagnosis despite conflicting clinical information. • Allows uncertainty to stall overall patient management.
	Reviewing decisions - Re-assessment of the patient in light of decisions made & actions taken.	• Re-assesses patient after intervention or treatment. • Uses strategies that facilitate appraisal of action taken & progress made • Alters management plan based on updated clinical assessments.	• Does not alter management plan in light of new clinical information or unexpected response to intervention. • Makes further clinical decisions without re-assessing the impact of prior decisions.
TEAMWORK & COMMUNICATION	**Establishing a shared mental model** - Communicating to facilitate a shared understanding between team members.	• Establishes a shared mental model by explicitly delineating the perceived situation. • Checks understanding of team members & invites questions. • Uses closed loop communication to verify task completion.	• Does not declare a clinical emergency. • Requests tasks without assigning a specific team member. • Requests clinical examinations or investigations without checking results.
	Demonstrating active followership - Proactive support of the leader & participation in team activities.	• Shows initiative by undertaking tasks without prompting. • Explicitly clarifies who is leading the team. • Offers suggestions to the leader to aid with decision making & task management.	• Does not take initiative to assist the leader when role is not defined. • Fails to update the leader when a clinical change has been observed.
	Patient involvement - Inclusion of the patient &/or their relatives within the team.	• Introduces self & addresses patient by their name. • Involves patient in decision-making, communicates decisions to patient & checks their understanding. • Acknowledges patient anxiety or distress.	• Fails to introduce self & explain role to patient. • Performs tasks or assessments on patient with no warning or explanation.
SELF AWARENESS	**Role awareness** - Understanding of role & responsibilities	• Communicates own role within the team to others. • Communicates division of responsibility in relation to individual tasks e.g. ensuring that venepuncture samples are both obtained & sent to the laboratory.	• Continues to try to manage a situation that exceeds own competence. • Fails to make team roles clear or changes roles within the team without discussion.
	Coping with stress - Minimising the impact of stress on the ability to perform effectively	• Utilises protocols/algorithms to reduce mental workload. • Articulates the impact of stress on own ability to synthesise information & make clear decisions. • Engages/recruits others who are less stressed to help with complex tasks.	• Displays emotional outburst as a result of stress. • Avoids communication with the team at times of stress. • Avoids making decisions at times of stress
	Speaking up - Communicating concerns regarding patient safety.	• Conveys the urgency of the situation when recruiting help from others. • Communicates critical information which may influence safety. • Challenges a colleague's behaviour or decision-making when a threat to patient safety is perceived.	• Accepts breaches of protocol that pose a risk to patient safety. • Does not acknowledge a concern regarding patient safety despite being aware of relevant clinical details.
ESCALATING CARE	**Situation Awareness**	• Ensures basic clinical info is available prior to escalating care. • Incorporates concerns in request for help from senior.	• Waits for inevitable deterioration before escalating care.
	Decision making & prioritisation	• Uses SBAR to clearly communicate clinical situation to senior & clarify the nature of the assistance requested. • Proactively seeks feedback from senior to validate decisions.	• Fails to obtain desired assistance from senior due to unclear or unstructured request. • Delays escalating care to wait for more results.
	Teamwork & Communication	• Prompts leader to consider escalating care at an apt time. • Communicates patient wishes to senior when known.	• Provides senior with inaccurate/'old' information. • Fails to relay key info regarding patient wishes.
	Self awareness	• Recognises own limits & calls for help from appropriate senior colleague. • Escalates care if stress significantly affecting ability to manage patient.	• Does not recognise limits of own competence & need for senior assistance. • Emotional state prevents clear communication to senior e.g. difficulty prioritising salient info.

Figure 2 Medi-StuNTS (Medical Students' Non-Technical Skills)—behavioural marker system. (SBAR - Situation; background; assessment; recommendation)

Table 2 Expert panel feedback: refining the prototype behavioural marker system

Initial observable behaviour	Feedback from expert panel	Amended observable behaviour
'Delegates complex tasks to other team members who are less stressed'	This could be interpreted as passing responsibility, rather than engaging or asking another member of the team who is less stressed. Perhaps rephrasing to reflect an active intention to recruit others to help might sound more positive.	'Engages or recruits others who are less stressed to help with complex tasks'
'Proactively communicates potential threats to patient safety'	Examples might be useful here, particularly if this is to be used for novice peer-to-peer feedback	'Proactively communicates potential threats to patient safety, for example, prompting prescription of drugs administered'
'Communicates diagnostic uncertainty with team members'	Medical students may not understand 'diagnostic uncertainty' as this could be interpreted as medical jargon. Perhaps rephrasing to acknowledge a working diagnosis may be a more positive example for medical students.	'Identifies a working diagnosis but communicates how this may change as additional information becomes available'

can be used to rate observed behaviour.[10–12 16] Having reviewed the initial 3-point rating scale and those used in existing BMS, the rating scale was amended to a 5-point rating system (as illustrated in figure 3). A 5-point rating system was chosen as this fitted with the design criteria shown in box 1 and was felt by the panel to enable a more robust reflection of student performance.

DISCUSSION

The Medi-StuNTS BMS has been designed to allow both peer-to-peer and tutor-to-student feedback in a formative setting. The Medi-StuNTS system defines key NTS and provides observable behaviours indicative of good and poor performance relating to the assessment and initial management of an acutely unwell patient. To our knowledge, this is the first attempt to define the NTS, and related observable behaviours, specifically relevant to medical students at an individual level. The observable behaviours described in the Medi-StuNTS system are designed to enable medical students to recognise key NTS while undertaking or observing an acute care simulation, and reflect on their relationship with patient outcomes. It provides an exciting opportunity for medical students to obtain a deeper understanding of NTS, and to translate this into practice when they begin work as newly qualified doctors.

There are a number of BMS in use within the healthcare sector. The Anaesthetists' Non-Technical Skills taxonomy has been validated, is endorsed by the Royal College of Anaesthetists and has been integrated into the UK anaesthetic training curriculum.[37 38] Similarly, the NOTSS system has been incorporated into the UK surgical curriculum with the subsequent development of both online workshops and masterclass learning designed to facilitate training of NTS in the operating environment.[18] With these BMS already integrated into UK specialist training pathways, a precedent is set to enable a BMS for primary medical training to be integrated into the outcomes for graduates defined by the GMC.[39]

BMS are designed to help users recognise the behaviours associated with good and poor performance. To ensure that only the most relevant NTS categories, elements and behaviours were included in the prototype BMS, some skill categories were merged. Communication was not included as a skill category in the European taxonomy of pilots' non-technical skills or some other BMS developed for doctors.[9 10 12] The authors of these studies felt that communication was inherent to all categories. Similar to the scrub practitioners' system, the Medi-StuNTS system has merged teamwork and communication into a single skill category.[14] Other work suggests that newly qualified doctors are better prepared for patient communication than communication with colleagues.[40 41] The panel felt that, in light of this existing evidence, explicitly including communication as part of a skill category would enhance recognition and knowledge of desired behaviours and better prepare medical students to communicate effectively with colleagues and patients.

The novel category self-awareness was derived to incorporate the skill elements of role awareness, coping with stress and speaking up. The ability of health professionals to communicate when the demands of their role or the clinical situation is overly taxing is of paramount importance, as it can influence the safety of patients. Incorporating coping with stress and speaking up as skill elements in the category of self-awareness encourages medical students to recognise and reflect on behaviours that may be exhibited in a stressful environment. Furthermore, it allows facilitated discussion relating to how the impact of stress can be minimised. This builds on previous work in which newly qualified doctors described difficulties associated with uncertainty of their role and taking responsibility for the first time.[42 43] Including role awareness in the Medi-StuNTS system provides an opportunity for medical students to discuss their role within the team or particular clinical context, and the responsibilities that it conveys.

Consistent with other BMS in use in healthcare, situation awareness was included as a broad category.[10–12 16] Interestingly, although medical students could recognise the phrase 'situation awareness', their knowledge and understanding was limited. Decision-making and prioritisation are complex processes that medical students often have difficulty mastering.[44] McGregor *et al* report subjective improvement in these skills through the use of a clinical decision-making tool in a simulated ward environment.[44] The skill elements incorporated into the situation awareness category of the Medi-StuNTS system reflect Endsley's theory of situation awareness, with the three skill elements mirroring the levels of situation awareness: collation of information, comprehension of the information and construction of a mental model with the information.[45] When managing acutely unwell patients, situation awareness, prioritisation and decision-making are inherently linked. An inexperienced doctor/medical student could be given the same observations/assessment but, due to lack of experience or knowledge, fails to comprehend the situation appropriately. Consequently, they do not prioritise efficiently, call for help appropriately or could select an inappropriate management strategy. Medical students should be taught the skills to undertake these complex cognitive and social tasks to aid clinical decision-making. Distinguishing situation awareness as a broad skill category and one's role within the team in the skill element role awareness encourages medical students to recognise and reflect on the 'external situation' in addition to their role within that situation and how they may be linked. The Medi-StuNTS system enables educators to be specific in

Rating Form

Skill Category	Skill Element	Behaviours Observed	Element Rating (1,2,3,4, 5 or not observed)	Category Rating (1,2,3,4, 5 or not observed)
Situation Awareness	Gathering information			
	Recognising & understanding information			
	Planning, preparing and anticipating			
Decision Making & Prioritisation	Prioritising			
	Recognising & dealing with uncertainty			
	Reviewing decisions			
Teamwork & Communication	Establishing a shared mental model			
	Demonstrating active followership			
	Patient involvement			
Self Awareness	Role awareness			
	Coping with stress			
	Speaking up			
Escalating Care	Situation Awareness			
	Decision making & prioritisation			
	Teamwork & Communication			
	Self awareness			

Rating Descriptors:

1. Excellent performance. Only positive behaviours observed.
2. Good performance. Positive behaviours observed but some room for improvement.
3. Acceptable performance. Mainly positive behaviours but improvement desirable.
4. Marginal performance. Lack of positive behaviours or mainly negative behaviours observed.
5. Poor performance. Only negative behaviours observed. Improvement required.

It is recognised that not all skill elements will be observed during a single session. A 'not observed' rating is therefore available.

Figure 3 Rating form for the Medi-StuNTS (Medical Students' Non-Technical Skills) system.

their feedback to students. This will not only improve students' understanding of the NTS relevant to the care of acutely unwell patients but also allow them to become familiar with the terminology of NTS and reflect on their personal strengths and weaknesses. Such individualised, contextualised feedback on performance is perhaps the holy grail of UK primary medical training.

Limitations

We have described the development of a novel BMS to provide feedback on the NTS of medical students. The methodology was adopted and modified to use a reflective, semistructured interview approach as the researchers felt medical students would not have had sufficient exposure to critical incidents to use this technique in a meaningful way. This study employed a cohort from a single medical school, and the results may therefore not be relevant to other training contexts. For this reason, the initial validation described in this study incorporated experts from three other Scottish medical schools. Furthermore, future validation studies will involve students from other medical schools in significantly larger numbers. The development of the BMS was based on interviews with medical students only, and it may be that a broader picture of NTS would have been obtained if healthcare providers and medical educators had also been interviewed.

As with all studies that use volunteers for interviews, there may have been individuals with particularly strong views or negative experiences. The researchers (ALH, JK, MAM) have all been medical students and newly qualified doctors within the past few years. The researchers were medical students at three different universities and undertook their foundation training in three different UK foundation schools. These experiences, both positive and negative, are likely to have impacted on both data collection and analysis. The prototype BMS therefore reflects the opinions and experiences of the participants, researchers and members of all expert panels.

Future work

This work opens up exciting opportunities for additional research, including further testing and validation of the BMS in simulated acute care contexts, and development of its utility for feedback including peer-to-peer feedback.

CONCLUSIONS

This paper describes the preliminary development of the Medi-StuNTS system through literature review, semistructured interviews and three expert panel reviews. This is the first BMS specifically designed to focus on the NTS of medical students. It provides an exciting opportunity to provide meaningful, individualised feedback to students and may ultimately help their preparedness as they transitioned to professional practice.

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