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**Tolerance of ambiguity in doctors-in-training and links with psychological well-being**

Submitted by Jason Robert Hancock, to the University of Exeter as a thesis for the degree of Doctor of Philosophy by Publication in Medical Studies, June 2021.



I certify that all material in this thesis which is not my own work has been identified and that any material that has previously been submitted and approved for the award of a degree by this or any other University has been acknowledged.

(Signature) 

## Abstract

There is a high prevalence of psychological morbidity in doctors-in-training (medical students and trainee doctors) with a subsequent impact on delivery of healthcare. The practice of medicine involves inherent ambiguity leading to uncertainty, and there is growing evidence that reduced tolerance of ambiguity in doctors-in-training may be associated with reduced psychological well-being. However research into this important construct is hampered by a lack of conceptual clarity relating to the underpinning constructs, and a lack of validated measurement tools. Furthermore, it remains unclear if tolerance of ambiguity, in medical students, doctors and similar professional groups, such as vets, is a dynamic state that can be influenced by medical education interventions.

The aim of this thesis is to develop understanding and approaches to measurement of the tolerance of ambiguity construct in doctors-in-training, using veterinary trainees as a comparison group, and to improve understanding of the potential association between tolerance of ambiguity and psychological well-being.

This thesis describes the development of a high quality Tolerance of Ambiguity in Medical Students and Doctors (TAMSAD) measurement scale. Variants of the scale were used to compare tolerance of ambiguity in medical and veterinary students. Existing literature was assessed to determine if there is an association between tolerance of ambiguity and psychological well-being in the medical population. A conceptual model is proposed relating to the tolerance of ambiguity construct, and the mediating and moderating factors that may influence the relationship with psychological well-being. The broader ambition of this thesis is to support development and evaluation of future educational interventions which will ultimately improve psychological well-being of doctors-in-training, and support improved workforce sustainability and high quality patient care.

## Acknowledgements

I am deeply grateful to my supervisor Professor Karen Mattick for her continuous support, patience, expertise, and the time that she has invested in me over the last 10 years. I am also grateful for the support and guidance of Professor Chris Dickens. Their shared experience, enthusiasm and belief in me has encouraged me to continue my academic training and PhD alongside my clinical career.

I would also like to thank my employers Devon Partnership NHS Trust for their support in completing this PhD.

Finally I would like to thank my fantastic family, Charlotte, Toby, Olivia and Jack for their unwavering support, patience and love. Without them I could never have completed this project.

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# List of Figures and Tables

## Author's declaration

Throughout this thesis I will use 'we' when referring to the work of the empirical co-authored chapters and 'I' when referring to this thesis, in particular the integrative Chapter. I have included detailed statements regarding the nature and extent of my individual contribution to each of the empirical co-authored papers below.

Two of the empirical chapters were undertaken in collaboration with the University of Glasgow and one of the co-authors of these two publications (Jennifer Hammond) was undertaking a doctorate in veterinary education (Training for uncertainty in veterinary education). Therefore I have been particularly careful to be transparent about the work presented in this thesis and that presented in hers.

Jennifer Hammond's thesis can be accessed at the link below:

http://theses.gla.ac.uk/9000/1/2017HammondDHPE.pdf

### Chapter 2: Medical student and junior doctors' tolerance of ambiguity: development of a new scale

**Hancock, J**., Roberts, M., Monrouxe, L. and Mattick, K.

I developed the research question and planned the study design. I updated the literature review on the subject and contributed items to the questionnaire. I authored the ethics application (to the Peninsula College of Medicine & Dentistry) and oversaw its progress through the revision process. I approached medical students and doctors and used feedback to pilot the scale, which in turn resulted in modification and further refinement of scale items. I planned and completed study recruitment, performed data cleaning and input and conducted initial statistical analysis. I then coordinated and attended meetings with statistician (MR). MR contributed his expertise in psychometrics to the scale development process which I led. I authored the first draft of paper, coordinated input and feedback from all contributors into subsequent drafts, and authored the final draft of paper for publication.

## Chapter 3: Development of a new scale to measure ambiguity tolerance in veterinary students

Hammond, J., **Hancock, J.,** Martin, M., Jamieson, S. and Mellor, D.

Jennifer Hammond approached me to learn more about Tolerance of Ambiguity and how my work in medical students could be applied to veterinary students. Subsequently I provided expert input and supported Jennifer Hammond to refine our existing (TAMSAD) scale to suit their context. Specifically this involved working with them to define the research question, plan the target population, recruitment strategy, study design, development of the questionnaire in the veterinary population and the sample size. I provided input and advice around the psychometric development of the TAVS scale, in particular around interpretation of the factor analysis, and co-constructed the validity argument for the scale with the first author. I wrote sections of the paper, specifically writing the first draft of the validity argument in the paper. This is a key component of the paper as it sets out the argument for the use of the scale in this population. I continued to provide high levels of input for ongoing development of the draft paper to the point of publication.

The aim of this Chapter in my thesis was to design a measurement scale for the evaluation of tolerance of ambiguity in veterinary students (TAVS), and to make use of a validity assessment framework to evaluate the scales validity.

The aim of Jennifer Hammond's thesis was to evaluate longitudinal changes in levels of tolerance of ambiguity in veterinary students (using the TAVS scale) and to explore the demographic factors that may influence this.

There is an overlap in one time point of the data used, however this data is used in different ways in each thesis. In my thesis this is used to inform scale development and develop a validity argument for the use of the scale in the veterinary student population. In Jennifer Hammond's thesis this data is used alongside data collected at two other time points to evaluate changes in ambiguity tolerance in this population over time.

Chapter 3 of my thesis is listed as an appendix within Jennifer Hammond's thesis.

## Chapter 4: Comparing tolerance of ambiguity in veterinary and medical students

**Hancock, J**. Hammond, JA. Roberts, M. and Mattick, K.

I defined the research question and planned the study design. I authored the application for ethical approval with the University of Exeter. I contributed data from original TAMSAD study (medical students and junior doctors in Exeter) and performed initial data comparisons between populations. I coordinated further data analysis through ongoing meetings and planning with statistician (MR) and took the lead on intellectual development of the paper. This included authoring the first draft, revising the draft manuscripts and writing the final manuscript based on co-author feedback.

The aim of this Chapter of my thesis was to compare levels of ambiguity tolerance in medical and veterinary students using the data reported in Chapter's 2 and 3.

The aim of Jennifer Hammond's thesis was to evaluate longitudinal changes in levels of tolerance of ambiguity in veterinary students (using the TAVS scale) and to explore the demographic factors that may influence this.

There is an overlap in one time point of the data used, however this data is used in different ways in each thesis. In my thesis this is used to allow comparison of ambiguity tolerance between medical and veterinary students at one point in time. In Jennifer Hammond's thesis this data is used alongside data collected at two other time points to evaluate changes in ambiguity tolerance in the veterinary student population over time.

*One component of this Chapter (Table 1) has been included as an appendix by Jennifer Hammond in her thesis. This table demonstrates which items were included in the final versions of the TAMSAD and TAVS scales.

## Chapter 5: Ambiguity tolerance and psychological well-being in medical training: a systematic review

**Hancock, J**. and Mattick, K.

I developed the research question and planned study design, performed initial literature review and subsequently planned and piloted the search strategy and protocol. I planned and piloted inclusion and exclusion criteria, completed the database search following discussions with an information specialist, screened all papers for inclusion/ exclusion (75 papers were co-screened with KM). I constructed the search protocol and performed the grey literature/ supplementary searches. I evaluated all 11 papers meeting the inclusion criteria for quality and extracted data from all included studies. I completed the narrative analysis of papers and authored the first draft of the paper and composed the final manuscript based on feedback from KM.

## Chapter 6: Mindfulness, complex interventions and conceptual clarity

**Hancock, J.** and Mattick, K.

I developed the initial plan for this commentary piece in discussion with KM. I authored the first draft of the paper and composed the final manuscript based on feedback from KM.

## Definitions and abbreviations

**Ambiguity:** lack of reliable, credible or adequate information (Han *et al.,* 2011).

**British Medical Association (BMA):** trade union for medical students and doctors in the United Kingdom.

**Cronbach's-alpha:** a measure of a scales internal consistency, i.e. how closely related a set of items are within a scale. It is also used as a component of the reliability of a scale.

**Doctors-in-training:** An umbrella term used to describe undergraduate medical students and postgraduate doctors in a medical training scheme.

**Foundation year doctors:** A doctor in the UK in their first two years of postgraduate training, known as Foundation Year 1 (F1) and Foundation Year 2 (F2) doctors.

**General Medical Council (GMC):** A public body in the United Kingdom with the responsibility for maintaining the official register of medical practitioners (doctors).

**General Practitioner (GP):** a community based doctor in the United Kingdom.

**Medical student:** An undergraduate student training to be a doctor.

**Reduced psychological well-being:** A term used in this thesis to describe range of negative psychological experiences which could include distress (stress), burnout or mental health disorders.

**TAMSAD:** quantitative Tolerance of Ambiguity in Medical Students And Doctors 29 item measurement scale.

**TAVS:** quantitative Tolerance of Ambiguity in Veterinary Students 27 item measurement scale.

**Tolerance of uncertainty:** positive or negative cognitive, emotional or behavioural response to uncertainty (Hillen *et al.,* 2017).

**Uncertainty:** conscious awareness of ignorance about particular aspects of the world in response to either ambiguity, probability or complexity (Han *et al.,* 2011).

**Veterinary student:** An undergraduate student training to be a vet.

# Chapter 1: Integrative Chapter

## Part A: General Introduction

### 1. Overview

The prevalence of stress, burnout and mental health disorders in medical students and doctors is alarmingly high (Frank *et al.,* 2000; Thommasen *et al.,* 2001; Goehring *et al.,* 2005; Firth-Cozens, 2006; Brook *et al.,* 2011; dos Santos *et al.,* 2018). This is recognised globally as a challenge to the sustainability and delivery of healthcare (The Lancet, 2019). Within the UK the 2020 NHS staff survey indicated that 40% of doctors reported feeling unwell due to work related stress over the preceding year (O'Dowd, 2021). This can result in absenteeism (where doctors miss work due to mental ill-health), presenteeism (where doctors come to work whilst unwell) and ultimately loss of the staff from the medical workforce (Carrieri *et al.,* 2020). Clearly this represents a significant challenge to the international medical workforce. In the UK in 2017 the Lord Select Committee stated:

"*We are concerned by the absence of any comprehensive national long-term strategy to secure the appropriately skilled, well-trained and committed workforce that the health and care system will need over the next 10–15 years. In our view this represents the biggest internal threat to the sustainability of the NHS*." (Lord Select Committee, 2017)

In 2019 a GMC report "The state of medical education and practice in the UK" suggested that well-being is key to addressing these workforce issues and that improving retention of doctors will improve the quality of patient care (GMC, 2019). However little is known about the individual, team, organizational or societal factors that increase the risk of medical students and doctors developing stress, burnout or mental health disorders (Dyrbye *et al.,* 2006). While it is likely that multiple factors contribute towards this there is growing evidence that intolerance of ambiguity in clinical practice can be associated with a range of negative cognitive, behavioural and emotional outcomes including reduced psychological well-being (Strout *et al.,* 2018).

The remainder of this introductory chapter will review what is known about tolerance of ambiguity within medicine, and the potential association with psychological well-being, to highlight what uncertainties remain and justify the empirical work undertaken in my PhD thesis.

## 2. Tolerance of ambiguity within medicine

The practice of medicine involves inherent ambiguity leading to uncertainty. Uncertainty may arise from multiple sources, including: limitations of knowledge, diagnostic problems, ambiguities of treatment and outcome and unpredictability of patient response (Geller *et al.,* 1990). The GMC document ‘‘Outcomes for Graduates’’ (GMC, 2018) states that newly qualified doctors must be able to recognise uncertainty, seek support from colleagues in managing clinical situations which involve uncertainty, and communicate this uncertainty sensitively to patients and their relatives.

## 3. Tolerance of ambiguity: conceptual clarity

It is therefore widely acknowledged that an ability to tolerate ambiguity and the resulting uncertainty are desirable qualities for a doctor. However research into this field has been limited by a lack of conceptual clarity around these terms and the underlying constructs. Subsequently developing validated measurement scales for these constructs has been a challenge. This is problematic as the lack of a validated scale limits educators ability to quantify tolerance of ambiguity within clinicians, identify associated factors, assess impact of low levels of tolerance of ambiguity, and ultimately develop and evaluate interventions aimed at enhancing tolerance of ambiguity.

Varying definitions for tolerance of ambiguity and uncertainty have been proposed, and used to underpin measures of these constructs in doctors-in-training (medical undergraduate students and postgraduate doctors in training). While at times the terms ambiguity and uncertainty have been used interchangeably, the majority of published studies in the field set out proposed differences. For example Greco and Roger (2002) suggest uncertainty is the response to an ambiguous situation, and Furnham and Ribchester (1995) suggest that tolerance of ambiguity may be “*the way an individual (or group)*

*perceives and processes information about ambiguous situations or stimuli when confronted by an array of unfamiliar, complex or incongruent clues*". Some suggest that an intolerance of ambiguity may be the tendency to perceive or interpret an ambiguous situation as an actual or potential source of psychological distress (Norton, 1975). Others suggest that tolerance of ambiguity might alternatively involve not only coping in ambiguous situations but may also involve actively seeking out and thriving within them (Budner, 1962).

Some conceptual clarity has been provided by Han *et al*. (2011) who following a comprehensive synthesis of the literature beyond just the medical education field defined ambiguity as "*lack of reliable, credible or adequate information*", and uncertainty as "*conscious awareness of ignorance about particular aspects of the world in response to either ambiguity, probability or complexity*" (Han *et al.,* 2011). These definitions have been further developed and incorporated into a broader conceptual model (Figure 1). This model was proposed by Hillen *et al.* (2017) following a review of 18 existing measures of uncertainty and ambiguity tolerance. This review outlines some of the challenges with existing measures and indeed this whole area of research, such as their poor conceptual clarity (e.g. using the terms uncertainty and ambiguity interchangeably) and inconsistent use of definitions for these constructs.

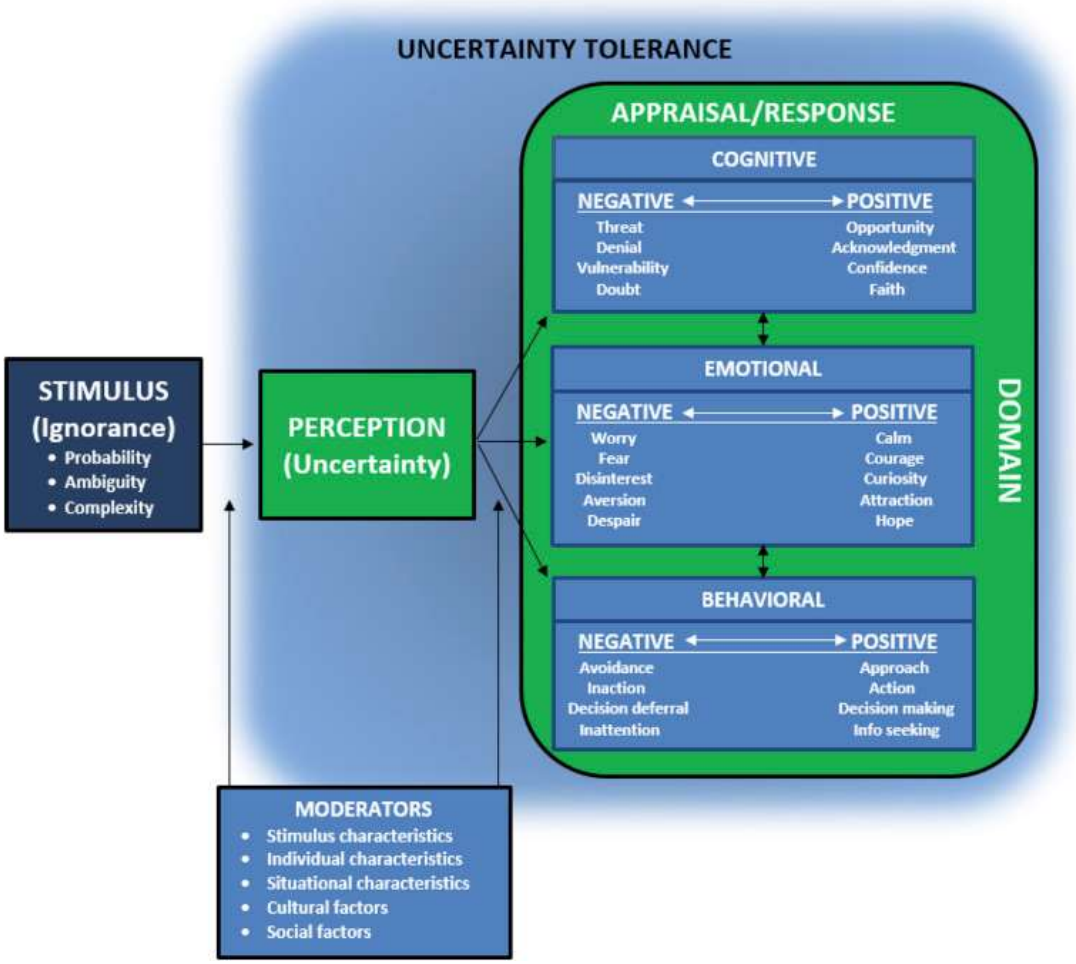


*Figure 1: Integrative model of uncertainty tolerance (Hillen et al., 2017). Reproduced with permission.*

A clear strength of the Hillen *et al.* (2017) model is that it is based on a comprehensive review of the literature and the measurement tools that have been developed to date. Further evidence for these definitions is provided through the field of functional neuroimaging, with one study demonstrating that different neural networks are responsible for decision making with risk, where the probability of potential outcomes is known, compared to decision making with ambiguity, where information is missing and therefore the probability of potential outcomes is unknown (Hsu *et al.,* 2015). Hillen *et al.* (2017) also set out a clear definition for what it means to tolerate uncertainty, which include a positive or negative cognitive, emotional or behavioural response. As this definition was published during the period of registration for this PhD the subsequent Chapters reflect the changing literature during that time period, in particular the evolving definitions of tolerance of ambiguity and uncertainty.

## 4. Unresolved conceptual issues with ambiguity tolerance research

Despite the improved conceptual clarity provided by the work of Hillen *et al.* (2017) significant unanswered questions remain regarding the tolerance of ambiguity construct. One of the key unresolved issues surround whether tolerance of ambiguity is a dynamic state that can change over time in individuals or populations, or a stable trait that is unlikely to be influenced by educational interventions. While the Hillen *et al.* (2017) model is designed to be flexible, and can be used by researchers adopting either a trait or state focussed approach, different approaches are evident and have influenced the scales that have been developed to date.

### 4.1 State versus trait and relation to personal epistemologies

Some, such as Budner (1962), argue that tolerance of ambiguity it is a static trait and may be associated with a number of different negative psychological traits such as dogmatism, conformity, and rigidity (Budner, 1962; Furnham and Ribchester, 1995). Subsequently this is reflected in the items included in the original Budner (1962) scale. Others argue that the similar construct of uncertainty tolerance should be considered a varied state, which can be tolerated by an individual to different degrees dependant on the context (Shihata *et al.,* 2016). The same author argues that the context in which it is experienced determines if an individual is to find uncertainty threatening. This view would be consistent with some of the published literature around the role of personal epistemologies within medical education.

Epistemology is a branch of philosophy that considers what it is to ‘know’, and how we understand, integrate, justify and apply knowledge. Early models of personal epistemology suggest that constructs such as tolerance of ambiguity may develop in a linear way along an essentially unidimensional scale (Perry, 1968). However more recent models challenge this and suggest that such a construct could have multiple dimensions. Some models describe the trajectory of an individual’s own epistemology developing during undergraduate training from a lay understanding of science – where science is considered to be based on ‘truths’ to an understanding that is much more contextualised and fluid. Knight and Mattick (2006) suggest that this progression will be different for

different parts of the undergraduate curriculum and can at times move forwards or backwards. For example early years students may be more likely to view anatomical knowledge as certain, while accepting that more fluidity exists within social sciences. This suggests that an individual's own personal epistemologies may be activated by different contextual cues. It is therefore important to remain open to the possibility that tolerance of ambiguity may change over time based on the contextual exposure and may be multidimensional.

### 4.2 Relationship to similar constructs

It remains unclear if ambiguity and uncertainty tolerance may be closely related to other concepts within medical education such as premature closure bias. This occurs when a diagnosis is assigned before it has been fully verified and can occur when clinicians reach for a diagnosis without seeking all available information, or anchor diagnosis on data collected early in diagnostic process without fully considering new information (Blisset and Sibbald, 2017). It is important to examine if and how these constructs may be related to an ability to tolerate ambiguity as a failure to do so may result in researchers missing existing literature, evidence and debates that could allow this research to inform practice more quickly than it could otherwise.

## 5. Gaps in our understanding of ambiguity tolerance in clinical training

### 5.1 Impact of medical education on tolerance of ambiguity

Due to the challenges already outlined of conceptual clarity, and the subsequent deficiencies of existing measurement scales, empirical research into how tolerance of ambiguity may change during medical training, and the factors that may be associated with this construct, has been limited. At present it is not clear, for example, if tolerance of ambiguity does or does not change over the course of undergraduate or postgraduate medical training and subsequently if it is a static trait or dynamic state. Some studies have suggested that uncertainty may increase throughout medical training, in particular postgraduate training (Deforge and Sobal, 1991). However other studies have either failed to identify an increase in ambiguity tolerance during undergraduate training (Geller *et al.,* 1990) or have demonstrated a reduction during undergraduate medical training (Han *et al.,* 2015). Even when no change is

reported it remains unclear if tolerance of ambiguity is a static trait, or that the curriculum or passage of time during medical school is not sufficient to cause a change. Similarly it may be that while undergraduate or postgraduate medical training causes a change in tolerance of ambiguity, other external factors ensure that any potential change is counteracted.

### 5.2 Sociodemographic factors

It remains unclear if tolerance of ambiguity is influenced by sociodemographic characteristics, as again findings have been inconsistent (Stout *et al.,* 2018). Some studies have demonstrated higher tolerance of ambiguity in female undergraduate students (DeForge and Sobal, 1989) while several studies of undergraduate students and postgraduate physicians showed higher tolerance of ambiguity in males (Geller *et al.,* 1990; Schor *et al.,* 2000; Nevalainen *et al.,* 2012). Finally one study has demonstrated higher tolerance of ambiguity in older students entering medical school (DeForge and Sobal, 1989), while another has demonstrated higher levels in younger medical students (Geller *et al.,* 1990).

## 6. Tolerance of ambiguity and association with health related outcomes

One systematic review has examined the relationship between the closely related tolerance of uncertainty construct and health related outcomes in health professionals and patients, categorising the potential outcomes as cognitive, emotional and behavioural (Strout *et al.,* 2018). Some of the findings of this review included potential associations between an intolerance of ambiguity and more negative attitudes towards underserved populations (Wayne *et al.,* 2011). In addition intolerance of uncertainty appeared to be associated with reduced accuracy in mammogram interpretation in radiologists (Carney *et al.,* 2004), and increased likelihood of specialist referrals (Franks *et al.,* 2000).

### 6.1 Tolerance of ambiguity and association with psychological well-being

In the general population some studies have demonstrated an association between intolerance of uncertainty and mental health (anxiety) disorders, arguing that intolerance of uncertainty may be a trans-diagnostic marker linked to a range of anxiety and affective disorders (Shihata *et al.,* 2016). In the medical population it has been proposed that the effects of anxiety due to

uncertainty may go some way to explain the high rates of distress, burnout and suicidal ideation in doctors (BMA, 2007).

Within the Strout *et al.* (2018) review a limited number of studies were identified which had examined the potential association between tolerance of uncertainty in medical students or doctors, and outcome measures which could be considered under the broader construct of psychological well-being.

One study of medical students investigated the association between tolerance of ambiguity, tolerance of uncertainty and psychological well-being. This cross sectional study demonstrated that in a population of 100 students those students with psychological distress (determined by having a General Health Questionnaire 12 score greater than 3) had a higher mean intolerance of uncertainty score (calculated using the Intolerance of Uncertainty Scale 12 (IUS-12)) compared to those without psychological distress (Lally *et al.,* 2014). However using the same measure students with psychological distress did not have a higher intolerance of ambiguity (calculated using a modified version of the original Budner 1962 scale).

In the postgraduate medical population several studies have investigated the potential association between tolerance of uncertainty and psychological well-being, however no studies attempted to measure tolerance of ambiguity. One study of 128 GP registrars training in Australia reported that doctors deemed to be at high risk of burnout (calculated using a single item of burnout from the Maslach Burnout Inventory) had a higher intolerance of uncertainty (calculated using the IUS-12 scale) compared to those deemed low risk of burnout (Cooke *et al.,* 2013). However the results appeared to be influenced by the tolerance of uncertainty scale used.

Despite these two studies limited robust empirical research has been conducted into the association between tolerance of ambiguity or uncertainty and psychological well-being in medical student and doctor populations. Those studies that have been identified, such as those described, have utilised cross sectional design, had small sample sizes and their findings appear to be conflicting. While a systematic review has identified some of the existing research into the association between tolerance of uncertainty and health

related outcomes, no attempt has been made to systematically review the existing literature for the potential association between tolerance of ambiguity and psychological well-being. Subsequently there has been little work done to develop a conceptual model to explain any potential association between these constructs. This limits the ability of medical educators to design and implement educational interventions aimed at either increasing tolerance to ambiguity or improving psychological well-being of medical trainee populations.

## 7. Cross professional research

Despite the remaining unanswered questions in the medical trainee population, relatively more is known about the tolerance of ambiguity construct compared to other educational fields. There is little evidence, for example, of cross professional research to describe and understand potential similarities and differences in tolerance of ambiguity in different professional groups. Subsequently it is difficult to know if an ability to tolerate ambiguity is of specific importance to medical trainees, or whether it is also important in other professional groups. One editorial made a strong argument that medical education research could be improved through collaborating with research colleagues from other schools within education, such as within veterinary medicine. In particular they argue that improved collaboration could improve the theoretical sophistication of educational research (Rees *et al.,* 2015).

## 8. Research now needed

### 8.1 Scale development

Development of a quantitative scale that could measure tolerance of ambiguity in medical students and doctors would support medical education researchers to identify associated factors and assess the impact of low levels of ambiguity tolerance on clinicians in these populations. To date many of the scales developed and used have either assumed that tolerance of ambiguity is a static trait (Budner, 1962) or have not attempted to measure tolerance of ambiguity within the clinical context. These deficiencies are discussed in more detail in Chapter 2.

While the debate around whether tolerance of ambiguity is a state or trait remains unresolved it would be reasonable to ensure that a measurement scale

be open to the possibility that tolerance of ambiguity may be a contextually influenced dynamic state. In addition scales should have sufficient number and range of items to be sensitive to subtle changes, and not assume that tolerance of ambiguity is a unidimensional construct but could be multidimensional and include several different factors.

Development of such a quantitative scale could aid conceptual clarity on the construct as if it is a dynamic state then this leads onto the possibility that it could be modified by evidence based complex educational interventions or through modifications to the medical training environment.

### 8.2 Cross professional research collaboration

By developing scales to evaluate tolerance of ambiguity across educational fields, such as within undergraduate medical and veterinary students, this would allow a comparison of this construct between populations. Doing so would allow a clearer understanding of the similarities and differences that exist between these student groups, and their different professional trajectories, as well as providing greater insights into the concept of tolerance of ambiguity through these comparisons. This may help to optimise educational opportunities between populations and ensure that any cross professional lessons can be learned.

### 8.3 Association with psychological well-being and middle range theory development

It is important to understand if there is an association between an ability to tolerate ambiguity in medical students and doctors and psychological well-being, as this has the potential to support development of educational or workplace interventions that may ultimately improve the psychological well-being of the medical workforce and improve training, retention and the quality of patient care.

Limited research has been done to date to develop a conceptual model to understand the potential association between tolerance of ambiguity and psychological well-being. However there is an opportunity to make use of middle-range theory development to progress this field. Middle-range theory sits between minor working hypothesis and the all-inclusive efforts to develop

unified theories (Laskov *et al.,* 2017). If we could develop a middle-range theory that sets out the potential mediating and moderating factors that may influence any association between these constructs, then this could be used to generate future hypothesis and research questions. In time this would support generation and interpretation of empirical data that could be used to further refine the theory through an iterative process.

Ultimately the hope is that development of this conceptual model may support researchers to design and evaluate complex educational interventions at the level of the individual or the workplace that may either enhance tolerance of ambiguity or psychological well-being. Any such complex intervention would benefit from making use of the Medical Research Council complex interventions framework (MRC framework, 2006).

## 9. Summary

Reduced psychological well-being (the presence of stress, burnout or a mental health disorder) in medical students and doctors is highly prevalent, and this represents a significant threat to the NHS workforce. While there remains limited understanding of the factors that increase the likelihood of an individual experiencing reduced psychological well-being, reduced individual tolerance of ambiguity may be an important factor. Further research into this construct is hampered by the lack of conceptual clarity including if tolerance of ambiguity is a static trait or dynamic state. This is limited in part by a lack of validated measurement scales, and more broadly by the lack of high quality or cross professional research. Developing a validated scale for use within doctors-in-training would aid further understanding of the construct. Further development of the scale in different professional groups, such as veterinary students, would allow improved cross professional learning and help to provide further conceptual clarity. Understanding if there is an association between an ability to tolerate ambiguity in medical students and doctors and psychological well-being would support future research planning. This may in turn may support development, evaluation and implementation of complex educational interventions to enhance tolerance of ambiguity in undergraduate students and doctors and improve psychological well-being.

# 10. Thesis outline

## 10.1 Aim of the thesis

The aim of this thesis is to develop understanding and approaches to measurement of the tolerance of ambiguity construct in medical trainees, using veterinary trainees as a comparison group, and to improve understanding of the potential association between tolerance of ambiguity and psychological well-being. The broader ambition of this thesis is to support the development and evaluation of educational interventions which will ultimately improve psychological well-being of medical trainees, and in turn support improved workforce sustainability and high quality patient care.

This will be achieved through meeting the following objectives in the subsequent empirical Chapters set out in Table 1 below.

## 10.2 Thesis objectives and hypotheses

| Objective number | Description | Chapter | Hypotheses |
|---|---|---|---|
| 1 | Scale development:<br>• To design measurement scales for the evaluation of tolerance of ambiguity in doctors-in-training, and for veterinary students. To make use of a modern validity assessment framework to evaluate the validity of scales in these populations. | 2. "*Medical student and junior doctors' tolerance of ambiguity: development of a new scale"*<br><br>3. "*Development of a New Scale to Measure Ambiguity Tolerance in Veterinary Students"* | • That the developed (TAMSAD) scale is valid when used in the doctors-in-training population (Chapter 2).<br>• That TAMSAD scale can be adapted to produce a valid and reliable measure of ambiguity tolerance in undergraduate veterinary students (Chapter 3). |
| 2 | Comparison of tolerance of ambiguity between student populations:<br>• To compare the tolerance of ambiguity of medical | 4. "*Comparing Tolerance of Ambiguity in Medical and Veterinary Students".* | • That veterinary students would have higher tolerance of ambiguity, given the less well-established evidence base underpinning their work and the multiple animal species |

| | | | |
|---|---|---|---|
| | and veterinary students in the UK. | | for which they may care (Chapter 4). |
| 3 | Association with well-being:<br>• To assess the nature and extent of the literature available, in order to determine if there is an association between levels of tolerance of ambiguity and psychological well-being within medical students and doctors. | 5. "*Tolerance of ambiguity and psychological well-being in medical training: A systematic review"* | • That intolerance of ambiguity in medical students and doctors could place an individual at increased risk of experiencing reduced psychological well-being (Chapter 5). |
| 4 | Conceptual development: provide clarity around the construct of tolerance of ambiguity and the potential relationship with psychological well-being:<br>• Make use of the learning from the development of tolerance of ambiguity | 2. "*Medical student and junior doctors' tolerance of ambiguity: development of a new scale"* | |

| | | | |
|---|---|---|---|
| | scales in different student and trainee populations to provide further clarity around the construct. i.e. is tolerance of ambiguity a uni or multidimensional construct, is it a static trait or dynamic state?<br>• To develop a conceptual model proposing the potential mechanism for any association between tolerance of ambiguity and psychological well-being. | 3. "*Development of a New Scale to Measure Ambiguity Tolerance in Veterinary Students"*<br><br>5. "*Tolerance of ambiguity and psychological well-being in medical training: A systematic review"* | |
| 5 | To use the example of mindfulness training to make the case for ensuring conceptual clarity and utilising a complex interventions development | 6. "*Mindfulness, complex interventions and conceptual clarity*" | |

| | | | |
|---|---|---|---|
| | framework when developing medical education interventions. | | |

*Table 1: Thesis objectives and hypothesis.*

The individual aims will be discussed in each Chapter. These Chapters will be followed by a discussion (Chapter 1 Part B) which considers the overarching results, their significance, and suggestions for the future research direction of this field.

*Please now read Chapters 2 to 6 before returning to Chapter 1 Part B.*

# Part B: General discussion

## 1. Overview

The aim of this thesis was to develop understanding and approaches to measurement of the tolerance of ambiguity construct in medical trainees, using veterinary trainees as a comparison group, and to improve understanding of the potential association between tolerance of ambiguity and psychological well-being. This aim has been achieved through engaging with the existing theoretical models and underpinning concepts in order to develop high quality measurement scales for the construct of tolerance of ambiguity in medical and veterinary professional populations. These scales were then used to compare levels of ambiguity tolerance in medical students and veterinary students, and finally the existing literature was assessed to determine if there is an association between tolerance of ambiguity and psychological well-being in the medical population. This learning was then used to help develop a middle-range theory relating to tolerance of ambiguity and the mediating and moderating factors that may influence the relationship between this construct and psychological well-being. The broader ambition of this thesis is to support the development and evaluation of educational interventions which will ultimately improve psychological well-being of medical trainees, and in turn support improved workforce sustainability and high quality patient care.

## 2. Key findings

### 2.1 Objective 1: Scale development

Following a process of literature review, discussions with medical education academics and clinicians, and reviewing existing scales, we developed a quantitative Tolerance of Ambiguity in Medical Students And Doctors measurement scale (TAMSAD). The final version contained 29 clinically contextualised items which evaluate the tolerance of ambiguity construct in the undergraduate and early postgraduate medical population (Chapter 2). We made a strong argument that this scale is valid within the medical student and foundation doctor population – albeit in one medical school and foundation programme setting, using the five criteria set out by Downing (2003). These include: content related validity evidence, response process, internal structure of scale, relationship to other variables, and

consequences of using the assessment scale. Despite our initial hypothesis the data suggested that the scale appeared to be acting in a unidimensional way in the population studied (Cronbach's alpha = 0.80). This interpretation is supported by the improvement in internal consistency observed when we removed three of the four items initially created to measure 'tolerant of ambiguity, but seeks to reduce ambiguity'. Whilst using exploratory factor analysis five factors could be identified accounting for 33% of total variance, numerous items had either no factor loadings > 0.3, or loaded moderately onto more than one factor. The finding that this scale is acting in a unidimensional way was not necessarily expected due to the assumed complexity of the tolerance of ambiguity construct, and the design of the scale based on three sub groups of items: 'tolerance of ambiguity, seeks out and thrives in ambiguous situations', 'tolerance of ambiguity, but seeks to reduce ambiguity', and 'intolerance of ambiguity'. It is also inconsistent with more recent models of personal epistemologies (Knight and Mattick, 2006*)* which suggest that a medical student's personal epistemologies may be multidimensional and progress and regress at different rates based on specific contextual cues.

Using this scale tolerance of ambiguity (shown by TAMSAD scores) was higher in the FY2 (second year postgraduate) doctors (62.34) compared to first (57.11, p = 0.012), third (56.36, p = 0.013) and fourth (57.72, p = 0.035) year medical students. These demonstrate moderate effect sizes. While this does raise the possibility that tolerance of ambiguity can increase in individuals between medical school and FY2 it is likely that multiple factors are underpinning this, including the increasing maturity of students and professionals. At this stage it is important to note that these findings are tentative and will require confirmation through larger studies with the validated TAMSAD scale.

Following publication of the TAMSAD scale one published conference abstract by Wilson *et al.* (2019) suggests that in a population of 102 Australian medical students it was not acting in a unidimensional way. They instead conclude that the construct may be complex and multi-faceted. The sample size of this study is small compared to our study (Chapter 2) and only included first and second year students in an anatomy educational setting. Further doubts are raised regarding the unidimensional structure of the TAMSAD scale by a qualitative study of preclinical medical student's

tolerance of uncertainty by the same research group in the same setting. This study found that preclinical students may appraise and respond to ambiguous educational stimuli in ways that could be categorised as both positive and negative, depending on the response domain discussed. For example if using Hillen *et al's.* (2017) model this may mean that a student could simultaneously express a positive cognitive response to ambiguity (e.g. information seeking), but a negative emotional response (e.g. fear) (Stephens *et al.,* 2021). It is important to note that these findings relate to one component of the undergraduate curriculum (anatomy). It has already been argued, in Part A of this Chapter, that students may engage differently with different topic areas with regard to how 'certain' they view those areas. These findings may not be replicated in different components of the undergraduate curriculum. Therefore it remains unclear if the TAMSAD scale is acting unidimensionally, and if this scale property would be replicated in larger or alternative medical training populations.

We utilised a similar methodology to develop a clinically contextualised scale for use in veterinary students. This required modification of the wording for 23 of the initial 41 items used in the development of the TAMSAD scale in the medical population to ensure that they were clinically contextualised for the veterinary population (Chapter 3). Most of the items required minor changes such as changing 'patient' to 'client' or 'doctor' to 'vet.' However two items needed more significant rephrasing. These items are shown in Table 2 below.

| Medical population (TAMSAD) | Veterinary population (TAVS) |
|---|---|
| As a doctor I would prefer the clear and definite work of someone like a surgeon to the uncertainties of a psychiatrist. | As a vet I would prefer the clear and definite work of someone like a surgeon to the uncertainties of a behavior specialist. |
| It's an exciting feeling when you listen to a patient tell you their symptoms and you just know what disease it is. | It's an exciting feeling when you listen to a client tell you their animal's symptoms and you just know what disease it is. |

*Table 2: Examples of change of wording for two items within the TAMSAD and TAVS scales.*

In contrast to the medical population the exploratory factor analysis indicated that the scale did appear to contain several facets: clusters of items that may be measuring slightly distinct constructs within the unifying construct of ambiguity tolerance within this population (See Table 3 below). However these four facets only cumulatively explained 26% of the total variance. It therefore remains likely that this scale is also measuring a unidimensional underlying construct. Following scale refinement a 27 item scale was developed (TAVS) which demonstrated an internal consistency (Cronbach's alpha) of 0.67. Again there is a strong argument that the scale is valid in this population using the Downing criteria.

| Proposed factor |
|---|
| 1. Novice view |
| 2. Discomfort from uncertainty |
| 3. Affinity for complexity |
| 4. Accepting indeterminacy (not being certain of the final outcome, closely related to probability) |

*Table 3: Summary of the proposed facets for the TAVS scale.*

In summary there is a strong argument for the validity of the TAMSAD scale in medical student and foundation doctors in this context (Chapter 2). This scale has been adapted to produce a measure of ambiguity tolerance in undergraduate veterinary students which appears to be valid in this setting (Chapter 3). However while both of these studies indicate that the scales may be acting in a unidimensional way in the populations studied this requires further exploration.

### 2.2 Objective 2: Comparing medical and veterinary student populations

The secondary data analysis (Chapter 4) comparing tolerance of ambiguity between these populations represented a methodological challenge as there are different measurement scale options available. After controlling for sex, graduate entry status and year of programme when the 29 item TAMSAD scale and the 27 item TAVS scale were used medical students had a higher level of tolerance to ambiguity compared to veterinary students (TAMSAD +1.95, $p < 0.01$, effect size 0.25, TAVS +

1.81, p = 0.02, effect size 0.19). However no difference was demonstrated when a new scale of 22 shared items between the two existing scales was used (-1.14, p = 0.513). It should be noted that the effect sizes found were small and it is therefore unclear how important these differences are. These findings were contrary to our initial *a priori* hypothesis that veterinary students would have higher tolerance of ambiguity, given the less well-established evidence base underpinning their work and the multiple animal species for which they may care. To date there have been no other studies comparing tolerance of ambiguity between these populations. From a methodological scale development perspective this highlights that for the tolerance of ambiguity construct even subtle changes to scale items can result in different findings. In particular this means that researchers must take care when using a scale that was validated in one setting in another. This will be discussed in more detail below.

### 2.3 Objective 3: Potential association with psychological well-being

In all 11 studies included within the systematic review (Chapter 5) there was a reported association between a higher level of intolerance of ambiguity or uncertainty and reduced psychological well-being within medical students and doctors. Studies were heterogeneous in terms of professional populations and country of study. Four studies were conducted within medical students. A range of measurements tools were used to measure tolerance of ambiguity or uncertainty and psychological well-being. Even when similar scales were used to evaluate tolerance of ambiguity, scale items, or interpretation were often modified without sufficient consideration to the potential impact on scale validity within the populations studied. This is problematic as in Chapter 4 we demonstrated that seemingly small technical decisions in scale design in this field can have significant implications for findings. Given the study designs involved, the heterogeneity of measurement approaches used and the different populations studied, it was not possible to draw firm conclusions about the direction of causality or strength of the identified association. A link to a podcast interview with Kevin Eva (the Editor-in-Chief of Medical Education) that explores these and other implications of the publication in Chapter 5 can be found in Appendix 4.

## 2.4 Objective 4: Conceptual development

### *2.4.1 Tolerance of ambiguity construct*

It appears increasingly likely that tolerance of ambiguity is a dynamic construct that can change between entry to medical school and the second year of medical postgraduate training. Support for this is provided by the TAMSAD scores across year groups at different stages of their medical training (Chapter 2). This view is further supported by a qualitative study of preclinical medical students engaged in anatomy training which suggests that multiple aspects of the learning environment may impact on student's tolerance of uncertainty (Stephens *et al.,* 2021). While to date evidence regarding the role of educational interventions in moderating tolerance of ambiguity is lacking our findings provide tentative evidence that tolerance of ambiguity may be a dynamic state that could be modified by complex medical education interventions. One implication of these findings is that extra caution should be applied when using existing scales that have assumed tolerance of ambiguity to be a static personality trait, such as the Bunder (1962) scale.

### *2.4.2 Association between ambiguity tolerance and psychological well-being*

To support more rigorously designed research programmes in order to advance this field a conceptual model is proposed (Chapter 5), drawing on the findings of this systematic review, and building on the previous work of Hillen *et al*. (2017, Figure 1). The model proposes that medical students and doctors may move through a range of psychological responses from an inability to tolerate ambiguity to intolerance of uncertainty, stress, burnout, and eventually the development of a mental health disorder. Stress, burnout and mental health disorders are included under the broader term psychological well-being. It may be that some students and doctors do not move through all stages, and some may not progress at all. The meditating and moderating factors that may influence this require further research. The conceptual model proposed that these factors could include personal factors (modifiable and non-modifiable), or cultural and workplace factors. A detailed description of the model is included in Chapter 5.

## 2.5 Objective 5: Complex intervention development

Chapter 6 uses the example of mindfulness training to make the case for ensuring conceptual clarity and utilisation of a complex interventions framework when

developing and evaluating medical education interventions. This is of particular relevance to the tolerance of ambiguity construct as any intervention developed to either enhance tolerance of ambiguity, or to modify the relationship between ambiguity tolerance and psychological well-being is likely to be complex. In this context complexity refers to any intervention with multiple components that are likely to interact in unforeseen ways with other components at various levels to influence the outcome. This includes individual, curriculum, organisation, and the wider health system components. While the Medical Research Council (2006) framework can be used to support the development and evaluation of these interventions this is often neglected in the field of medical education. In particular insufficient emphasis is often placed on identifying and refining theory within the development phase of an intervention (Mattick *et al.,* 2013). There is now an opportunity to make use of the TAMSAD scale developed in Chapter 2 to help build and refine theoretical understanding of the ambiguity tolerance construct. This will be discussed in more detail later in this thesis.

## 3. Methodological strengths and limitations

Methodological strengths and limitations will be split into discussion regarding the scale development, and discussion regarding the systematic review and subsequent development of the conceptual model. The strengths and limitations of each empirical study have been covered in depth in Chapters 2 – 5, and therefore this section will focus on the overall strengths and limitations of this thesis.

### 3.1 Scale development

The main strengths of both the TAMSAD and TAVS scales and the strong validity arguments for each have already been discussed. The direct comparison of medical and veterinary populations is a rare example of truly cross professional collaboration and is more sophisticated and nuanced than previous attempts. However in both cases data collection only took place in one site, meaning that claims regarding the validity of each scale only relates to the specific settings and populations described. Subsequently it can be difficult to attribute observed differences to profession, location or curriculum design.

One limitation of both scales is the lack of published data regarding the test-retest reliability. However an analysis of a component of each scale's reliability was possible through reviewing the Cronbach's alphas (0.8 for the TAMSAD, and 0.67 for the TAVS). This is a measure of a scale's internal consistency, which provides evidence that the individual items of a scale are consistently measuring the same underlying construct (Field, 2005). More details and interpretation of the Cronbach's alphas for both scales are reported in Chapters 2 and 3.

The lack of clarity around test-retest reliability does mean that it remains unclear how stable the underlying tolerance of ambiguity construct may be, and how much for example it may change day to day. In order to determine this further evaluation is required. This will be possible for the TAMSAD through analysing the data collected through a national longitudinal evaluation of interim Foundation year doctors (see Table 4), where serial TAMSAD scales have been completed by participants.

One criticism of self-reported scales such as the TAMSAD and TAVS is that they often use hypothetical scenarios rather than real life encounters by the professional. While it is likely that there is a high correlation between intention and action (theory of planned behaviour) it has been suggested that other factors may restrain this association (Hamui-Sutton *et al.,* 2015). Despite these concerns the scenarios included within the scales were clinically contextualised, carefully constructed, and directly relevant for their respective populations. This is not the case for many of the scales developed prior to the TAMSAD, which were largely acontextual.

Literature around definitions of ambiguity and uncertainty, and what it means to tolerate these, changed during the course of the PhD registration. At the point the TAMSAD scale was developed this was based on definitions which considered ambiguity (vagueness) as a stimulus present within the clinical environment, and uncertainty as the response within an individual. The TAMSAD scale developed in Chapter 2 was later included in the Hillen *et al.* (2017) review which resulted in the published integrative model of uncertainty tolerance. This model suggests that ambiguity, probability or complexity within the clinical environment causes an individual to experience uncertainty (conscious awareness of ignorance), which can result in responses that can be categorised as positive or negative, and cognitive,

emotional, or behavioural. In their review paper Hillen *et al.* (2017), using these new definitions, judge that the TAMSAD scale does not only evaluate ambiguity, but may also implicitly measure complexity, error, impermanence, incompleteness, indefinitiveness, insolubility, non-transparency, unfamiliarity, unpredictability and variety. They also judge that the 'tolerance' measured by the scale relates to cognitive (attraction/aversion, denial) and emotional (anger, comfort/discomfort, enjoyment, worry/anxiety) outcomes. From my perspective I continue to hold the view that the TAMSAD scale is measuring tolerance of ambiguity. By this I mean it is assessing the cognitive, emotional and behavioural responses of an individual in response to a clinical scenario in which there is imprecise, missing or conflicting information (ambiguity). In addition, in part due to the clarifications and developments in our understanding of the construct over the course of the research programme, it is also likely that several items of the TAMSAD scale are assessing the cognitive, emotional and behavioural responses of an individual to related (and similar) constructs, such as complexity.

In order to better understand how the items within the TAMSAD scale map onto the Hillen *et al.,* (2017) model, and how the items included within the scale may converge and diverge with the current published definitions, further evaluation of the scale items are required. This would benefit from a qualitative approach, such as a 'think aloud' protocol for each item of the scale (Willis and Artino, 2013). This represents a potential new exploratory use for the TAMSAD scale, i.e. supporting the development and refinement of existing conceptual models and theory, which will be discussed in more detail in the future research section of this Chapter.

Further consideration must also be given to the strengths and limitations associated with the Classical Test Theory (CTT) that underpins the TAMSAD scale development. CTT in this context makes the assumption that there is a 'true score' for the psychological construct of ambiguity tolerance that can be calculated, and that this score, along with an unknown degree of error, is being calculated by the TAMSAD scale. The strength of this approach is that if we assume that ambiguity tolerance cannot be directly observed, nor measured by a single variable or item, then using multiple items can account for item specific measurement errors and can lead to more accurate measurement of the construct (Boateng, 2018).

One criticism of CTT is that the validity and reliability of the scale only applies to the population studied, as has already been discussed. It cannot therefore be assumed that the scale is valid and reliable for future, subtly different populations. The implications of this for future research is that the validity of the scale in future populations should be carefully considered, and a further validity argument for the scales may be required. The TAMSAD scale utilises a five point likert response ranging from ‘strongly disagree’ to ‘strongly agree’ and there is an argument that ordinal likert responses, such as these, should not be assumed to be interval. Subsequently it has been suggested that non-parametric measures, such as the median or mode, may be most appropriate to evaluate participant responses in these circumstances (Jamieson, 2004). In our populations as the data was found to be normally distributed we determined that it was acceptable to use parametric statistical measures.

Alternative quantitative measurement strategies could include the use of Item Response Theory (IRT). This approach can have several theoretical and practical advantages over CCT including the possibility of using less items for each participant, and the greater certainty that the scales produced are interval, rather than ordinal. However the disadvantage to using IRT for a construct such as tolerance of ambiguity is that it cannot be used for multifaceted and complex constructs. Given our initial hypothesis (that tolerance of ambiguity would be a multifaceted construct) it appeared more appropriate to use CCT when developing the TAMSAD measurement scale (Streiner and Norman, 2008).

### 3.2 Systematic review/ conceptual model development

The strengths of the systematic review (Chapter 5) include the exhaustive search of the peer-reviewed and grey literature, clear inclusion and exclusion criteria, double screening of a proportion of the identified studies, standardised data extraction techniques and the quality assessment of included studies. It is one of the first studies to conduct rigorous research exploring the impact and implications of intolerance of ambiguity on psychological well-being in this population. The careful synthesis of a complex and diverse literature into a clear picture helped to support development of the conceptual model offering an explanation for the observed association. This is an example of developing a middle-range theory which is an

important and often neglected component of the development phase of a complex intervention.

The limitations of the review are discussed in detail in Chapter 5. While the diverse range of literature identified was a strength it does mean that the review may be combining slightly different constructs, depending on the definitions adopted and the scales used. For example the concept of burnout differs between countries, cultures and studies. Finally the self-reported nature of scales used, particularly when evaluating psychological well-being, risk under or over reporting rates of stress, burnout or presence of a mental health disorder.

It is important to acknowledge that while this review was termed a systematic review it does sit at the theory generating end of the spectrum. In part this is a reflection of the state of knowledge in this field, however the review also aims to configure existing data in an attempt to determine what the emergent concepts may be and generate new middle-range theory in the form of a conceptual model (Gough and Thomas, 2016). Some may have termed this a scoping review as it aims to identify nature and extent of research evidence, and assess the quantity and quality of literature in order to plan future research questions and direction (Grant and Booth, 2009). One criticism may be that identifying relevant research for a construct such as tolerance of ambiguity is somewhat problematic as – by its nature – the field is multidisciplinary, crossing the disciplines of health care, communication, sociology, cultural studies and others (Teunissen, 2016). It may be therefore that the review could have benefitted from a much broader search criteria across various fields outside of medicine, psychology and medical education, with a specific focus on identifying qualitative research or research utilising mixed methodologies. However this would have required a far greater time resource than was available in the context of a PhD.

With regard to the development of the conceptual model many of the strategies used in the development of this middle-range theory have been recognised in similar fields such as nursing (Eun-Ok, 2018). Development of this theory makes use of a deductive (making use of existing theory) and inductive process (using research findings from Chapter 5, *a priori* knowledge and experience and data from Chapters

2 – 4). Subsequently it is important to consider the potential impact of my own worldview on the development of this model. I reflect on this in more detail in my Author biography in Appendix 1. Unlike the majority of middle-range theories this model does not rely on one empirical study alone but a systematic review of the current literature including multiple studies. The model would have been strengthened further by involving stakeholders including students, medical postgraduate trainees, medical educators and academics, and clinicians. This will be discussed in more detail in the Future Research section below.

## 4. Key academic contributions of this thesis

The key academic contribution of Chapters 2 to 4 relate to the development of high quality measurement scales that allow evaluation of tolerance of ambiguity in medical students and junior doctors (TAMSAD) and veterinary students (TAVS). In both cases a strong validity argument has been made for their use in the populations described. The development of these tools has already and will continue to support the research community to further advance this field. Both the TAMSAD scale (Lodewyk *et al.,* 2020; Ndoja *et al.,* 2020; Babenko *et al.,* 2021), and the TAVS scales (Fernandez *et al.,* 2021) have already been used in a number of published studies. The TAMSAD scale has also been utilised in a national General Medical Council funded survey within the UK in order evaluate Interim Foundation Programme (FiY1) posts in the context of the COVID-19 pandemic (2020 medical graduates). In addition the scale has been modified and translated into a number of languages (French, Italian and Portuguese) in order to allow researchers in different countries to research tolerance of ambiguity in medical training populations. The current interest in use of the TAMSAD scale largely reflects a growing academic interest in this topic area and the limited availability of high quality measurement scales prior to the development of the TAMSAD. Some of the examples of the TAMSAD scale use are outlined in Table 4. Information within this table has been compiled following direct correspondence with lead researchers for each study.

| Country | Description of reseaech | Modifications within TAMSAD tool |
|---|---|---|

| | | |
|---|---|---|
| UK | An evaluation of Interim Foundation Programme (FiY1) posts in the context of the COVID-19 pandemic.<br><br>The TAMSAD scale forms one of the questionnaires that FiY1 doctors were asked to complete longitudinally. | No modification. |
| Brazil | Analyse the impact of ambiguity intolerance on student performance during undergraduate medical assessments. | TAMSAD 29 item scale translated into Portugese. |
| Italy | TAMSAD scale administered to a sample of medical students in Italy before and after a training on diagnostic errors. | TAMSAD 29 item scale translated into Italian. |
| France | TAMSAD used to evaluate programme aiming to enhance tolerance of uncertainty in French GPs. | TAMSAD 29 item scale translated into French. |
| Canada | Modified version of TAMSAD used to offer insights into the association of ambiguity tolerance with demographic variables, stage of training, and other measures of mindfulness and well-being of counsellors in training. | Modified version of TAMSAD developed and validated. |

*Table 4: Examples of use of TAMSAD scale by other researchers.*

A further key methodological contribution is the finding that even subtle changes in the items constituting a tolerance of ambiguity scale can produce statistically significant differences in the mean tolerance of ambiguity of the population studied. This was demonstrated when using three subtly different scales to compare levels of tolerance of ambiguity between medical and veterinary student populations. This is

particularly important when scales, such as the original Budner (1962) scale, have often been modified without sufficient consideration for the impact on validity, for example in the study by Lally *et al.* (2014) described in Chapter 5. This is of importance as it has been proposed that medical schools should do more to assess prospective students' tolerance to ambiguity as part of the admissions process (Geller, 2013), and some institutions appear to be using tolerance of uncertainty quantitative measures for assessment of medical education curricula and students (Stephens *et al.,* 2021). There are also implications for cross professional learning as this indicates that researchers should exercise caution when using measurement scales and extrapolating research findings from the medical undergraduate population to either the veterinary student setting or other health professional populations.

The combined scale development work has also provided some welcome conceptual clarity around the construct of tolerance of ambiguity in these populations, that it is likely to be a dynamic state and that it may be acting in a unidimensional way. The importance of this is set out in Chapter 6 where it is argued that conceptual clarity is required prior to the development of a complex educational intervention, for example those aiming to enhance tolerance of ambiguity.

Chapter 5 is the first systematic review to investigate the potential association between tolerance of ambiguity and the broader concept of psychological well-being. The proposed conceptual model is offered as a starting point for future research and again development of underlying theory represents an often neglected phase of the development of a medical education intervention (Mattick *et al.,* 2013).

## 5. Implications for future research

### 5.1 Remaining unanswered questions

This thesis has supported improved conceptual clarity around the tolerance of ambiguity construct, the measurement of tolerance of ambiguity in the medical and veterinary training populations, and the potential association between tolerance of ambiguity and psychological well-being. Despite these developments several key questions remain regarding the TAMSAD scale. Further exploration is required in order to determine the test-retest reliability of the scale, and to determine if the scale

is indeed measuring a unidimensional construct, as Chapter 2 suggests, or a multi-dimensional construct as had been initially hypothesised. One challenge associated with the CTT approach to TAMSAD scale development is the need to ensure that the scale is reliable and valid in populations beyond those already studied. Future research could also make use of the TAMSAD scale in a more exploratory way, for example to determine how the items included within the TAMSAD scale map onto the Hillen *et al.,* (2017) conceptual model. This may support further refinement of the TAMSAD scale, and further understanding of the underlying tolerance of ambiguity construct.

Further work is required to refine and improve the proposed conceptual model in Chapter 5 through an iterative process, initially through stakeholder engagement and then through the planning and delivery of further empirical studies. In particular the model would benefit from further clarity regarding the direction and strength of the relationship between tolerance of ambiguity and psychological well-being. Further exploration into the mediating and moderating factors that may influence this relationship at the level of the individual and the wider system is also required. Clarification of these questions will support the future development of medical education interventions that aim to either enhance tolerance of ambiguity, or modify the relationship between ambiguity intolerance and psychological well-being, in the medical trainee and practitioner population. In time the hope is that this can support improved medical workforce sustainability and the delivery of high quality patient care.

### 5.2 Future research

It will soon be possible to further explore psychometric properties of the TAMSAD scale thanks to the ongoing research studies utilising the scale. For example the evaluation of Interim FY1 doctors as they transitioned into a novel postgraduate training programme in the context of the COVID-19 pandemic in the UK (2020 medical graduates). Utilising the scale in a multi-centre study such as this will allow evaluation of the scale's validity in a population of newly qualified doctors who have been exposed to a wide range of educational approaches during their undergraduate training, and may provide further insights into the dimensionality of the scale. It may also allow us to understand the test-retest reliability of the scale through examining

participant's serial TAMSAD scores. This evaluation also used qualitative methodologies to better understand the experiences of Interim FY1 doctors which may provide further insights into the tolerance of ambiguity construct at a national level.

A further study, currently in development, plans to make use of the TAMSAD scale in a more exploratory way, through using a think aloud protocol, to determine how doctors-in training understand, internalise, and respond to items from the scale (Lazarus *et al.,* 2021). The think-aloud data will be analysed thematically, and this information will be used to determine how the items from the scale converge or diverge from the proposed Hillen *et al.* (2017) model. In turn this may support further refinement of the items within the TAMSAD scale (Willis and Artino, 2013) and/ or further improve our understanding of the tolerance of ambiguity construct.

Further refinement is also required of the conceptual model proposed in Chapter 5 before it can be used to guide the development of further empirical studies and medical education interventions. Results from Chapter 5 and the conceptual model could be presented to a group of stakeholders selected for their diverse perspectives and insights in the areas of undergraduate and postgraduate medical education and training, psychological well-being of doctors and health services research. The purpose of this process would be to consider validity of the findings of the systematic review, and consider the mechanisms that may underpin the relationship between tolerance of ambiguity and psychological well-being, along with the potential mediating and moderating factors that may influence this relationship. This process would help to triangulate findings of Chapter 5 and ensure that the proposed model is grounded in real-world medical education and clinical practice.

This process would require purposeful sampling of key medical education stakeholders. The findings of Chapter 5, and the current proposed conceptual model, would be presented to stakeholders and they would be asked to comment on the model. It is anticipated that their responses would help guide the planning of future empirical studies in order to further refine this conceptual model, in particular to help prioritise where in the conceptual model to test and how this should be tested. This process is outlined in Figure 2. 'Stakeholder engagement' and 'further empirical

research' relate to the work that is now required to aid further refinement of the conceptual model developed in Chapter 5.

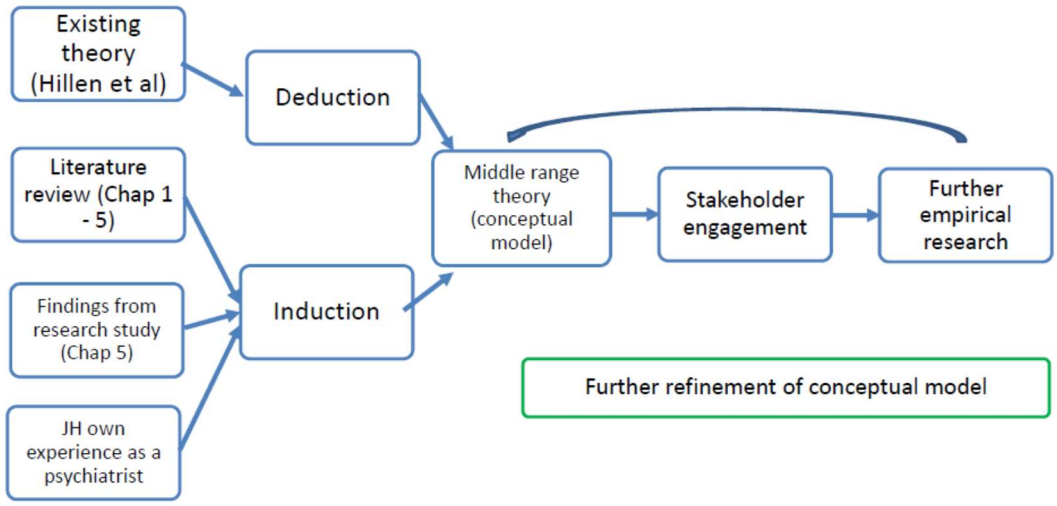


*Figure 2: Process of conceptual model development (Chapter 5).*

It is likely that future research will require the use of qualitative methodologies to support the iterative development of this model through better understanding of the mechanisms that may underpin the relationships between tolerance of ambiguity and psychological well-being.

Finally it is important to consider how the TAMSAD scale may be utilised in populations, both within and outside the field of medical education. It is promising that to date both the TAMSAD and TAVS scales have generated interest from research colleagues in a range of countries and educational settings. However it is important to emphasise the need for future researchers to see the use and development of these scales within their own populations as a process, rather than viewing the scale as a ready to use finished product. Chapter 3 describes how the TAMSAD scale can be modified for a specific population outside of medical education (veterinary students). In this Chapter the psychometric properties and validity of the scale in this new population are carefully considered. This Chapter describes some of the challenges associated with tailoring the TAMSAD scale for use in this population, and ultimately different items were included in the final versions of the two scales. Chapter 4 demonstrates some of the practical and methodological challenges associated with using different versions of a similar scale to compare ambiguity tolerance in different populations and settings. Subsequently

use of quantitative scales, such as the TAMSAD or TAVS, alone, may fail to provide the cross professional insights necessary to further the field.

## 6. Implications for education and clinical training

At the level of the individual the TAMSAD scale has been used in educational settings to encourage clinicians to reflect on their own responses to ambiguity and to consider how this may compare to that of their colleagues. This has at times stimulated conversations between professionals from within the same clinical group, such as General Practitioners. In the future the scale could be used to stimulate reflection and discussion between trainee and supervisor regarding a trainee's response to ambiguous clinical scenarios, which may in turn result in modifications to their clinical practice.

More broadly this thesis will support future researchers to design and evaluate complex educational interventions at the level of the individual, or the workplace, that may enhance tolerance of ambiguity or psychological well-being. While it may be too soon to propose and outline specific educational interventions in detail it is likely that workplace cultures, environments, and undergraduate and postgraduate training programmes, could be designed differently to support improved psychological well-being within medical trainees and medical practitioners. It is also likely that interventions would involve multiple, concurrent changes. These could include interventions to support increased tolerance of ambiguity within an individual, or their working environment, or could target the mediating or moderating factors that may influence the relationship between tolerance of ambiguity and psychological well-being.

My thesis has contributed towards the development phase of these potential complex interventions through identifying the existing evidence base regarding the tolerance of ambiguity construct (Chapters 2, 3 and 4), and identifying and developing theory in the form of the conceptual model proposed in Chapter 5 (Medical Research Council, 2006). Development of these interventions is of particular importance as early postgraduate doctors in the UK continue to report a lack of preparedness in managing uncertainty in their clinical practice (Monrouxe *et al.,* 2018). In addition health system wide uncertainty, both within the UK and

beyond, has increased in the context of the COVID-19 pandemic (Carrieri *et al.,* 2020; Simpkin, 2020).

## 7. Conclusion

This thesis has supported improved conceptual clarity around the tolerance of ambiguity construct, through the development of validated measurement scales for use in doctors-in-training (TAMSAD) and veterinary students (TAVS). It has also demonstrated an association between intolerance of ambiguity and reduced psychological well-being in medical students and doctors, and proposed a middle-range theory to conceptualise this association, along with the potential mediating and moderating factors that may underpin it.

Further clarification is needed to determine if the TAMSAD scale is measuring a unidimensional construct, and to determine if the scale remains valid in different medical training populations. This scale may also prove useful in supporting further understanding of the tolerance of ambiguity construct. Work is needed to refine the proposed conceptual model through a process of stakeholder engagement to help inform future quantitative and qualitative empirical research.

The hope is that this research will support medical education researchers to develop complex medical education interventions, making use of the MRC framework, to improve psychological well-being of medical trainees, and the wider medical workforce. This could include interventions to support increased tolerance of ambiguity within an individual, or environment, or could target the mediating or moderating factors that may influence the relationship between tolerance of ambiguity and psychological well-being. In time these interventions could help to support improved workforce recruitment, retention and ultimately the quality of patient care.

# Chapter 2: Medical student and junior doctors' tolerance of ambiguity: development of a new scale

Hancock, J., Roberts, M., Monrouxe, L. and Mattick, K. (2015) Medical student and junior doctors' tolerance of ambiguity: development of a new scale, *Advances in Health Sciences Education,* 20(1): 113-130.

## Chapter 3: Development of a new scale to measure ambiguity tolerance in veterinary students

Hammond, J., Hancock, J., Martin, M., Jamieson, S. and Mellor, D. (2017) Development of a new scale to measure ambiguity tolerance in veterinary students. *Journal of Veterinary Medical Education,* 44(1): 38-49.

# Chapter 4: Comparing tolerance of ambiguity in veterinary and medical students

Hancock, J. Hammond, JA. Roberts, M. and Mattick, K. (2017) Comparing tolerance of ambiguity in veterinary and medical students*, Journal of Veterinary Medical Education,* 44(3): 523- 530.

## Chapter 5: Ambiguity tolerance and psychological well-being in medical training: a systematic review

Hancock, J. and Mattick, K. (2020) Tolerance of ambiguity and psychological well-being in medical training: A systematic review, *Medical Education*, 54:125–137.

## Chapter 6: Mindfulness, complex interventions and conceptual clarity

Hancock, J. and Mattick, K. (2020) Mindfulness, complex interventions and conceptual clarity, *Medical Education*, 54(9): 774-776.

# Appendix

1. Author biography
2. Written permission for third party material
3. Link to the podcast interview to discuss Chapter 5
4. Ethical approval participant information sheets and consent forms for participants (Chapters 2 and 4)
5. Final 29 item TAMSAD scale (Chapter 2)
6. Additional information for empirical chapters:

## 1. Author biography

I have included the following background information about myself as I now hold the view that my beliefs, clinical and educational experiences will influence the research questions that I am asking, my interpretation of the data, and will have heavily influenced the development of the conceptual model included in Chapter 5.

I am a consultant liaison psychiatrist in Exeter with a clinical interest in integrated psychological medicine. In particular I have an interest in supporting medical teams to better recognise and support patients who present with medically unexplained symptoms. I have developed and continue to run a joint psychodermatology clinic with a consultant dermatologist in Exeter.

I first became interested in how medical students and doctors tolerate ambiguity within clinical settings when I was working as a medical education university fellow, shortly after I had completed foundation training. At that time I noticed that ambiguity was present in almost all aspects of medicine and that my medical (foundation doctor) colleagues seemed to have a range of different responses to ambiguity in the clinical setting.

At that time I had a broadly positivist worldview, likely influenced by my biomedical training. I set out to develop and evaluate the TAMAD scale based on the assumption that the construct of tolerance of ambiguity existed, and could be accurately and objectively measured. The quantitative methodology associated with the scale development and validation was selected as I believed that if I used the 'correct' scale items then a scale could be used to help answer 'objective' scientific questions about the construct of ambiguity tolerance in this population. Specifically that the scale could be used to predict causal connections and associations with other measurable constructs such as psychological well-being.

Since publication of the first paper from this thesis in 2015 I have continued to progress this research alongside core psychiatry and later higher specialist general adult and old age psychiatry training in Devon. As I have been exposed to, and engaged with, a range of clinical and educational training experiences my worldview has changed, as well as my ontological and epistemological assumptions. I now hold a more interpretivist view of the world. That is a belief that there may be multiple

realities, and that these realities are complex and context dependant. Subsequently it has become clear to me that my own beliefs, clinical and educational experiences will influence the research questions that I am asking. In particular this was evident when developing the conceptual model outlined in Chapter 5.

While I still feel the development and use of the TAMSAD scale has added value to the research field my current view is that rather than using this scale in an objective way to test theory we should use the scale in a more tentative way to support theory building. For example around how tolerance of ambiguity may be associated with closely related constructs such as psychological well-being in the doctors-in-training population. It is now clear to me that further understanding of this important construct and the associated theory is going to require qualitative methodologies, potentially alongside the scale, such as using think aloud protocols (as described in Chapter 1 Part B).

I hope to continue to develop research skills in this field and in time to better understand the mediating and moderating factors that may influence the relationship between tolerance of ambiguity and psychological well-being in doctors-in-training. I also hope to develop and evaluate educational interventions at the level of the individual and organisation to better support medical students and doctors tolerate ambiguity and uncertainty within medical practice.

## 2. Written permission for third party material

Paul Han <hanp@mmc.org>

Thu 2/13/2020 1:45 PM

To: Hancock, Jason

Dear Jason,

Thanks for your note, and it's nice to meet you virtually. I've come across your papers as well in the past, and am very glad to see you are pursuing this area further. It's fine with me to include the UT model/figure, and please let me know if you need any other information. I will be interested in seeing more of your work in the future, and wish you all the best!

Paul

From: Hancock, Jason <jrh221@exeter.ac.uk>

Sent: Wednesday, February 12, 2020 3:30:05 PM

To: Paul Han

Subject: Request to include model/ figure within my PhD

Dear Dr Han,

I am writing to you regarding your work developing an integrative model to better understand what it means to tolerate ambiguity and uncertainty in healthcare. This is an area that I am also researching and I have read your papers many times over the last few years. They have been influential in shaping my own research investigating a potential association between ambiguity tolerance and psychological well-being in medical training (medical students and doctors).

I have published several papers in the field and am now writing an integrative chapter to convert these papers into a PhD by publication with the University of Exeter (UK).

I would like to ask for permission to reproduce Figure 2: Integrative model of uncertainty tolerance, from the paper "Tolerance of uncertainty: Conceptual analysis, integrative model, and implications for healthcare", Social Science and Medicine, 2017, 180: 62-75, within my PhD introduction chapter. Including this would be really helpful in visually displaying the current definitions and models within this field. This would of course be fully acknowledged as your work.

I would be happy to answer any questions that you have. Thank you for considering this request.

Jason

Dr. Jason Hancock

### 3. Link to the podcast interview to discuss Chapter 5

https://medicaleducation.podbean.com/e/tolerance-of-ambiguity-and-psychological-well-being-in-medical-training-a-systematic-review-interview-with-jason-hancock/

## 4. Ethical approval participant information sheets and consent forms for participants (Chapters 2 and 4)

PENINSULA
COLLEGE OF MEDICINE & DENTISTRY
UNIVERSITIES OF EXETER & PLYMOUTH

Our Ref: PF/CJB/58Δ1

3rd April 2012

[redacted]

***Please reply to:***
*Peta Foxall, PhD*
*Chair, PCMD Research Ethics Committee*
*Peninsula College of Medicine & Dentistry*
*c/o Carol Barkle*
*Administrator to PCMD REC*
*Knowledge Spa*
*Royal Cornwall Hospital*
*TRURO*
*Cornwall*
*TR1 3HD*
*Tel: /01872 256460*
*Fax: 01872 256401*
***Email:*** carol.barkle@pms.ac.uk

Dear Dr Hancock

**Application Number: 12/03/144**
**Project Title: Assessing medical students and foundation doctors' tolerance of ambiguity**

I am writing to confirm that I am now happy that you have addressed all the points made by the PCMD Research Ethics Committee relating to the above project. I have approved this project under Chair's Action with immediate effect and have pleasure in enclosing your Certificate of Approval.

Approval of this study will be formally ratified by the Peninsula College of Medicine and Dentistry Research Ethics Committee when it meets again on the 26th April 2012.

Good luck with your study.

Yours sincerely,

[redacted]

**Peta Foxall, PhD**
**Chair**
**Peninsula College of Medicine & Dentistry Research Ethics Committee**

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Interim Associate Dean for Cornwall **Dr Nicki Saulsbury**

PENINSULA
COLLEGE OF MEDICINE & DENTISTRY
UNIVERSITIES OF EXETER & PLYMOUTH

# Peninsula College of Medicine & Dentistry
# Research Ethics Committee

## Certificate of Ethical Approval

**School/Institute/Department:** Institute of Clinical Education

**Title of Project:** Assessing medical students' and foundation doctors' tolerance of ambiguity

**Name(s) of Project Research Team member(s):** Dr Jason Hancock
Dr Karen Mattick

**Project Contact Point:** Dr Jason Hancock

**This project has been approved for the period**

**From:** April 2012

**To:** April 2013

**Peninsula College of Medicine & Dentistry**
**Research Ethics Committee approval reference:** Apr12/CA/144

**Signature:** [redacted]

**Date:** 3rd April 2012

**Name of Chair**
**Peta Foxall, PhD**

Your attention is drawn of the attached paper "Guidance for Researchers when Ethics Committee approval is given", which reminds the researcher of information that needs to be observed when Ethics Committee approval is given.

Application Reference Number 12/03/144

PENINSULA
MEDICAL SCHOOL
UNIVERSITIES OF EXETER & PLYMOUTH

**Assessing medical students' and foundation doctors' tolerance of ambiguity**

**INFORMATION SHEET Version 4, 9/3/12, FOR PARTICIPANTS**

Thank you for showing an interest in this project. Please read this information sheet before deciding whether or not to participate. If you decide to participate we thank you. If you decide not to take part there will be no disadvantage to you of any kind and we thank you for considering our request.

**What is the aim of the project?**
We aim to determine if medical students' tolerance of ambiguity changes during the course of their undergraduate studies and during their time working as a foundation doctor. In addition we wish to determine if students/doctors tolerance of ambiguity has an effect on their perceived final career destination.

**What type of participants are needed?**
All undergraduate medical students at Peninsula Medical School and foundation doctors working within the Peninsula Deanery.

**What will participants be asked to do?**
Should you agree to take part in this project, you will be asked to complete a 41 item Tolerance of Ambiguity of Medical Students and Doctors (TAMSAD) questionnaire. You will be asked what speciality you currently see yourself working within in the future, your sex and if you completed a degree before starting medical school. The questionnaire takes 5 minutes to complete. Please be aware that you may decide not to take part in the project at any time without any disadvantage to yourself.

Should you decide to take part in the survey you will have the opportunity of receiving feedback allowing you to compare your own tolerance of ambiguity with that of your peers – this would give you the opportunity to reflect on your own tolerance of ambiguity should you wish to do so. If you wish to receive feedback you will need to provide us with a contact e-mail address.

**Payment to volunteers/interviewees**
All students or doctors completing the questionnaire will be entered into a prize draw for £75.

**What data or information will be collected and what use will be made of it?**
We will collect your survey responses as well as asking you to provide us with your current year of study, your current perceived final career destination, your gender and if you completed a degree before starting medical school. We will ask you no further personal information apart from your e-mail address should you wish to receive feedback. Results of this project may be published but any data included will not be individually identifiable. The data collected will be stored securely in such a way that only those mentioned below will be able to gain access to it.

**What if participants have any questions?**
If you have any questions about our project, either now or in the future, please feel free to contact one of the research team. You are most welcome to request a copy of the results of the project should you wish.

Jason Hancock [redacted] or Karen Mattick [redacted]

**Complaints**

If you have any complaints about the way in which this study has been carried out please contact the Chair of the Peninsula College of Medicine and Dentistry Research Ethics Committee:-

Peta Foxall, PhD

Chair, PCMD Research Ethics Committee

Email [redacted]

**Dr Jason Hancock**
**Academic Clinical Fellow**

[redacted]

**This project has been reviewed and approved by the Peninsula College of Medicine and Dentistry Research Ethics Committee**

**Assessing medical students and foundation doctors tolerance of ambiguity**

**CONSENT FORM FOR PARTICIPANTS**
[VERSION 4: 9/3/12]

I have read the Information Sheet Version [4] Date [9/3/12] concerning this project and understand what it is about. All my questions have been answered to my satisfaction. I understand that I am free to request further information at any stage.

I know that:-

1. My participation in the project is entirely voluntary; Y/N
2. I am free to withdraw from the project at any time without any disadvantage; Y/N
3. The data will be retained in secure storage
3. The results of the project may be published but my anonymity will be preserved. Y/N

I agree to take part in this project.

| | | |
|---|---|---|
| ..... (Printed name of participant) | ..... (Signature of participant) | ..... (Date) |
| ..... (Printed name of researcher) | ..... (Signature of researcher) | ..... (Date) |

**This project has been reviewed and approved by the Peninsula College of Medicine and Dentistry Research Ethics Committee**

UNIVERSITY OF EXETER | MEDICAL SCHOOL

Our Ref: PF/CB/CA116

15th October 2015

***Please reply to:***
*Peta Foxall, PhD*
*Chair, UEMS Research Ethics Committee*
*University of Exeter Medical School*
*c/o Carol Barkle*
*Administrator to UEMS REC*
*Knowledge Spa*
*Royal Cornwall Hospital*
*TRURO*
*Cornwall*
*TR1 3HD*
*Tel: 01872 256460*
***Email:*** *c.barkle@exeter.ac.uk*

Dr Jason Hancock
[redacted]

Dear Dr Hancock

**Application Number: PCMD 12/03/144 & CA116**
**Project Title: Assessing medical students' and foundation doctors' tolerance of ambiguity**

I am delighted to inform you that I have reviewed the paperwork for the secondary analysis project you wish to conduct using data from the above study. I am able to confirm that further ethical review and approval is not required from the University of Exeter Medical School Research Ethics Committee.

I am content that ethical approval for the University of Glasgow element of this collaboration is in place and I have granted permission by Chair's Action for the University of Exeter element. In line with the University of Glasgow conditions, approval is granted until 31st December 2017. Our requirements for the governance and safe storage of the data are assured by the underpinning systems of the University of Exeter. Please let us have a copy of your final study report upon completion.

Good luck with your study.

Yours sincerely,

[redacted]

**Peta Foxall, PhD**
**Chair**
**University of Exeter Medical School Research Ethics Committee**

## 5. Final 29 item TAMSAD scale

**Tolerance of Ambiguity of Medical Students and Doctors (TAMSAD): 29 item version**

*Please place a X or a √ in the box that most applies to you for each statement.*

| | Statement | Strongly disagree (1) | Disagree (2) | Neutral (3) | Agree (4) | Strongly agree (5) |
|---|---|---|---|---|---|---|
| 1 | I would enjoy tailoring treatments to individual patient problems | | | | | |
| 2 | I have a lot of respect for consultants who always come up with a definite answer* | | | | | |
| 3 | I would be comfortable if a clinical teacher set me a vague assignment or task | | | | | |
| 4 | A good clinical teacher is one who challenges your way of looking at clinical problems | | | | | |
| 5 | What we are used to is always preferable to what is unfamiliar* | | | | | |
| 6 | I feel uncomfortable when people claim that something is 'absolutely certain' in medicine | | | | | |
| 7 | A doctor who leads an even, regular work life with few surprises, really has a lot to be grateful for* | | | | | |
| 8 | I think in medicine it is important to know exactly what you are talking about at all times* | | | | | |
| 9 | I feel comfortable that in medicine there is often no right or wrong answer | | | | | |
| 10 | A patient with multiple diseases would make a doctor's job more interesting | | | | | |
| 11 | I am uncomfortable that a lack of medical knowledge about some diseases means we can't help some patients* | | | | | |
| 12 | The unpredictability of a patient's response to medication would bring welcome complexity to a doctor's role | | | | | |
| 13 | It is important to appear knowledgeable to patients at all times* | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 14 | Being confronted with contradictory evidence in clinical practice makes me feel uncomfortable* | | | | | |
| 15 | I like the mystery that there are some things in medicine we'll never know | | | | | |
| 16 | Variation between individual patients is a frustrating aspect of medicine* | | | | | |
| 17 | I find it frustrating when I can't find the answer to a clinical question* | | | | | |
| 18 | I am apprehensive when faced with a new clinical situation or problem* | | | | | |
| 19 | I feel uncomfortable knowing that many of our most important clinical decisions are based upon insufficient information* | | | | | |
| 20 | No matter how complicated the situation, a good doctor will be able to arrive at a yes or no answer* | | | | | |
| 21 | I feel uncomfortable when textbooks or experts are factually incorrect* | | | | | |
| 22 | There is really no such thing as a clinical problem that can't be solved* | | | | | |
| 23 | I like the challenge of being thrown in the deep end with different medical situations | | | | | |
| 24 | It is more interesting to tackle a complicated clinical problem that to solve a simple one | | | | | |
| 25 | I enjoy the process of working with a complex clinical problem and making it more manageable | | | | | |
| 26 | A good job is one where what is to be done and how it is to be done are always clear* | | | | | |
| 27 | To me, medicine is black and white* | | | | | |
| 28 | The beauty of medicine is that it's always evolving and changing | | | | | |
| 29 | I would be comfortable to acknowledge the limits of my medical knowledge to patients | | | | | |

**Scoring**

If you wish to compare your scores to our published study, you will need to calculate your TAMSAD score out of 100 using the following steps:

Step 1: Reverse the codes for the items asterisked* (e.g. a 2 becomes a 4).

Step 2: Calculate your mean score out of 5 across the 29 items (e.g. 3.14)

Step 3: Transform your mean score from a 1–5 scale to a 0–100 scale using the formula; New score = 25(Old score -1). So for example, using the previous example, the new score would be 25(3.14-1) = 25*2.14 = 53.5.

## 6. Additional information for empirical chapters

| Chapter | Title | Journal (impact factor, year) | Number of citations as of 14/6/21<br><br>(Total: 77) |
|---|---|---|---|
| 2 | Medical student and junior doctors' tolerance of ambiguity: development of a new scale | Advances in Health Sciences Education (2.938, 2019) | 42 |
| 3 | Development of a new scale to measure ambiguity tolerance in veterinary students | Journal of veterinary medical education (0.579, 2019) | 8 |
| 4 | Comparing tolerance of ambiguity in veterinary and medical students | Journal of veterinary medical education (0.579, 2019) | 4 |
| 5 | Ambiguity tolerance and psychological well-being in medical training: a systematic review | Medical education (4.619, 2018) | 23 |
| 6 | Mindfulness, complex interventions and conceptual clarity | Medical education (4.619, 2018) | 0 |

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