RESEARCH ARTICLE

Re-evaluating the factor structure of the Tolerance of Ambiguity of Medical Students And Doctors (TAMSAD) scale in newly qualified doctors [version 1; peer review: awaiting peer review]

Jason Hancock[1,2], Obioha C Ukoumunne[3], Karen Mattick[4], Thomas Gale[5], Bryan Burford[6]

[1]Consultant Psychiatrist, Devon Partnership NHS Trust, Exeter, England, UK
[2]Honorary Clinical Associate Professor, Health Professionals Education and Wellbeing Research Group, Department of Health and Community Sciences, Faculty of Health and Life Sciences, University of Exeter, Exeter, UK
[3]Professor in Medical Statistics, NIHR Applied Research Collaboration South West Peninsula (PenARC), Department of Health and Community Sciences, Faculty of Health and Life Sciences, University of Exeter, Exeter, UK
[4]Professor in Medical Education, Health Professionals Education and Wellbeing Research Group, Department of Health and Community Sciences, Faculty of Health and Life Sciences, University of Exeter, Exeter, UK
[5]Professor of Medical Education, Peninsula Medical School, University of Plymouth Faculty of Medicine and Dentistry, Plymouth, UK
[6]Senior Lecturer, School of Medicine, Newcastle University, Newcastle upon Tyne, England, UK

v1 **First published:** 20 Mar 2024, **14**:16
https://doi.org/10.12688/mep.20132.1
Latest published: 20 Mar 2024, **14**:16
https://doi.org/10.12688/mep.20132.1

Abstract

Background

Ambiguity and uncertainty are inherent within the practice of medicine. While theory suggests the construct may be multidimensional, scales such as the Tolerance of Ambiguity of Medical Students And Doctors (TAMSAD) act unidimensionally, at least in a local population. Therefore, the dimensionality of the Tolerance of Ambiguity (ToA) construct remains unclear. This study aims to explore the dimensionality of ToA in early postgraduate doctors using the TAMSAD scale in a UK national sample and consider the implications of this dimensionality for theory and practice.

Methods

We used data from 428 respondents in a national research project examining the experiences of newly qualified doctors in the UK (2020). We undertook an exploratory factor analysis (extracting one-factor to

Open Peer Review

Approval Status *AWAITING PEER REVIEW*

Any reports and responses or comments on the article can be found at the end of the article.

six-factor solutions) of the 29-item TAMSAD scale and compared findings to an existing integrative model of uncertainty tolerance.

Results

The analysis suggested that the ToA construct is multidimensional. The three-factor model and five-factor model provided clinically interpretable factors and had different merits. It appears that having an affinity for complexity is not simply the opposite of experiencing discomfort from uncertainty, and that a professional's epistemological beliefs about the nature of medicine may influence their ToA.

Conclusions

These findings support an extension to a key integrative model of uncertainty tolerance, and support development of interventions to increase ToA in doctors. For example, through encouraging increased reflection on an individual's own epistemological beliefs about medicine and the role of doctors. The potential impact of such interventions can be evaluated using scales such as the TAMSAD.

Keywords
Ambiguity, uncertainty, uncertainty tolerance, tolerance of ambiguity, psychometric scale development, wellbeing

Corresponding author: Jason Hancock (j.hancock2@exeter.ac.uk)

Author roles: Hancock J: Conceptualization, Methodology, Project Administration, Validation, Visualization, Writing – Original Draft Preparation, Writing – Review & Editing; **Ukoumunne OC**: Formal Analysis, Investigation, Methodology, Visualization, Writing – Original Draft Preparation, Writing – Review & Editing; **Mattick K**: Conceptualization, Funding Acquisition, Methodology, Resources, Supervision, Validation, Visualization, Writing – Review & Editing; **Gale T**: Funding Acquisition, Resources, Validation, Writing – Review & Editing; **Burford B**: Conceptualization, Data Curation, Formal Analysis, Funding Acquisition, Investigation, Methodology, Resources, Supervision, Validation, Writing – Review & Editing

Competing interests: No competing interests were disclosed.

Grant information: This secondary analysis study received no funding. The data used within this study was collected as part of a previous study funded by the General Medical Council UK (Ref GMC1263).
The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

How to cite this article: Hancock J, Ukoumunne OC, Mattick K *et al.* **Re-evaluating the factor structure of the Tolerance of Ambiguity of Medical Students And Doctors (TAMSAD) scale in newly qualified doctors [version 1; peer review: awaiting peer review]** MedEdPublish 2024, **14**:16 https://doi.org/10.12688/mep.20132.1

First published: 20 Mar 2024, **14**:16 https://doi.org/10.12688/mep.20132.1

Introduction

The practice of medicine involves inherent ambiguity, which may arise from a range of sources including limitations of knowledge, diagnostic problems, ambiguities of treatment and outcome, and patient response[1].

An inability to tolerate ambiguity and the subsequent uncertainty have been associated with poorer outcomes for clinicians including reduced psychological well-being[2], and poorer outcomes for patients, including higher levels of psychological distress and avoidant coping behaviours[3]. Given the prevalence of ambiguity and uncertainty within medicine, an ability to tolerate these closely related constructs is a desirable quality for a newly qualified doctor; indeed, an ability to recognise and manage clinical uncertainty is included within the General Medical Council's (GMC) "Outcomes for Graduates" in the UK[4].

Quantifying clinicians' tolerance of ambiguity (ToA) is important to allow identification of associated variables, assess impact of low ToA, and ultimately develop and, potentially, evaluate interventions to enhance ToA. In order to support this research field and improve conceptual clarity around this important construct we (first and third author with other researchers) developed the Tolerance of Ambiguity of Medical Students And Doctors (TAMSAD) scale[5]. This new scale was needed because existing scales either did not contain clinically contextualised items, did not have a sufficient number and range of items to be sensitive to subtle changes, were not open to the possibility that ToA may be a multidimensional construct, or did not demonstrate good evidence of validity[1,5–9].

We considered it important for ToA scales to be open to the possibility that it is a multidimensional construct following consideration of personal epistemologies, *i.e.* the philosophy of what it is to 'know'. Earlier models of personal epistemologies suggest that constructs such as ToA may be unidimensional and develop in a linear fashion[10]. However more recent models challenge this view instead suggesting that constructs such as ToA could have multiple dimensions that develop and change in individuals at different rates depending on many factors including contextual exposure[11].

For our original study, we defined ambiguity as the "*stimulus*" and used Greco and Roger's definition of uncertainty as the "*response to an ambiguous situation*"[12]. The final scale as reported consisted of 29 items and, despite our initial hypothesis, the internal structure appeared to be unidimensional in the local population of medical students and early postgraduate doctors studied[5]. We argued at the time that there is strong validity evidence for the use of this scale in this population[5].

Following publication, the TAMSAD scale was included by Hillen *et al.*[13] in a narrative review and conceptual analysis resulting in the integrative model of uncertainty tolerance. This model proposes that ambiguity is one of the stimuli that can result in an experience of uncertainty within an individual, which may then be associated with positive or negative cognitive, behavioural or emotional responses. The model also suggests potential moderators of the relationship between an ambiguity stimulus and an uncertainty response, however these remain intentionally broad and ill defined, for example "individual characteristics". The model can be used by researchers approaching ToA as either a static trait or a dynamic state. However, the evidence is strengthening that ToA should be considered a dynamic state that can be modified, for example by educational interventions[14]. The Hillen model does not provide any insights into the dimensionality of the construct of ToA. It does however suggest that the TAMSAD scale may be examining a range of related and overlapping constructs, such as impermanence, incompleteness, indefiniteness, insolubility, non-transparency and unfamiliarity[13].

A number of researchers have subsequently made use of the TAMSAD scale in a range of published studies[15–18] and it has so far been translated into three languages[19]. The scale has also been modified by various authors to tailor it to their specific context and the internal structure has been investigated in different clinical education settings[11]. In a study with veterinary students for example, the final 27-item Tolerance of Ambiguity of Veterinary Students (TAVS) scale was found to be acting in a unidimensional way, but with four identified 'facets' ("*Novice view", "Discomfort from uncertainty", "Affinity for complexity" and "Accepting indeterminacy"*)[20]. In addition, Wilson *et al.*[21] found that in a population of 102 Australian medical students from one university the TAMSAD scale was not acting unidimensionally, concluding that the measure may be complex and multi-faceted.

We propose that based on theory related to personal epistemologies[11] and recent research utilising the TAMSAD we should remain open to the possibility that ToA may be a multidimensional construct, in contrast to earlier indications based on data collected in a single site.

If we were able to better understand the internal structure of the TAMSAD scale, specifically whether it is examining a unidimensional or a multidimensional construct with definable factors, then this would provide useful insights into the construct of ToA, allowing refinement of existing theoretical models. In addition, if the construct were multidimensional and we were to identify different dimensions, this could provide specific targets for medical education interventions aiming to enhance ToA in early career doctors, and in turn improve outcomes for clinicians and patients.

Therefore, we set out to answer the following research questions:

1. What is the dimensionality of the ToA construct in early postgraduate doctors using the TAMSAD scale in a UK national sample of newly qualified doctors?

2. What are the implications of this dimensionality for theory and practice?

Methods

The aims of this study were to evaluate the dimensionality of the TAMSAD scale in a national early postgraduate population of doctors and consider the implications of the dimensionality for theory and practice.

Ethics approval

Ethical approval was obtained on the 28/4/20 following review by the Newcastle University Faculty of Medical Sciences Research Ethics Committee (ref 1910/2410). Informed consent was obtained from participants through providing them with an information sheet about the project alongside a link to an online sign up form. When completing this form, participants were asked to provide a contact e-mail address in order that questionnaires could be sent to them in subsequent phases of the research. This information sheet included information about the use of the participant's anonymised data. This process for obtaining consent was approved by the ethics committee.

Participants and recruitment

In May to July 2020, due to the COVID-19 pandemic, final year medical students in some UK medical schools were able to graduate early, gain provisional registration with the GMC, and start work in a novel role known as Foundation Interim Year 1 posts (FiY1).

FiY1s worked across a range of clinical environments, with the majority of these involving exposure to patients with COVID-19. However, the composition of FiY1s work was comparable to that of traditional postgraduate Foundation year 1 (F1) roles[22]. Full details of the wider project methods are available in the full project report[22]. Participants were initially invited to sign up to the study from early May 2020, with an email cascaded to all Final Year medical students across the UK with the support of the Medical Schools Council (MSC), UK Foundation Programme Office (UKFPO), Health Education England, NHS Education for Scotland, Health Education and Improvement Wales and the Northern Ireland Medical and Dental Training Agency. Sign up links were also shared on Twitter by the MSC, UKFPO, and GMC. Participants who had agreed to take part were then contacted again in June and July up to three times to ask them to consider completing an online questionnaire survey as outlined below.

Study design

The data for the analysis came from a large national mixed methods research project, which aimed to examine the experiences of newly qualified doctors in the UK[22]. Questionnaires comprised a battery of scales and items relevant to work and well-being, including the perceived stress scale (PSS)[23], the Hospital Anxiety and Depression Scale (HADS)[24], the work and personal burnout subscales of the Copenhagen Burnout Inventory[25], and the TAMSAD[5].

This manuscript focusses solely on the TAMSAD scale. It is the first time TAMSAD has been used in a national sample of early career doctors. Sampling bias was mitigated by repeated reminders through different channels. No *a priori* power analysis conducted, as this was a convenience sample.

Data collection

The 29-item TAMSAD scale[5,26] was completed online, as part of the battery of items mentioned above. All items were written as statements with which respondents were asked to indicate their position on a five-point Likert scale: strongly disagree (1), disagree (2), neutral (3), agree (4), strongly agree (5). If items were negatively worded, then they were reverse coded prior to analysis such that higher scores on items always indicate higher levels of ToA in participants.

Data analysis

We only included participants in the factor analysis if they responded to all the TAMSAD items. As the dimensionality of ToA construct remains unclear we undertook an exploratory factor analysis of the data arising from the use of the 29-item TAMSAD scale[26]. As the items are ordinal (categorical), models were fitted using robust weighted least squares estimation (WLSMV). Parallel analysis[27] based on simulated data across 10 replications was used to identify the maximum number of factors that should be considered for extraction. Both the model estimation and application of the parallel method were based on the polychoric correlations between the TAMSAD items. For analyses with more than one factor the exploratory factor analysis solution was rotated using an oblique rotation method (geomin). The number of factors that best describes the data was decided based on the interpretability of the factors (factor loadings greater than 0.4 were considered salient) and goodness of fit indices. For each model we report the root mean square error of approximation (RMSEA – values close to or below 0.06 are indicative of good fit), the comparative fit index (CFI – values close to or above 0.95 are indicative of good fit), the Tucker-Lewis index (TLI – values close to or above 0.95 are indicative of good fit) and the standardised root mean square residual (SRMR – values close to or below 0.06 are indicative of good fit)[28].

Mplus version 8 software was used to fit the exploratory factor analysis models and *Stata* version 17 software was used for the parallel analysis.

The initial data collection and analysis was completed by a team led by the fifth author, with the exploratory factor analysis being conducted by second author. The whole research team reviewed the exploratory factor analysis statistical output independently to consider the interpretability of the factors in the fitted models. The research team then met twice (5/5/22 & 8/6/22) to discuss factor interpretability and descriptive titles for each of the factors included within the final models, where possible.

The research team consisted of medical education researchers with a range of quantitative and qualitative methodological experience, theoretical perspectives and expertise. This team included one statistician (second author), and two practising senior clinicians (first and fourth author). The team's differing theoretical perspectives were brought to bear in the analysis meetings, where differing interpretations were shared, and team members challenged each other's' thinking. Overall, the team took a pragmatic theoretical approach ensuring that the

research methods were selected to answer the research questions, with an inductive approach used to support interpretation of the quantitative output produced by the factor analysis.

Results

Sample

428 participants completed all 29 items of the TAMSAD and were included in the analyses in this paper. With 4662 FiY1 posts filled at some point between April and June, this represents approximately 9% of all FiY1s. Basic demographics of participants are included in Table 1.

Factor analysis

The correlations between items were generally not large. Of the 406 inter-item polychoric correlation coefficients only 5 were above 0.4 and the largest one was 0.57. Parallel analysis indicated that no more than six factors should be extracted in the factor analysis. Consequently, we fitted models for one- to six-factor solutions. The goodness of fit statistics are reported in Table 2. The results for the RMSEA and SRMR (both of which quantify the absolute fit of the models) indicate that only models with at least three factors have an acceptable fit. This provided us with initial evidence that TAMSAD scale is measuring a multidimensional, rather than a unidimensional construct as previously reported. The CFI and TLI, however, indicate that none of the models provide marked improvements in fit relative to the null (baseline) model that assumes no correlation amongst the items. A possible reason for the poor relative fit is that the correlations amongst the items, even amongst those loaded on by the same factor, are generally not very large and thus the fit of the null model is already closer to the best fitting model than it would be for scenarios where the correlations are large.

Beyond statistical fit, the utility of a solution is determined by the extent to which derived factors can be meaningfully interpreted and labelled. In the following section we consider this.

Interpreting the factors within the proposed models

Different solutions indicated different interpretations of the potential factors comprising the scale. We considered all candidate solutions and found most to have some potential value in understanding the overarching construct.

Table 1. Basic demographic details of respondents. This table describes the demographic details of the 428 respondents.

		N (%)
Gender	Female	278 (65%)
	Male	145 (34%)
	Other	1 (<1%)
	Unknown	4 (<1%)
Age group	< 25	275 (64%)
	25–30	138 (32%)
	> 30	13 (3%)
	Unknown	2 (1%)
Ethnicity	White	325 (76%)
	Black	11 (3%)
	South Asian	31 (7%)
	East Asian	19 (4%)
	Unspecified Asian	17 (4%)
	Middle Eastern	2 (<1%)
	Unspecified Other	2 (<1%)
	Not given	21 (5%)
Disability	None	401 (94%)
'Are your day-to-day activities limited because of a health problem or disability which has lasted, or is expected to last, at least 12 months?'	Yes, a little	7 (2%)
	Yes, a lot	
	Unknown	20 (5%)

Table 2. The goodness of fit statistics. This table outlines the goodness of fit statistics for each of the models for the proposed one- to six-factor solutions. RMSEA = Root mean square error of approximation, CFI = Comparative fit index, TLI = Tucker-Lewis index, SMSR = Standardised root mean square residual.

Model	Chi-squared test of model fit: statistic (df); p-value	RMSEA (95% CI)	CFI	TLI	SMSR
1 factor	1544.2 (377); <0.001	0.085 (0.081 to 0.089)	0.514	0.477	0.100
2 factors	1044.0 (349); <0.001	0.068 (0.063 to 0.073)	0.711	0.663	0.076
3 factors	745.9 (322); <0.001	0.055 (0.050 to 0.061)	0.824	0.777	0.060
4 factors	591.9 (296); <0.001	0.048 (0.043 to 0.054)	0.877	0.831	0.050
5 factors	501.5 (271); <0.001	0.045 (0.038 to 0.051)	0.904	0.856	0.044
6 factors	433.8 (247); <0.001	0.042 (0.035 to 0.049)	0.922	0.872	0.040

While the one-, two-, four- and six-factor models contained some factors that appeared to be interpretable, many of the potential factors were not and so these models were rejected.

Here we consider the three- and five-factor solutions in detail, with a view not to establishing a definitive structure, but exploring the potential explanatory value of each. The intention is to use this process to develop our understanding of the overarching ToA construct, use these findings to refine existing theoretical models, and provide targets for medical education interventions. Table 3 summarises the items included in each labelled factor within the proposed three- and five-factor solutions including the associated Cronbach's alpha. Factor loadings for individual items within both the three-factor and five-factor models are included in Table 4.

In the three-factor model (Table 3), factor one (M3-F1) contained six items with individual item loadings of > 0.4, M3-F2 contained six items and M3-F3 contained five items. We labelled M3-F1 as "*Discomfort from uncertainty*", reflecting a negative affective response to uncertainty. M3-F2 as "*Doctors should be clear (and medicine is clear)*", reflecting a perception of certainty within medicine and M3-F3 as "*Affinity for complexity*" with items reflecting positive affect in the face of complexity.

In the five-factor model (Table 3), factor one (M5-F1) contained two items with individual item loadings greater than 0.4, M5-F2 contained six items, M5-F3 contained four items, M5-F4 contained three items, and M5-F5 contained three items. Following much debate, M5-F1 was provisionally named *"Desire for clear and definite working environments"*. This factor appeared to reflect a desire for career simplicity, potentially related to what participants admire in other doctors or related to a desire to be in control in working environments. M5-F2 was named *"Discomfort from uncertainty*". M5-F3 was named "*Affinity for complexity*". M5-F4 was named "*The mystery of medicine*" reflecting a positive affective and cognitive response to the beauty and mystery that can be present within medicine. M5-F5 was named "*Medicine is clear*" reflecting a perception of certainty within medicine.

The factor "*Discomfort from Uncertainty"* was identified in the three-factor, four-factor, five-factor and six-factor models. Items within this factor explore feelings of discomfort, frustration, and apprehension in response to clinical uncertainty, with five of the six items using ambiguity as the stimulus of uncertainty. This includes: "insufficient information", "lack of medical knowledge", "incorrect information", "contradictory evidence", and "can't find the answer".

The factor "*Affinity for complexity"* was identified in the two-factor, three-factor, four-factor, five-factor and six-factor models, with affinity relating to "enjoyment", "interest", and "challenge" in the face of complexity (including "patients with multiple diseases" and "complicated clinical cases"). It appears that having affinity for complexity is not simply the opposite of experiencing discomfort from uncertainty, as otherwise they would not have been consistently identified as different factors across multiple models.

Discussion

The aims of this study were to evaluate the dimensionality of the TAMSAD scale in a national early postgraduate (FiY1) population of doctors and consider the implications of the dimensionality for theory and practice. The presence of at least two models that produce interpretable and distinct factors, the three- and five- factor models provide strong evidence that the construct measured by TAMSAD scale is multidimensional. Both of the identified solutions have merit, and the factors that are identified across the models provide useful insights into the construct of ToA. Having Affinity for complexity is not simply the opposite of experiencing Discomfort from uncertainty. The factor "*The mystery of medicine"* suggests that for some first-year postgraduate doctors in training it can be appealing, even pleasurable, to encounter mystery or uncertainty within medicine.

Table 3. Summary of proposed factors identified from exploratory factor analysis. This table outlines the proposed three- and five-factor solutions. For each factor within these two proposed solutions, a description of the factor, number of items, details of the items and the Cronbach's alpha (α) are included.

Three-factor model			
Factor	**Number of items**	**Items**	**Internal consistency of subscale (α)**
1.Discomfort from Uncertainty [M3-F1]	6	I feel uncomfortable knowing that many of our most important clinical decisions are based upon insufficient information I am uncomfortable that a lack of medical knowledge about some diseases means we can't help some patients I feel uncomfortable when textbooks or experts are factually incorrect Being confronted with contradictory evidence in clinical practice makes me feel uncomfortable I find it frustrating when I can't find the answer to a clinical question I am apprehensive when faced with a new clinical situation or problem	0.61
2.Doctors should be clear (and medicine is clear) [M3-F2]	6	No matter how complicated the situation, a good doctor will be able to arrive at a yes or no answer To me, medicine is black and white A good job is one where what is to be done and how it is to be done are always clear I think in medicine it is important to know exactly what you are talking about at all times It is important to appear knowledgeable to patients at all times What we are used to is always preferable to what is unfamiliar	0.60
3.Affinity for complexity [M3-F3]	5	I enjoy the process of working with a complex clinical problem and making it more manageable It is more interesting to tackle a complicated clinical problem that to solve a simple one I like the challenge of being thrown in the deep end with different medical situations I would enjoy tailoring treatments to individual patient problems A patient with multiple diseases would make a doctor's job more interesting	0.62
Five factor model			
Factor	**Number of scale items**	**Items**	**Internal consistency of subscale (α)**
1. Desire for clear and definite working environments [M5-F1]	2	I have a lot of respect for consultants who always come up with a definite answer A doctor who leads an even, regular work life with few surprises, really has a lot to be grateful for	0.43
2.Discomfort from Uncertainty [M5-F2]	6	I feel uncomfortable knowing that many of our most important clinical decisions are based upon insufficient information I feel uncomfortable when textbooks or experts are factually incorrect I find it frustrating when I can't find the answer to a clinical question Being confronted with contradictory evidence in clinical practice makes me feel uncomfortable Variation between individual patients is a frustrating aspect of medicine I am uncomfortable that a lack of medical knowledge about some diseases means we can't help some patients	0.64
3.Affinity for complexity [M5-F3]	4	A patient with multiple diseases would make a doctor's job more interesting It is more interesting to tackle a complicated clinical problem that to solve a simple one I like the challenge of being thrown in the deep end with different medical situations I enjoy the process of working with a complex clinical problem and making it more manageable	0.64
4.The mystery of medicine [M5-F4]	3	I feel comfortable that in medicine there is often no right or wrong answer I like the mystery that there are some things in medicine we'll never know The beauty of medicine is that it's always evolving and changing	0.51
5.Medicine is clear [M5-F5]	3	To me, medicine is black and white There is really no such thing as a clinical problem that can't be solved No matter how complicated the situation, a good doctor will be able to arrive at a yes or no answer	0.41

MedEdPublish 2024, 14:16 Last updated: 29 MAR 2024

Table 4. Factor loadings from the three- and five-factor models. This table shows the factor loadings for individual items within both the three-factor and five-factor models. A darker shading indicates a factor loading for an individual item of > 0.4.

#	Statement	3-factor model			5-factor model				
		F1	F2	F3	F1	F2	F3	F4	F5
19	I feel uncomfortable knowing that many of our most important clinical decisions are based upon insufficient information*	0.561	-0.012	-0.149	-0.035	0.610	0.005	-0.091	0.002
11	I am uncomfortable that a lack of medical knowledge about some diseases means we can't help some patients*	0.540	-0.092	-0.228	-0.062	0.555	-0.155	0.001	-0.064
21	I feel uncomfortable when textbooks or experts are factually incorrect*	0.508	0.019	-0.340	0.011	0.594	-0.187	-0.089	0.077
14	Being confronted with contradictory evidence in clinical practice makes me feel uncomfortable*	0.486	0.228	0.015	0.130	0.471	0.216	-0.012	0.034
17	I find it frustrating when I can't find the answer to a clinical question*	0.486	0.182	-0.073	0.149	0.416	0.042	0.128	-0.052
16	Variation between individual patients is a frustrating aspect of medicine*	0.384	0.392	0.062	0.034	0.414	0.258	0.072	0.271
18	I am apprehensive when faced with a new clinical situation or problem*	0.409	0.032	0.280	0.04	0.306	0.365	0.02	-0.207
8	I think in medicine it is important to know exactly what you are talking about at all times*	0.240	0.498	-0.195	0.300	0.228	-0.009	0.149	0.256
20	No matter how complicated the situation, a good doctor will be able to arrive at a yes or no answer*	-0.009	0.541	-0.144	0.175	0.104	0.078	-0.015	0.525
27	To me, medicine is black and white*	-0.057	0.528	0.103	-0.042	-0.068	0.105	0.359	0.483
22	There is really no such thing as a clinical problem that can't be solved*	-0.097	0.323	-0.136	-0.028	0.03	-0.036	0.001	0.480
26	A good job is one where what is to be done and how it is to be done are always clear*	0.200	0.514	-0.008	0.379	0.145	0.220	0.082	0.161
13	It is important to appear knowledgeable to patients at all times*	0.134	0.405	-0.280	0.275	0.142	-0.140	0.125	0.237
5	What we are used to is always preferable to what is unfamiliar*	0.167	0.403	-0.01	0.326	0.099	0.158	0.098	0.084
1	I would enjoy tailoring treatments to individual patient problems	0.015	0.097	0.439	-0.393	-0.002	0.335	0.230	0.194
25	I enjoy the process of working with a complex clinical problem and making it more manageable	0.03	0.159	0.676	-0.134	0.004	0.746	-0.07	0.038
24	It is more interesting to tackle a complicated clinical problem that to solve a simple one	-0.026	0.131	0.655	0.004	-0.03	0.885	-0.325	-0.004
23	I like the challenge of being thrown in the deep end with different medical situations	0.368	-0.028	0.538	-0.007	0.190	0.572	0.065	-0.348
10	A patient with multiple diseases would make a doctor's job more interesting	-0.033	0.299	0.429	0.131	-0.103	0.538	0.007	0.04
7	A doctor who leads an even, regular work life with few surprises, really has a lot to be grateful for*	0.062	0.337	-0.084	0.548	-0.027	0.12	-0.038	-0.073
2	I have a lot of respect for consultants who always come up with a definite answer*	-0.051	0.385	-0.257	0.690	-0.15	-0.043	-0.041	-0.01
9	I feel comfortable that in medicine there is often no right or wrong answer	0.243	0.329	0.092	0.103	0.043	-0.015	0.570	-0.011
15	I like the mystery that there are some things in medicine we'll never know	0.366	0.208	0.043	0.018	0.227	-0.015	0.422	-0.045

#	Statement	3-factor model			5-factor model				
		F1	F2	F3	F1	F2	F3	F4	F5
28	The beauty of medicine is that it's always evolving and changing	0.122	0.313	0.259	0.006	-0.063	0.169	0.493	0.013
3	I would be comfortable if a clinical teacher set me a vague assignment or task	0.338	-0.118	0.289	-0.117	0.193	0.210	0.186	-0.285
4	A good clinical teacher is one who challenges your way of looking at clinical problems	0.111	0.068	0.328	-0.103	-0.003	0.251	0.229	-0.079
6	I feel uncomfortable when people claim that something is 'absolutely certain' in medicine	-0.157	0.312	0.068	0.164	-0.274	0.005	0.319	0.099
12	The unpredictability of a patient's response to medication would bring welcome complexity to a doctor's role	0.225	0.082	0.315	0.065	0.033	0.266	0.269	-0.254
29	I would be comfortable to acknowledge the limits of my medical knowledge to patients	0.128	0.283	0.018	-0.059	0.085	-0.02	0.326	0.203

Unlike the factors "*Affinity for complexity"* and "*Discomfort from uncertainty"*, some factors focussed less on individual responses to uncertainty and more on their individual perceptions of what medicine is, or should be, like. For example, for "*Doctors should be clear (and medicine is clear)"* and *"Medicine is clear"*, both of these factors appear to be related to the facet named *"Novice view"* identified when using a modified version of the TAMSAD in veterinary students[20] with items 20 and 27 present across models. However, we felt that the term Novice view did not accurately reflect or describe this factor in the FiY1 population. While the view expressed that "Medicine is black and white" (item 27) might be expected to be seen in less experienced students and doctors, in this population for some participants this view has persisted beyond undergraduate training and into professional practice. This, therefore, challenges the assumption that this is simply the view of novices, but may in fact be a more longstanding view that a number of individuals within the medical profession may hold, potentially those with a lower ToA.

The first factor in the five-factor model was provisionally named *"Desire for clear and definite working environments"*. While this factor seems to relate to career simplicity or perceptions of what you admire in other doctors, it could equally relate to control in working environments. On balance it was felt that while we could provisionally name this factor it may be that the items identified represent an under-developed evaluation of a factor. This may also be reflected by the lower Cronbach's alpha of this factor (0.43) particularly when compared to the other factors that were named with more certainty.

It is unclear why the TAMSAD scale performed in a multidimensional way in this national sample of FiY1 doctors, but unidimensionally when used in a smaller local sample of medical students and Foundation doctors[5]. This could reflect the more diverse experiences of the population examined.

Despite the differences identified between these findings and that of our previous work the factor structures identified across the three- and five-factor models within this study do appear to closely relate to three of the facets identified when using a modified version of this scale within the veterinary student population[20]. This includes *"Novice view", "Discomfort from uncertainty",* and *"Affinity for complexity"* but not *"Accepting indeterminacy*". The authors of this paper view the TAVS scale to be acting unidimensionally but containing four correlated and related facets. We go further and consider our models to be describing aspects of factors within a multidimensional construct, in part because the factors we have identified appear to be independent and describing different components of the integrative model of uncertainty tolerance[13].

The similarities in the meanings of these clusters of items do suggest that the ToA construct may have strong similarities across these professional populations. This may have implications for medical education interventions. For example, if an intervention was found to support ToA development in medical students it may also have merit in the veterinary student population.

Although the models with at least three factors provided adequate absolute fit to the TAMSAD items, the CFI and TLI statistics indicated that none of the models were an adequate fit relative to the null model that specifies no correlation amongst the items. The absence of large correlations amongst the items, even for those items from the same factor, means there is less scope to improve fit relative to the null model.

Implications for theory and practice

This study also allows us to propose an extension to the integrative model of uncertainty tolerance originally proposed by Hillen *et al.*[13] The factors *"Doctors should be clear (and medicine is clear)"* and "*medicine is clear"* suggest that an individual's epistemological beliefs regarding the nature

of medicine and the role of a doctor may influence their response to clinical ambiguity. Therefore, an individual's epistemological beliefs, such as these, could be considered a moderator to the relationship between ambiguity and the experienced uncertainty. This provides further refinement to the already described moderator "individual characteristics" within the existing model. This is important as it may suggest that interventions aimed at supporting improved ToA could consider, as a starting point, drawing a professional's conscious awareness to their own epistemological beliefs regarding the nature of medicine and the role of doctors.

By making use of the items contained within these factors ("*Doctors should be clear (and medicine is clear)", "The mystery of medicine" or "Medicine is clear*") in a supported educational environment, such as educational supervision, postgraduate trainees could be encouraged to reflect on their own beliefs and the impact of these on their own ToA within clinical medicine. This is particularly important as one qualitative study identified reflective learning as a potential moderator to a medical student's uncertainty tolerance[29], and a recent scoping review indicated that interventions may be more likely to support development of uncertainty tolerance if they are delivered in a psychologically safe educational environment where reflection is encouraged and facilitated[30].

We believe that an improved understanding of the dimensionality of the ToA construct will underpin the design of more nuanced and sophisticated educational and support interventions in the future.

Strengths and limitations

This study represents the first time that the dimensionality of the TAMSAD scale has been examined in a national sample of this size. However, a limitation is that the sample size of 428 represent 9% of those completing a FiY1 post during the study period. This figure reflects the significant challenge of obtaining responses from practising clinicians and this challenge is reflected in similar published national surveys. For example, one national study of preparedness of F1 doctors reported a response rate of 11.7% in 2020 compared to response rates of between 12.7 – 21.9% in the preceding three years[31].

Throughout the study, the team of medical education experts and clinicians met on several occasions to discuss potential interpretations of the factors, and following a rigorous process identified potential interpretations of the three- and five-factor models. The team saw this process as an exploratory one, aiming to support understanding of the TAMSAD scale and the ToA construct, rather than attempting to identify a definitive model.

It is important to note that the original study was conducted in the early stages of the COVID-19 pandemic when the population under study were performing new and novel roles (FiY1). Given that Stephens *et al.*[29] suggest that a medical student's capacity for managing clinical uncertainty can be influenced by many factors, including the degree of administrative uncertainty that surround a clinical placement, it is possible that FiY1s exposed to high levels of societal and role uncertainty may have reported different responses to clinical ambiguity and uncertainty not present outside of this context. However, despite this it is notable that the factors identified in this population appear to be similar to those facets identified in the veterinary student population examined prior to the COVID-19 pandemic.

Future research

In this paper we have presented evidence that the TAMSAD scale may have a three- or five-factor solution, which provides important insights for theory and practice. However, the lack of a definitive structure indicates the ToA construct itself still requires further theoretical development. This could also include further development of the factors identified within the TAMSAD scale such as "*The mystery of medicine", "Medicine is clear"* and in particular the provisionally named factor "*Desire for clear and definite working environments*" within the five-factor model. This factor may reflect career simplicity, it could be about perceptions of what you admire in other doctors, or it could relate to control in working environments. The suggestion that this may be related to a desire for career simplicity is supported by the fact that there is an inverse loading (-0.393) with the item "I would enjoy tailoring treatments to individual patient problems". If we accept classical measurement theory, then for factors such as this the current included items represents only a small sample number from a potential infinite number of items. Therefore, it may be possible to develop further items to better explore this factor.

It appears highly likely that ToA is a dynamic state. This opens up the possibility that the TAMSAD scale could be used to evaluate the impact of educational interventions on ToA within medical students or early career doctors.

The finding that ToA is multidimensional also provides an opportunity to explore those different dimensions and their relations and the implications. For example, one factor of the TAMSAD might correlate more strongly with psychological wellbeing while others may correlate more strongly with alternative clinician or patient outcomes.

Conclusion

The TAMSAD scale is acting multidimensionally in national sample of FiY1 doctors providing strong evidence that the ToA construct is multidimensional. Both the three- and five-factor models identified have different merits. Our findings indicate that having an affinity for complexity is not the opposite of experiencing discomfort from uncertainty, and that a professional's epistemological beliefs about the nature of medicine may influence their response to clinical ambiguity.

This could be considered an extension to an existing integrated model of uncertainty tolerance[13] as a moderator of an individual's response to ambiguity. It also appears that the factors identified in a population of FiY1 doctors are similar to those facets identified within veterinary students.

Future research could explore some of the currently underdeveloped factors identified, through the development and testing of new items. These findings could also be used to support educators to develop interventions to increase ToA in doctors, perhaps through supporting increased reflection on an individual's own epistemological beliefs about medicine and the role of doctors, with the potential impact on ToA being evaluated using the TAMSAD tool.

Data availability

Underlying data

Newcastle University: Questionnaire data files for study of interim Foundation Year 1 (FiY1) doctors transition to practice in 2000. https://doi.org/10.25405/data.ncl.22537099[26].

The project contains the following underlying data:

- final phase 1 data for repository.csv
- final phase 2 data for repository.csv

Extended data

Newcastle University: Questionnaire data files for study of interim Foundation Year 1 (FiY1) doctors transition to practice in 2000. https://doi.org/10.25405/data.ncl.22537099[26].

The project contains the following extended data:

- README.txt (brief description of the contents of all files)
- Phase 1 questionnaire.pdf
- Phase 2 questionnaire.pdf
- questionnaire field key for repository.xlsx

References

1. Geller G, Faden RR, Levine DM: **Tolerance for ambiguity among medical students: Implications for their selection, training and practice.** *Soc Sci Med.* 1990; **31**(5): 619–624.
PubMed Abstract | **Publisher Full Text**
2. Hancock J, Mattick K: **Tolerance of ambiguity and psychological well-being in medical training: A systematic review.** *Med Educ.* 2020; **54**(2): 125–137.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**
3. Strout TD, Hillen M, Gutheil C, *et al.*: **Tolerance of uncertainty: a systematic review of health and healthcare-related outcomes.** *Patient Educ Couns.* 2018; **101**(9): 1518–1537.
PubMed Abstract | **Publisher Full Text**
4. General Medical Council: **Outcomes for graduates 2018**. 2018.
Reference Source
5. Hancock J, Roberts M, Monrouxe L, *et al.*: **Medical student and junior doctors' tolerance of ambiguity: development of a new scale.** *Adv Health Sci Educ Theory Pract.* 2015; **20**(1): 113–130.
PubMed Abstract | **Publisher Full Text**
6. Budner S: **Intolerance of ambiguity as a personality variable.** *J Pers.* 1962; **30**(1): 29–50.
PubMed Abstract | **Publisher Full Text**
7. Geller G, Tambor ES, Chase GA, *et al.*: **Measuring physicians' tolerance for ambiguity and its relationship to their reported practices regarding genetic testing.** *Med Care.* 1993; **31**(11): 989–1001.
PubMed Abstract | **Publisher Full Text**
8. Gerrity MS, DeVellis RF, Earp JA: **Physicians' reactions to uncertainty in patient care. A new measure and new insights.** *Med Care.* 1990; **28**(8): 724–736.
PubMed Abstract | **Publisher Full Text**
9. Sidanius J: **Intolerance of ambiguity, conservatism, and racism: Whose fantasy, whose reality?: A reply to Ray.** *Political Psychol.* 1988; **9**(2): 309–316.
Publisher Full Text
10. Perry WG: **Forms of intellectual and ethical development in the college years— a scheme**. New York, Holt, Rinehart and Winston, 1968.
11. Knight LV, Mattick K: **'When I first came here, I thought medicine was black and white': Making sense of medical students' ways of knowing.** *Soc Sci Med.* 2006; **63**(4): 1084–1096.
PubMed Abstract | **Publisher Full Text**
12. Greco V, Roger D: **Uncertainty, stress, and health.** *Pers Individ Differ.* 2002; **34**(6): 1057–1068.
Publisher Full Text
13. Hillen MA, Gutheil CM, Strout TD, *et al.*: **Tolerance of uncertainty: conceptual analysis, integrative model, and implications for healthcare.** *Soc Sci Med.* 2017; **180**: 62–75.
PubMed Abstract | **Publisher Full Text**
14. Stephens GC, Rees CE, Lazarus MD: **Exploring the impact of education on preclinical medical students' tolerance of uncertainty: a qualitative longitudinal study.** *Adv Health Sci Educ Theory Pract.* 2021; **26**(1): 53–77.
PubMed Abstract | **Publisher Full Text**
15. Babenko O, Linkiewich D, Lodewyk K, *et al.*: **Ambiguity Tolerance and Prospective Specialty Choice Among Third-Year Medical Students.** *PRiMER.* 2021; **5**: 2.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**
16. Babenko O, Lee A: **Ambiguity and uncertainty tolerance and psychological needs of medical students: A cross-sectional survey.** *Clin Teach.* 2022; **19**(6): e13523.
PubMed Abstract | **Publisher Full Text**
17. Lodewyk K, Linkiewich D, Lee A, *et al.*: **From Jerseys to Scrubs: Is Sport Background Associated with Medical Students' Tolerance of Ambiguity and Uncertainty?** *Health Prof Educ.* 2020; **6**(4): 501–505.
Reference Source
18. Ndoja S, Chahine S, Saklofske D, *et al.*: **The erosion of ambiguity tolerance and sustainment of perfectionism in undergraduate medical training: results from multiple samplings of a single cohort.** *BMC Med Educ.* 2020; **20**(1): 417.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**
19. Hancock J: **Tolerance of ambiguity in doctors-in-training and links with psychological well-being**. Thesis, University of Exeter, 2021.
Reference Source
20. Hammond JA, Hancock J, Martin MS, *et al.*: **Development of a new scale to measure ambiguity tolerance in veterinary students.** *J Vet Med Educ.* 2017; **44**(1): 38–49.
PubMed Abstract | **Publisher Full Text**
21. Wilson A, Stephens G, Lazarus M: **Ambiguity: What' s Your Tolerance?** *The FASEB journal.* 2019.
22. Burford B, Vance G, Goulding A, *et al.*: **2020 Medical Graduates: The work and wellbeing of interim Foundation Year 1 doctors during COVID-19**. 2021.
Reference Source
23. Cohen S, Kamarck T, Mermelstein R: **A global measure of perceived stress.** *J Health Soc Behav.* 1983; **24**(4): 385–396.
PubMed Abstract | **Publisher Full Text**

24. Zigmond AS, Snaith RP: **The Hospital Anxiety And Depression Scale.** *Acta Psychiatr Scand.* 1983; **67**(6): 361–70.
PubMed Abstract | **Publisher Full Text**

25. Kristensen TS, Borritz M, Villadsen E, *et al.*: **The Copenhagen Burnout Inventory: A new tool for the assessment of burnout.** *Work & Stress.* 2005; **19**(3): 192–207.
Publisher Full Text

26. Burford B: **Questionnaire data files for study of interim Foundation Year 1 (FiY1) doctors transition to practice in 2000.** Newcastle University, [Dataset]. 2023.
http://www.doi.org/10.25405/data.ncl.22537099

27. Humphreys L, Montanelli R: **An investigation of the parallel analysis criterion for determining the number of common factors.** *Multivariate Behav Res.* 1975; **10**(2): 191–205.
Publisher Full Text

28. Hu LT, Bentler PM: **Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives.** *Struct Equ Modeling.* 1999; **6**(1): 1–55.
Publisher Full Text

29. Stephens GC, Sarkar M, Lazarus MD: **Medical Student Experiences of Uncertainty Tolerance Moderators: A Longitudinal Qualitative Study.** *Front Med (Lausanne).* 2022; **9**: 864141.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**

30. Patel P, Hancock J, Rogers M, *et al.*: **Improving Uncertainty Tolerance in Medical Students: a scoping review.** *Med Educ.* 2022; **56**(12): 1163–1173.
PubMed Abstract | **Publisher Full Text** | **Free Full Text**

31. Moore CJS, Blencowe NS, Hollén L, *et al.*: **Interim Foundation Year One (FiY1) and preparedness for foundation year 1: A national survey of UK foundation doctors.** *Med Teach.* 2022; **44**(6): 622–628.
PubMed Abstract | **Publisher Full Text**