

The relevance of anatomical variations to South African clinicians: Questionnaire & Scoping review



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Declaration

I, Ozyl Tinetariro Marufu, declare that this dissertation is my own work. It is being submitted for the degree of Master of Science (Medicine) at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination, at this or any other University.

A handwritten signature in black ink, appearing to read 'Ozyl Tinetariro Marufu', is written over a horizontal line.

Ozyl Tinetariro Marufu

28th day of October 2024, in Parktown.

Abstract

Background and aim:

Anatomical variation research has been conducted extensively by anatomists for centuries and is meant to aid and improve clinical practice. However, a dearth of literature is available to understand if clinicians are receiving sufficient exposure and training on these variants in their specific specialization. Many malpractice claims could be directly tied to a lack of anatomical knowledge but even more so variant anatomy. In addition, no study has interrogated the use of reliability techniques in anatomical variant studies as a measure of repeatability and reproducibility of the results being generated from these studies. Hence the aim of the current study was to investigate the perceptions of South African clinicians (surgeons & radiologists) on the relevance of and exposure to anatomical variants in both medical training and clinical practice

Methods:

A validated, anonymous, self-administered questionnaire was disseminated to clinicians (surgeons and radiologists) practicing in South Africa through professional societies, SA universities and private and public clinics. Relationships between professional details, exposure to variations in practice and perceived value of variant research of clinicians were investigated statistically. In addition to test the second aim on the use of reliability techniques a scoping review was conducted to assess the reliability of abdominal arterial variation studies. The steps were conducted using the JBI Scoping Review manual.

Results:

A total of 52 clinicians responded surgeons (n=36) and radiologist (n=16). Most clinicians (90.4%) acknowledged the necessity of anatomical knowledge in medical training. Many clinicians encountered variants in clinical practice often (30.8%), or sometimes (25%). However, most clinicians (65.4%) only engaged with anatomical variant research occasionally (26.9%) or almost never (17.3%). Findings indicated that the more exposure to variants the more clinicians are sourcing variant research articles. Clinicians used more scientific manuscripts than case reports for interacting with variation studies. The major finding of the

scoping review indicates that the majority (75.4%) of variant research studies had no reliability (repeatability and reproducibility) within the methodology.

Conclusion:

There is discordance in clinicians interacting with variant research especially when anatomical studies are aimed to generate conclusion for safer clinical practice. Concurrently, majority of variant research has been devoid of reliability measures which offer sound input to medical research and practice.

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CHAPTER 1

Introduction

Anatomical variations are described as anatomical structures that may appear different morphologically but generally exhibit typical physiological functioning (Kachlík *et al.*, 2020; Alraddadi, 2021). Historically, anatomical variations have been investigated extensively over centuries (Georgiev, 2017; Saniotis and Henneberg, 2021) and tied to several clinical implications (Kachlík *et al.*, 2020; Alraddadi, 2021; Dzmitry and Aksana, 2021; Smith, 2021). These variations are not always innocuous and can lead to deadly consequences, especially when unknown to the clinician (Ogeng'o, 2013; Alraddadi, 2021; Kowalczyk and Majewski, 2021). Additionally, poor knowledge of anatomical variations has been linked to malpractice claims for clinicians (Ogeng'o, 2013; Bernardes, 2017)

Lack of knowledge has been the basis of 41% of malpractice claims in the USA against surgeons, with 13% of these claims attributed to abnormal anatomy (Rogers *et al.*, 2006). Therefore, comprehensive anatomical understanding including normal and abnormal anatomy is crucial in improving clinical outcomes and facilitating safer surgical procedures (Cahill and Leonard, 1999; Willan and Humpherson, 1999; Farina *et al.*, 2019, Kowalczyk and Majewski, 2021).

Subsequently, understanding clinicians' perception of anatomical knowledge and variation exposure is imperative for better clinical practice. The relevance of anatomical variants in contemporary medical practice has been questioned based on improvements in diagnostic imaging techniques and the practical use of anatomical variant studies to surgeons for their medical procedures (Sañudo *et al.*, 2003). Thousands of anatomical variation studies have been produced over centuries since the nineteenth century (Bergman, Afifi and Miyauchi, 2015, Żytkowski *et al.*, 2021, Alraddadi, 2021). However, few studies interrogate whether clinicians are exposed to these studies or general anatomical variant training during their medical education and surgical practice (Raikos and Smith, 2015). Furthermore, few studies have scrutinised methods (i.e. the appropriateness of the use of repeatability measures) used in recording data on anatomical variants (Henry *et al.*, 2016; Alraddadi, 2021).

The goal of this study was therefore to firstly determine whether clinicians (specifically surgeons and radiologists) consider anatomical variants relevant in their medical practice using a cross-sectional self-administered questionnaire. Secondly, it was to assess, using a scoping

review, whether researchers are applying appropriate reliability methods (repeatability and reproducibility) during the collection of anatomical variant data.

CHAPTER 2

Literature review

2.1. History of anatomical variations

What is termed “normal” anatomy has been discussed and implemented continuously in past studies by specialists and subsequent committees and societies (Kachlík *et al.*, 2020; Alraddadi, 2021). Normal is commonly described as adhering to a pattern or set of rules and should refer to any anatomical feature that is “within the normal range of variation” (Moore, 1989, p. 236). However latter aspect of the definition is contradictory and reaffirms how ambiguous the standardisation of normality and variation is (Kachlík *et al.*, 2020).

Anatomical variations were first recognized by anatomists trying to establish what is normal (Żytkowski *et al.*, 2021). Whilst Claudius Galenus (129-200 AD) is noted for his significant contribution to the history of anatomy, it was Andreas Vesalius (1514-1564) in the 16th century that progressed anatomic variation discoveries (Sañudo *et al.*, 2003; Erjavic, 2018; Alraddadi, 2021; Żytkowski *et al.*, 2021; Mastranunzio, 2022). This was conducted through the referenced muscular, osteological, venous, and arterial variations in his dissections of the human body (Sañudo *et al.*, 2003; Alraddadi, 2021; Żytkowski *et al.*, 2021). Vesalius recognized that bodies and organs could vary in size, shape, and arrangement (Sañudo *et al.*, 2003) and sometimes considered these variations as the ideal anatomical arrangement (e.g., an extra ossicle on the base of a metacarpal was considered auxiliary) which were seen as more functionally efficient (Żytkowski *et al.*, 2021).

However, Vesalius ignored morphological variants which he could not describe the function of, (e.g. palmaris longus) (Żytkowski *et al.*, 2021), which led to the implementation of a one-dimensional way of teaching anatomy and dissections which does not fully incorporate variations, common or rare (Kowalczyk and Majewski, 2021). It was only in the 18th and 19th century that a systematic summary of anatomical variations of the human body was collated under the direction of Bartolomeo Eustachi (1513-1574) (Adanır and Bahşi, 2019, Żytkowski *et al.*, 2021). This period (18th to 19th century) was regarded as crucial for the discovery of anatomical variations, and dissections were seen as a resource to acquire anatomical knowledge by researchers and clinicians (Żytkowski *et al.*, 2021).

2.2 Modern medical education on anatomical variations and resources used by clinicians on anatomical knowledge and variations

Adequate anatomical knowledge and, equally, knowledge concerning anatomical variations is considered a fundamental requirement for clinical practice (Raikos and Smith, 2015; Nzenwa, Iqbal and Bazira, 2023). In earlier periods, traditional anatomical tools used were dissection, textbooks, and lectures (Papa *et al.*, 2019). However, in the 21st century globally, tools commonly used by students to learn basic anatomy shifted to include websites, problem-based learning, tutorials, and computer software (Papa *et al.*, 2019). British and Irish students, clinicians and anatomy educators agree that lectures and laboratory practicals are the preferred methods of learning anatomy (Sbayeh *et al.*, 2016) but another group of British students deem anatomy websites the most useful learning tool for anatomy (Leung *et al.*, 2020). In Poland, textbooks are ranked highly for improving anatomical knowledge, but cadaver workshops are ranked as the least preferred tool (Kowalczyk *et al.*, 2022). This demonstrates preferential differences in the use of anatomical educational tools across different regions of the world for normal anatomical knowledge. However, there might be specific preferences when interrogating the educational tools used for variant anatomy.

Anatomical variant knowledge is vital for clinical practice (Alraddadi, 2021; Nzenwa, Iqbal and Bazira, 2023) and a variety of tools can be used to comprehend this knowledge, including dissection, prosection, plastinated specimens, software, radiological anatomy, and web resources (Chapman *et al.*, 2013, Riederer, 2014; Pirri *et al.*, 2021; Aland *et al.*, 2023). However, there seems to be a preference for the specific tools used to acquire anatomical variant knowledge from medical students. For example, dissection and prosection has been highlighted by both medical students as the preferred educational tool to appreciate and understand variant anatomy (Turney, 2007; Kerby, Shukur and Shalhoub, 2010; Flack and Nicholson, 2017; Dua *et al.*, 2020; Abdullah *et al.*, 2021).

Dissection is an integral part of basic medical science in the undergraduate medical curriculum (Ahmed *et al.*, 2010; Trivedi *et al.*, 2018; Jeyakumar, Dissanayake and Dissabandara, 2019; Asante *et al.*, 2021). This teaching tool offers the first contact to patient care and facilitates tactile features which is essential for future surgeons (Selcuk, Tatar and Huri, 2019; Asante *et al.*, 2021) but more significantly for the identification of anatomical variations (Bernardes, 2017; Nzenwa, Iqbal and Bazira, 2023). Over the last few decades, a steady decline in the use of and allocated time to dissections has been observed (Rizzolo, 2002; Yammine, 2014; Ghosh, 2015; Alraddadi, 2021; Kowalczyk and Majewski, 2021). This reduction may be justified by

some clinicians not seeing the value of practical anatomy learning (Tibrewal, 2006; Almizani *et al.*, 2022), however, these restrictions may lead to reduced exposure to anatomical variants, subsequently diminishing the foundational knowledge required by clinicians during their medical education (Nzenwa, Iqbal and Bazira, 2023).

As anatomical variations are being continually discovered (Keats, 1993; Beser, 2018; Kachlík *et al.*, 2020); medical textbooks are not updated regularly to match these novel discoveries (Bergman, 2011). Even though anatomical textbooks are typically known to have little to no variations (Flack and Nicholson, 2017; Kiss, 2018; Kachlík *et al.*, 2020; Smith, 2023); some have suggested the inclusion of anatomical variant specific textbooks as an alternative approach to gaining this knowledge (Parikh, 2023). The lack of updates of variant anatomy may also be true for plastic anatomical models and digital content that are more regularly being implemented widely in anatomy teaching (Narang *et al.*, 2021). Medical students agreed that plastic models were poor tools of exposure to anatomical variations (Kerby, Shukur and Shalhoub, 2010, Abdullah *et al.*, 2021). The inclusion of more plastic models, implementation of virtual teaching methods and curated digital content in the anatomy curricula (Schulte *et al.*, 2022; Éléonore Brumpt *et al.*, 2023; Kaplan, Tarolli, and Doughty, 2023; Aland *et al.*, 2023) might be an affordable and more practical alternative teaching approach but may drastically reduce exposure to anatomical variations in medical undergraduate students (Nzenwa, Iqbal and Bazira, 2023).

Multiple techniques are available for anatomy education, but it seems that there are specific tools for the acquisition of anatomical variant knowledge. The main resource being dissection, but this is on the decline and suggested alternative might be anatomical variant specific textbooks and possibly image-based anatomy from living patients (i.e. radiographs, CT scans (Mutalik and Belsare, 2016).

2.3 Exposure to variations in clinical practice

As mentioned, clinicians generally agree on the importance of having adequate anatomical knowledge to assist them in their clinical practice (Sbayeh *et al.*, 2016, Triepels *et al.*, 2018, Almizani *et al.*, 2022), however, very few studies explore the perceptions of clinicians on the importance of anatomical variants in their daily practice (Raikos and Smith, 2015). Raikos and Smith (2015) highlight that for Canadian and Australian senior clinicians, exposure to anatomical variants in their clinical practice occurred in 39% of patients (monthly), 25% of patients (weekly) and 21% of patients (daily). Based on these numbers it is no surprise that

these clinicians deem anatomical variant knowledge to be highly beneficial to their field of expertise (Raikos and Smith, 2015). Some clinicians suggested that their exposure to variants is primarily guided by their clinical relevance, usually relying on incidental findings (Raikos and Smith, 2015) and not personal interest or research into these variants but this might not be a shared opinion amongst clinicians. The perceived value of anatomical variant knowledge was shared by a European group of clinicians (Kowalczyk *et al.*, 2022) but there is no data on African and more specifically South African clinicians' opinion on this topic. This dearth of information highlights the need for more input from clinicians on their perceived value of variations across different regions from the world.

2.4 Sources of anatomical variants used by clinicians

A vast majority of anatomical knowledge information comes from published research in multiple media formats (Yammine, 2014a). These formats include scientific manuscripts, clinical trials, magazines, conferences, and other training events (Röhrig *et al.*, 2009). Of these sources scientific manuscripts are generally the major dissemination format and a point of medical student engagement (Lee, 2021), however, very little is known regarding the actual interaction clinicians have in this regard. Raikos and Smith (2015) found that clinicians preferred interacting and learning about anatomical variations through published scientific manuscripts the least compared to other training formats or tools. The reasons why were not stated, but an inference can be made that published research may require improvement.

While information is limited, there appears to be a lack of transfer of anatomical variant information between research produced by anatomists and what is used by clinicians. Anatomical variant research is intended to improve clinical practice, but if clinicians are not engaging with the research, or anatomists are not aware of the relevance to clinicians of this research, then progress is hindered, as the two fields may be in discordance with each other.

2.5. Research quality in anatomical variation studies

Anatomical variations studies are rarely scrutinised, or quality assured for best research practice (Yammine, 2014a; Georgiev 2017). The methods used in anatomical research have been slow to evolve when compared to other medical science research (Henry *et al.*, 2016). Studies on clinical anatomy tend to be singular studies with no summarised overview of the anatomical variations specific to each medical field (Henry *et al.*, 2016). As such, evidence-based anatomy might be the solution for more scientifically sound anatomical variant studies.

Evidence-based anatomy focuses on using scientific techniques and concepts in anatomical research, such as systematic reviews and meta-analyses with concise and reproducible data (Henry *et al.*, 2016). Some of the often-overlooked indicators of quality research are reproducibility and repeatability (Garfinkel, 1975; Leonelli, 2018). Reproducibility is defined as the probability of obtaining the same result should a different tool and/or observer be used (Bartlett and Frost, 2008). Repeatability has been described as the measurement of the probability of obtaining the same result from the original experiment if duplicated using the same methods and tools by the same investigators (Slezák, Waczulíková, and Slezák, 2011; MacKenzie, 2019).

Reproducibility has been associated with inter-observer error and repeatability has been associated with intra-observer error (Slezák, Waczulíková, and Slezák, 2011). Repeatability provides a course for the investigator/s to confirm their results as precise and not having occurred by chance (Leonelli, 2018; MacKenzie, 2019). Yet according to the author's knowledge repeatability and reproducibility are often found lacking or overlooked in anatomical variation studies, specifically relating to arterial variant studies but this has not been empirically tested. This gap in knowledge was addressed in the current study. Many comprehensive anatomical variation studies lack reliability tests which is exemplified by the following (e.g., Henneberg and George, 1992a; Henneberg and George, 1992b; Rodríguez-Niedenführ *et al.*, 2003; Claassen, Schmitt and Wree, 2008; Potu *et al.*, 2011; Chakravarthi, 2014; Cheruiyot *et al.*, 2017; Konarik *et al.*, 2020).

The abdomen is a region with a high frequency of arterial variations that may cause major clinical complications (Wamanrao and Ramakrishna, 2016). The current study applies an evidence-based approach to identify if arterial variant studies concerning the abdominal region (high number of variants), utilise the best methodological practices such as repeatability and reproducibility measures. If anatomical variation studies do not have sound methodology or are not presented in a manner easy to use by clinicians, they may either present false and imprecise information or continue being overlooked, increasing the risk of misdiagnosis and medical complications (Henry *et al.*, 2016).

2.6. Rationale

No study, to date, has tested whether anatomical variant research is conducted accurately using best practice methodological tools. In summation, this study questioned the relevance of anatomical knowledge and exposure to anatomical variants during medical training and clinical

practice. From the above-mentioned literature, the levels of exposure and training on anatomical variations seems to differ, therefore the current study sought to investigate how South African clinicians perceive anatomical knowledge and how these compares. Moreover, how South African clinicians are trained and exposed to anatomical variations. Whilst anatomy has been identified as an essential part of clinical training, some clinicians questioned whether the inclusion of anatomical variants is necessary and variants are in fact relevant for clinical practice, an unclear, consistent consensus exists on the level of sufficient exposure of variants being introduced, either during undergraduate training or during post-university training. Only two studies have investigated the perceptions of clinicians (surgeons and radiologists) on the impact of anatomical variants in their specialised field of practice fully (Raikos and Smith, 2015; Kowalczyk *et al.*, 2022).

Aims and objectives

Aim: To investigate the perceptions of South African clinicians (surgeons & radiologists) on the relevance of anatomical knowledge and exposure to anatomical variants during medical training and clinical practice. In addition, the study assessed through a scoping review the prevalence of the use of reliability methods in anatomical arterial variant studies of the abdomen.

Objective 1: Investigate clinicians' perceptions regarding anatomical variations in clinical, practice within South Africa through a cross-sectional self-administered questionnaire.

Sub-Objectives:

- 1.1. Determine the frequency of clinicians' (surgeons and radiologists) encounters in daily practice with anatomical variations in South Africa.
- 1.2. Assess the exposure to various anatomical tools for medical training and the associated level of preparedness in university and clinical practice training.
- 1.3. Assess the perceived value of anatomical knowledge to clinicians.
- 1.4. Assess how clinicians' surgical and diagnostic interventions change in response to the presence of anatomical variations.
- 1.5. Assess the level and type of engagement clinicians have with information resources related to anatomical variations
- 1.6. Investigate comparisons between surgeons and radiologists against professional details, exposure, and perceptions around anatomical variants.

Objective 2: Through a scoping review, the study assessed the reliability employed by researchers on arterial variant studies (abdominal region) in a global context.

Sub-Objectives:

- 2.1. Establish the prevalence of different types of studies (case report, original research manuscripts) available in the literature on abdominal arterial variants between the period of 2006 and 2023.

2.2. Determine the frequency of journal themes (i.e., medical, anatomical, surgical etc.) of the studies available in literature between 2006 and 2023.

2.3. Determine the different sample types (i.e., living patients, cadavers, radiographs etc.) used in abdominal arterial variant studies between 2006 and 2023.

2.4. Determine the frequency of the use of repeatability and reproducibility as an indicator of research quality in abdominal arterial variant studies.

CHAPTER 3

3. **Materials and Methods**

3.1 Questionnaire description

A self-administered questionnaire (Appendix B) was facilitated through Redcap (REDCap, 2019). The questionnaire was anonymous, and the participation information sheet (Appendix A, A1) was linked to the questionnaire and consent was inferred by completion of the questionnaire. There were 28 questions within the questionnaire. These questions included a demographic section on profession details and then addressed five major themes. The five themes included: prior training and exposure to variations; current variation exposure; intervention shift based on variation encounters; perceived value of variation research; and engagement with variation research. Lastly, open-ended questions were included for multiple questions in the questionnaire. These responses were then grouped under general themes without extensive qualitative analysis within grounded theory, due to the limited sample size and limited response. Questions included single option button, multiple checkboxes, Likert-style, and open-ended formats. The expected time to complete the questionnaire was approximately 10-20 minutes.

3.2 Questionnaire validation

Content validation of the questionnaire was conducted by circulating the questionnaire to ten experts which included senior anatomists and clinicians either based locally or internationally. The anatomists had extensive teaching and research experience and among the clinicians were practising physiotherapists, medical doctors, and a retired surgeon. Any questions found to be ambiguous or unclear were rephrased or removed based on the validators' feedback. Thereafter, a test-retest assessment was conducted with ten clinicians (medical interns, dentists, and a physiotherapist) to test the statistical consistency and reliability of the questionnaire.

3.3. Questionnaire sampling and inclusion & exclusion criteria.

The target sample was surgeon and radiologist specialists practicing in South Africa. The country criteria were restricted specifically as the study was assessing the relevance of anatomical variations in a South African context. The area of specialization was broad and therefore included general surgery, vascular surgery, radiology, trauma, emergency medicine,

plastic surgery, urology, orthopedics, and pediatric specialties. Practicing surgeons/radiologists who were conducting their surgical/radiological training were included. To gauge exposure to anatomical variations for both medical education and clinical practice, only practicing surgeons/radiologists participated (clinical medical students and interns were excluded).

3.4. Questionnaire distribution

As of the 2021-2022 HPCSA numbers, there are 3081 surgeons and 1022 radiologists registered. The questionnaire was initially approved for distribution to three major societies: Radiological Society of South Africa, Surgeons for Little Lives, and the Association of South African Surgeons. Few individuals completed the questionnaire through this initial distribution. Reminder emails were sent to the selected societies every two weeks for two months. The response rate was low and one of the societies retracted permission for redistribution after only one round of distribution.

Therefore, an ethical amendment was submitted to approach individual clinicians in both private and public sectors associated to the University of the Witwatersrand as well as Heads of Departments related to surgery and radiology in an attempt to improve the response rates. The questionnaire link was distributed to these individuals via email for a further two months with bi-weekly reminders. This process also included in person recruitment of surgeons and radiologists who were affiliated with the university. In the current study, 36/3081 (1.2%) of South African surgeons and 16/1022 (1.6%) of South African radiologists participated.

3.5. Questionnaire data analysis.

Collected data was exported from RedCap (Research Electronic Data Capture System) as a .csv file into Microsoft Excel (Microsoft Corporation, 2021). The data was stored on an external hard drive and on a desktop computer. Data was cleaned to ensure no missing values in Excel, partial or incomplete entries were removed. Data was analysed with the Statistical Package for Social Sciences (SPSS® version 28) (IBM, 2022). For all statistical tests, the alpha value was set at 0.05. The test-retest statistical validation was assessed with the participation of ten raters (who were not part of the final sample size). Test-retest responses were statistically assessed through the ICC and Cronbach alpha test (tests for internal consistency and reliability of the questionnaire). Descriptive statistics were computed to produce frequency tables for relevant demographic information as well as the frequency of clinicians' encounters with variations throughout training and practice. The Fisher-Freeman-Halton Exact Test and a Mann Whitney U test were used to assess how clinicians' surgical and diagnostic interventions change

in response to the presence of anatomical variations (sub-objective 1.2). The Fisher-Freeman-Halton Exact test was then used for sub-objective 1.3. to assess the level and type of engagement clinicians have with information sources related to anatomical variations. Additionally, the Fisher-Freeman-Halton Exact test was also used for sub-objective 1.4 to assess the perceived value clinicians attribute to the literature specific to anatomical variation studies. A Spearman's correlation was run to assess the relationships between clinician professional details, periods of undergraduate clinical training and perceptions around anatomical variants (sub-objective 1.5). Furthermore, to assess the relationship between the frequency of engagement of research articles or other academic sources and the frequency in which clinicians encounter anatomical variations in daily practice a Spearman's correlation test was used. A Kruskal Wallis ANOVA by ranks test was used to investigate the relationship between the frequency of anatomical variations encountered by clinicians and the sector in which the clinicians work in. Based on the extremely low proportions of questionnaire respondents for both surgeons (1.2%) and radiologists (1.6%), any statistical inferences made in the current study are not representative of the South African clinician (surgeons and radiologists) population, but only to the current study's sample.

3.6.1 Scoping review

A scoping review was conducted to identify the evidence source types available, and examined how often repeatability and reproducibility measures are used when abdominal arterial research is conducted (Peters *et al.*, 2020) between 2006 and 2023.

The scoping review followed the updated JBI Scoping Review method (Peters *et al.*, 2020). The following steps implemented from this framework (Peters *et al.*, 2020) were as follows:

- ☐ Assessment of literature
- ☐ Selection of the relevant literature for assessment
- ☐ Analysis of the literature results
- ☐ Presentation of the literature results
- ☐ Summarising the resulting literature in relation to the purpose of the review, making conclusions and noting any implications of the findings

The objectives and questions of the study were defined and aligned to the available research from a preliminary search on the PubMed database (Peters *et al.*, 2020). The inclusion and exclusion criteria are shown in Table 3.6.1.

The timeline (2006-2023) for the literature search was selected since from 2006, a sharp and steady increase in the number of abdominal variation studies was noted (PubMed Labs, 2021). The shift in volume in 2005 was 109 papers to 119 papers in 2006 to 139 papers in 2007. The number of sources increased steadily in the last 17 years (PubMed Labs, 2021).

Table 3.6.2: Scoping review inclusion and exclusion criteria

	Inclusion	Exclusion
Context	- Abdominal arterial variant research - Global context	- Experimental abdominal variant studies - Evidence from work conducted on non-human animals
Concept	Methodological approaches used in anatomical variant research	No qualitative or quantitative data presented
Sources of evidence	- Published papers (including case reports) - Grey literature	- Experimental studies - Case notes - Systematic review or any type of review - Pictorial essays
Language	English	--
Time	2006-2023	--

3.6.2 Assessment of literature

A preliminary search was conducted to assess the volume of publications. Based on this preliminary search and due to the excessive volume of sources identified ($\approx 1\,000\,000$) with the broad term ‘anatomical variations’, inclusion and exclusion criteria were readjusted to be specific to a particular region of anatomical variations (abdomen). To investigate the methodological approaches in abdominal arterial studies the following electronic databases were searched: PubMed (PubMed Labs, 2021) and Web of Science (Clarivate, 2019). The keywords used were:

- abdom* AND arter* AND varia*: abdominal arterial variants (PET OR MRI OR MRA OR angiograms) scans,*
- abdom* AND arter* AND varia* AND cadaver: abdominal arterial variants cadaveric OR cadaveric studies.*

3. *abdom* AND arter* AND varia* AND dead body: abdominal arterial variations OR variants OR variant dead bodies.*
4. *abdom* AND arter* AND varia* AND dead bodies: abdominal arterial variations OR variants OR variant dead bodies.*
5. *abdom* AND arter* AND varia* AND living: abdominal arterial variant AND living.*

3.6.2.1 Selecting the relevant literature for assessment

- Phase one (initial search):

An initial search was conducted on PubMed (PubMed Labs, 2021) and Web of Science (Clarivate, 2019). Thereafter, text words in the title, abstract and index items were reviewed. Studies not considered relevant to the scoping review or not in-line with the inclusion criteria were excluded.

- Phase two (second search):

After the initial search (phase one) conducted, a review was conducted on the entirety of each included published source. Sources which had been selected based on the abstracts were read (with a focus on the methods and results section) to extract the relevant data. Data extraction was grouped into four main categories: evidence source type, theme of journal, sample type and the absence/ presence of repeatability and reproducibility measures.

Under evidence source type: there were two options of which the articles could be assigned namely case report and original research manuscript (retrospective study and prospective study). The following definitions were used for this selection:

Case report: a scientific document that describes a singular observation under a clinical setting (Gopikrishna, 2010) and is a shortened account which does not include an outlined methodology and results section (Sun, 2013). Case reports often record incidental findings (Sun, 2013; Rosie, Khumalo and Nethathe, 2016)

Original research manuscript: a type of evidence source type that adopts a traditional, scientific based format (Viglianti *et al.*, 2019). It has a concise structure of a title, abstract, introduction, methods, results, discussion, and other information (Liumbruno *et al.*, 2013). This classification was further subdivided into retrospective and prospective studies.

Retrospective study: A study where individuals are selected and researched and the information about the individuals are gathered (IOE, UCL's Faculty of Education and Society, 2024). The study is used to create original research, and the research question is generated after data collection is complete (Hess and Faarc, 2004, Smith, 2012)

Prospective study: A study that investigates individuals over a period and is analysed in the present and continues for future research investigations (Song and Chung, 2010; National Cancer Institute, 2011).

Under theme of journal the possible options were categorised into nine journals. Several themes in journals were observed in the studies included, namely Medical, Anatomical, Surgical, Radiological, Surgical and Radiological, Medical Science, Scientific, Life Science and Biomedical Engineering. The types of journals were classified from the types of journals the articles were published in e.g. Journal of Anatomy was considered an anatomical journal.

Under sample type there were three possible options namely living, cadaveric and both (living & cadaveric). The following definitions were used:

Living: an individual who is alive (Dictionary.com, 2019). Studies that have records relating to an individual or patient who is alive stored data in any form (e.g., radiographs).

Cadaver: a deceased human individual primarily utilized for medical or scientific research (Ariyanachi Kaliappan *et al.*, 2023). Studies that have records, stored data in any form (e.g. X-ray), relating to an individual who is dead such as in an anatomical repository/collection or through a dissection, or a donor who is no longer alive at the time the study is conducted.

Both: studies with both living patient and cadaveric samples that were used in the same study.

Under Absence/presence of reliability (repeatability and reproducibility) there were two possible options: absence or presence of repeatability and/or reproducibility. The following definitions were used:

Repeatability: also described as intra-observer error, is a method whereby a single

investigator conducts data collection and records the observations (Popović and Thomas, 2017). After some time has lapsed the same investigator conducts the same method of data collection retrieval and reporting and assesses any differences or the agreement between the two sets of reporting (Popović and Thomas, 2017).

Reproducibility: also described as inter-observer error, is a method whereby two investigators conduct data collection and record the observations using the same method (Popović and Thomas, 2017). Any differences or the level of agreement between the two is assessed (Popović and Thomas, 2017).

3.6.3 Scoping review data analysis

Frequency and contingency tables were used to analyse the data using Microsoft Excel. Tables were used to organize the included sources by including the evidence source type, theme of journal, sample type and the absence/presence of repeatability and reproducibility.

4. **Ethics**

Ethical approval was granted by the University of Witwatersrand's Human Research Ethics Committee (medical) for permission to distribute the questionnaire to clinicians (Ethics number MED23-02-037, Appendix C). Due to the low response rate, an amendment was requested to the Human Research Ethics Committee to allow the questionnaire to be distributed to University of Witwatersrand associated and private practice-based clinicians. Permission was granted for this amendment (Ethics number MED23-02-037, Appendix D).

CHAPTER 4

5. **Results**

The current study comprised two main components. The first consisted of a self-administered questionnaire investigating the perceptions of South African clinicians (surgeons & radiologists) on the relevance of and exposure to anatomical variants. The second component utilised a scoping review to assess the prevalence of validation techniques in anatomical arterial variant studies of the abdomen.

5.1. Questionnaire statistical consistency

The Cronbach 's alpha was used to measure the internal consistency and reliability of the questionnaire. Cronbach alpha values range from 0 to 1. The closer the Cronbach alpha value is to 1, the higher the reliability and consistency of the questionnaire (Tavakol and Dennick, 2011). The general internal consistency of the questionnaire was good (Cronbach-alpha = 0.700; bootstrapped 95% confidence interval, $p < 0.05$, $n = 35$) as 0.6 or 0.7 are considered acceptable values (van Griethuijsen *et al.*, 2014). The value also indicated that the questionnaire structure was not redundant (Taber, 2018) (Appendix F).

5.2. Questionnaire statistical reliability validation

A test-retest was run on the different types of questions in the questionnaire. For Likert scale type questions, an intraclass correlation (ICC) test was run using a two-way mixed model and absolute agreement type. Single measures are reported (Appendix J). Based on Koo and Li (2016), the ICC inter-rater agreement measures are interpreted as follows: below 0.50: poor; between 0.50 and 0.75: moderate; between 0.75 and 0.90: good; above 0.90: excellent. For yes/no type questions, a McNemar test was run. For questions with more than three categorical options, a Cochran-Mantel-Haenszel test was run (Appendix J).

At an individual question level, majority ($n=9/13$) of the Likert type questions were considered acceptable based on reliability scores (Appendix J). Four questions ($n=4/13$) were moderately reliable. Four questions ($n=4/13$) had good reliability score and one question ($n=1/13$) had excellent reliability. However, two questions ($n=2/13$) were below 0.5 and therefore had poor

reliability (Appendix J). There were also two questions (n=2/13) which had negative scale variance. The reason for this may be that the study used the minimum required number of raters despite numerous efforts for more raters. Additionally, two raters' set of answers varied greatly. Therefore, the results were considered spurious, which results in the ICC value being reset to zero (Bartko, 1976).

At an individual question level, all yes/no type questions between the two sets of responses were in perfect agreement (n=4). Four multi-option nominal questions had good agreement (Appendix J), however, majority had multiple options and too few testers responded with those options consistently. Due to many answers having multiple potential options with few testers repeating the same response across trials, reliability for question 4 to 11 could not be computed using a Mantel-Haenzel test. One out of these questions had a notable level of disagreement with most testers responding differently between each testing trial, however, the question was considered important to address the study's goal and hence retained.

5.3 Questionnaire respondent demographic data

There was a total of 52 participants of which 30.8% (n = 16) were radiologists and 69.2% (n = 36) were surgeons. Most of the clinicians that were surgeons specialised in general surgery (32.7%, 17/52) and most radiologists specialised in diagnostic radiology (15.4%, 8/52) (Table 5.3.1.) Other fields of specialisation such as gastroenterology, trauma, urology, paediatric and neurological surgical fields ranged between 3.8%- 9.6% (Table 5.3.1.). The specialisation with the least responses was an even distribution between the fields of oncology, ENT (ear, nose, and throat) and interventional radiology (1.9%, 1/52) (Table 5.3.1.).

Table 5.3.1 Areas of specialisation of respondents

Specialisation	Frequency	
	n	%
Surgery		
General Surgery	17	32.7
Neurosurgery	5	9.6
Urology	4	7.7
Paediatric Surgery	3	5.8
Trauma Surgery	2	3.8
Other	2	3.8
Orthopaedic Surgery	1	1.9
Oncology Surgery	1	1.9
Ear, Nose and Throat Surgery	1	1.9
Radiology		
Diagnostic Radiology	8	15.4
All fields of Radiology	7	13.5
Interventional Radiology	1	1.9
Total	52	100

5.3.2. Level of qualification, country of which qualification is obtained, current position, province, and sector of work for clinicians

Clinicians were asked to select more than one qualification that applied to them. Most of the clinicians (69.2%, 36/52) had completed the fellowship for specialty college exams (Table 5.3.2). Regarding research related degrees, more clinicians had acquired a Master of Medicine (38.8%, 20/52) degree than a PhD in Medicine (7.7%, 4/52). Most of the clinicians studied their undergraduate degree in South Africa (86.5%, 45/52). Few clinicians had studied in another African country (7.7%, 4/52) or an international country (5.8%, 3/52) (Table 5.3.2). In their current position, most of the participants occupied senior positions through either being consultants (36.5%, 19/52) or senior consultants (19.2%, 10/52) followed by professors (19.5%, 7/52) and senior registrars (19.5%, 7/52) (Table 5.3.2). Most clinicians were based in Gauteng (63.5%, 33/52), followed by KwaZulu-Natal (17.3%, 9/52) and the Western Cape (11.5%, 6/52) (Table 5.3.2). A larger cohort of clinicians worked in the public sector (51.9%, 27/52) while fewer individuals were in the private (28.8%, 15/52) or both sectors (19.2%, 10/52). (Table 5.3.2).

Table 5.3.2 Qualifications held by clinicians, country in which the undergraduate degree was obtained, current position, province, and sector of practice

Professional details	Number of clinicians (n= 52)	Percentage (%)
Qualification		
Fellowship for Specialty (College Exams)	36	69.2
Undergraduate medical degree (MBBCh or equivalent)	27	51.9
Master of Medicine	20	38.5
Doctorate in Medicine	4	7.7
Other	4	7.7
Undergraduate dental degree (BDS or equivalent)	1	1.9
Country in which undergraduate qualification was obtained		
South Africa	45	86.5
Other African Country	4	7.7
Other Country outside Africa	3	5.8
Current position		
Junior Registrar	3	5.8
Consultant	19	36.5
Senior Consultant	10	19.2
Senior Registrar	7	13.5
Professor	7	13.5
Medical Officer	3	5.8
Junior Registrar	3	5.8
Other	3	5.8
Province		
Gauteng	33	63.5
KwaZulu-Natal	9	17.3
Western Cape	6	11.5
Free State	2	3.8
Eastern Cape	1	1.9
Northern Cape	1	1.9
Limpopo	0	0
Mpumalanga	0	0
North-West	0	0
Sector		
Public	27	51.9
Private	15	28.8
Both	10	19.2

5.3.3 Years in practice as a surgeon or radiologist

The clinicians indicated their experience as a practising surgeon or radiologist through the number of years worked. The mean years of practice experience across all clinicians was 10.67 $\pm$ 10.41 years (N=52, range: 1-43 years).

5.4. Prior training and exposure to anatomical variations of clinicians

**UG-undergraduate, PG- postgraduate*

Dissection was the most used tool reported in UG training (59.6%, 31/52) and plastic models was the most used tool reported in PG training (23.1%, 12/52) (See Table 5.4.1 and Table 5.4.2). The least used tool in UG (55.8%, 29/52) and PG (73.1%, 38/52) training was non-human dissection (See Table 5.4.1 and Table 5.4.2).

Table 5.4.1 Frequency of clinicians' exposure to various anatomical tools during undergraduate training

Undergraduate Training										
*Frequency	Often		Sometimes		Occasionally		Rarely		Never	
	n	%	n	%	n	%	N	%	N	%
Human dissection	31	59.6	10	19.2	3	5.8	4	7.7	4	7.7
Non-human dissection	1	1.9	2	3.8	6	11.5	14	26.9	29	55.8
Plastinated human specimens	16	30.8	9	17.3	7	13.5	4	7.7	16	30.8
Plastic, anatomically relevant models	11	21.2	5	9.6	11	21.2	11	21.2	14	26.9
Computer software	4	7.7	7	13.5	9	17.3	8	15.4	24	46.2

**Frequencies were determined using a 5-point Likert scale and included: Often (more than once per week); Sometimes (more than once per month); Occasionally (more than once every six months); Rarely (more than once per year); Never (no previous exposure).*

Table 5.4.2 Frequency of clinicians' exposure to various anatomical tools during postgraduate training

Postgraduate Training										
*Frequency	Often		Sometimes		Occasionally		Rarely		Never	
	n	%	n	%	n	%	n	%	n	%
Human dissection	4	7.7	0	0	1	1.9	16	30.8	31	59.6
Non-human dissection	0	0	1	1.9	5	9.6	8	15.4	38	73.1
Plastinated human specimens	1	1.9	4	7.7	4	7.7	10	19.2	33	63.5
Plastic, anatomically relevant models	12	23.1	4	7.7	7	13.5	6	11.5	23	44.2
Computer software	4	7.7	0	0	1	1.9	16	30.8	31	59.6

*Frequencies were determined using a 5-point Likert scale and included: Often (more than once per week); Sometimes (more than once per month); Occasionally (more than once every six months); Rarely (more than once per year); Never (no previous exposure).

Clinicians were asked to rank the necessity of anatomical knowledge in clinical practice. Most respondents (90.4%, 47/52) strongly agreed that anatomical knowledge was necessary, interestingly one respondent was neutral (Table 5.4.3)

Table 5.4.3 Necessity of anatomical knowledge in clinical practice according to clinicians

Degree of necessity of anatomical knowledge in clinical practice	Frequency	
	n	%
Strongly agree	47	90.4
Agree	4	7.7
Neutral	1	1.9
Total	52	100

Clinicians were asked whether anatomical variations were incorporated in their undergraduate and postgraduate training (Table 5.4.4.). Most clinicians (71.2%, 37/52) were taught about anatomical variations in both undergraduate and postgraduate training. Few clinicians were taught about anatomical variations either in undergraduate training only (13.5%, 7/52), or in postgraduate training only 13.5% (7/52) (Table 5.4.4.). Oddly, one respondent (1.9%) was not taught about any anatomical variations in either undergraduate or postgraduate training (Table 5.4.4.)

Table 5.4.4 Clinicians' exposure to anatomical variations education in undergraduate and postgraduate training

In your undergraduate or postgraduate anatomical training, were you taught about any anatomical variations?	Frequency	
	n	%
Yes, in both undergraduate and postgraduate training	37	71.2
Yes, in undergraduate training	7	13.5
Yes, in postgraduate training	7	13.5
No, none in both undergraduate and postgraduate training	1	1.9
Total	52	100

Following clinicians' completion of UG training, clinicians were asked at which phase of their career they started encountering anatomical variations. Clinicians mostly encountered anatomical variations in junior registrarship (53.8%, 28/52) followed by medical officer training 34.6% (18/52) and senior registrarship 28.8% (15/ 52). Few clinicians indicated during consultancy (7.7%, 4/52) or during senior consultancy (1.9%, 1/52) as their first exposure to variants.

Overall, most clinicians felt adequately prepared for clinical practice based on their anatomical training, but more clinicians (86.5%, 45/52) felt adequately prepared for clinical practice based on their PG rather than UG anatomical training (69.2 %, 36/52) (See Table 5.4.5).

Table 5.4.5 Clinician preparedness based on their undergraduate and postgraduate anatomical training

Clinical preparedness based on UG anatomical training			Clinical preparedness based on PG anatomical training		
	n	%		n	%
Yes	36	69.2	Yes	45	86.5
No	16	30.8	No	7	13.5
Total	52	100	Total	52	100

Clinicians were asked to elaborate on their reasons as to why they felt adequately prepared for clinical practice. The option to provide a reason was open ended and not compulsory. Various themes were extracted from the reasons given. Under UG anatomical training, out of 36

clinicians who said they felt adequately prepared, 15 stated the reason why (Table 5.4.6.). Most clinicians (47.7%, 7/15) cited sufficient dissection as the reason for preparedness. Out of 16 clinicians who said they felt inadequately prepared based on their UG training, 10 stated the reasons why. Majority of clinicians (60.0%, 6/10) mentioned that their UG training was not sufficient and additionally 30 % (3/10) of clinicians indicated that variant anatomy was not taught enough.

Under PG training, out of 45 clinicians who said they felt adequately prepared, 17 clinicians stated the reasons why (Table 5.4.7). Most clinicians (47.6%, 10/17) indicated that variant anatomy was sufficiently taught through practical/surgery trials (Table 5.4.7). Out of 7 clinicians who mentioned that they felt inadequately prepared based on their PG training, 4 clinicians provided the reason why. Half of the clinicians (2/4) stated that there was not enough exposure to dissection in PG training (Table 5.4.7).

Table 5.4.6 Themes and the frequencies on the reason why clinicians felt prepared for clinical practice based on undergraduate training

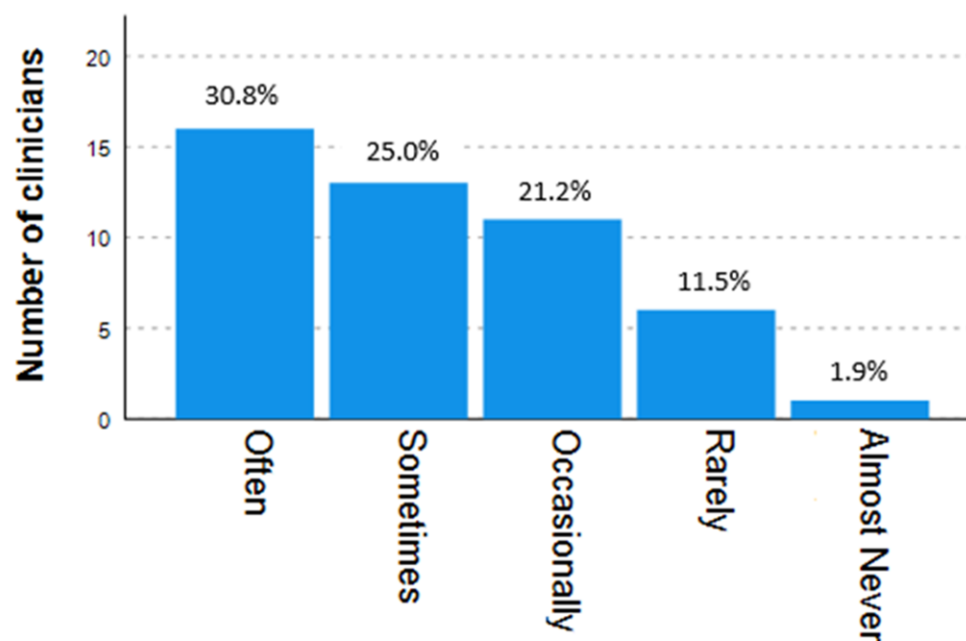
Themes in undergraduate training	Frequency	
	n	%
Reasons clinicians felt adequately prepared for clinical practice		
Undergraduate training was sufficient	7	47.7
Variant anatomy was sufficiently taught	1	6.7
Sufficient dissection which aided in preparedness	7	47.7
Total	15	100
Reasons clinicians felt inadequately prepared for clinical practice		
Undergraduate training was insufficient	6	60.0
Insufficient dissection/late implementation of dissection	1	10.0
Variant anatomy not taught enough/ insufficient exposure	3	30.0
Total	10	100

Table 5.4.7 Themes and the frequencies on the reason why clinicians felt prepared for clinical practice based on postgraduate training

Themes in postgraduate training	Frequency	
	n	%
Reasons clinicians who felt adequately prepared for clinical practice		
Postgraduate training was sufficient	7	33.3
Variant anatomy was sufficiently taught through practicals /surgery trials	10	47.6
Total	17	100
Reasons clinicians felt inadequately prepared for clinical practice		
Postgraduate training was insufficient	1	25.0
Variant anatomy not taught enough/ insufficient exposure	1	25.0
Implementation of dissection in the final years/ not enough exposure	2	50.0
Total	4	100

5.5. Current exposure to anatomical variations

Most clinicians (90.4%, 47/52) indicated that they had recent exposure to the anatomical variants in their current position. Furthermore, most clinicians stated that they were exposed to anatomical variations often (30.8%, 16/52)



**Frequencies were determined using a 5-point Likert scale and included: Often (more than once per week); Sometimes (more than once per month); Occasionally (more than once every six months); Rarely (more than once per year); Never (no previous exposure).*

Figure 5.5.1 Frequency of exposure to anatomical variations in daily practice (N=52)

According to profession, radiologists (75%, 12/16) encountered anatomical variations more often than surgeons (12.9%, 4/31) (Table 5.5.1). Additionally, only surgeons 22.6% (7/31) rarely and almost never encountered anatomical variations when compared to radiologists (Table 5.5.1). Majority of surgeons (64.6%) encountered anatomical variations fewer times than radiologists (25.1%, 4/16). (Table 5.5.1).

Table 5.5.1 Frequency of anatomical variation encounters between surgeons and radiologists in their current position

Frequency of anatomical variation encounters	Profession				Total	
	Radiologist		Surgeon			
	N	%	n	%	n	%
Almost Never	0	0	1	3.2	1	2.1
Rarely	0	0	6	19.4	6	12.8
Occasionally	1	6.3	10	32.3	11	23.4
Sometimes	3	18.8	10	32.3	13	27.7
Often	12	75.0	4	12.9	16	34.0
Total	16	100	31	100	47	100

**Frequencies were determined using a 5-point Likert scale and included: Often (more than once per week); Sometimes (more than once per month); Occasionally (more than once every six months); Rarely (more than once per year); Never (no previous exposure).*

Clinicians were asked which class of anatomical variation is encountered the most in daily practice (Table 5.5.2). Half of the respondents encountered arterial variations most often (50.0%, 26/52) in daily practice (Table 5.5.2). The second most common variation type were organ variations (19.2%, 10/52) with a relatively even distribution for the other classes of variants (Table 5.5.2). Circulatory anatomical variations were the most encountered bodily system variation (48.4%, 15/31) and the least encountered variants were, nervous (3.2%, 1/31), respiratory (3.2%, 1/31), and reproductive (3.2%, 1/31) ones (Table 5.5.2).

Table 5.5.2 Frequency of the most encountered class of variation and the most encountered bodily system of specific variations observed by clinicians

Class of anatomical variation	n	%
Arterial	26	50.0
Organ	10	19.2
Skeletal	4	7.7
Venous	4	7.7
Nervous	3	5.8
N	47	100
Bodily systems of where specific variations were encountered the most		
Circulatory	15	48.4
Digestive	6	19.4
Urinary	4	12.9
Skeletal	3	9.7
Nervous	1	3.2
Respiratory	1	3.2
Reproductive	1	3.2
N	31	100

5.6.1 Relationships between frequency of anatomical variation encounters and demographic details

A significantly weak positive correlation was found ($\rho = 0.356$; $n=47$; $p= 0.014$) (Figure 5.6.1) indicating that more years of experience a clinician had, the more likely they were to encounter anatomical variations.

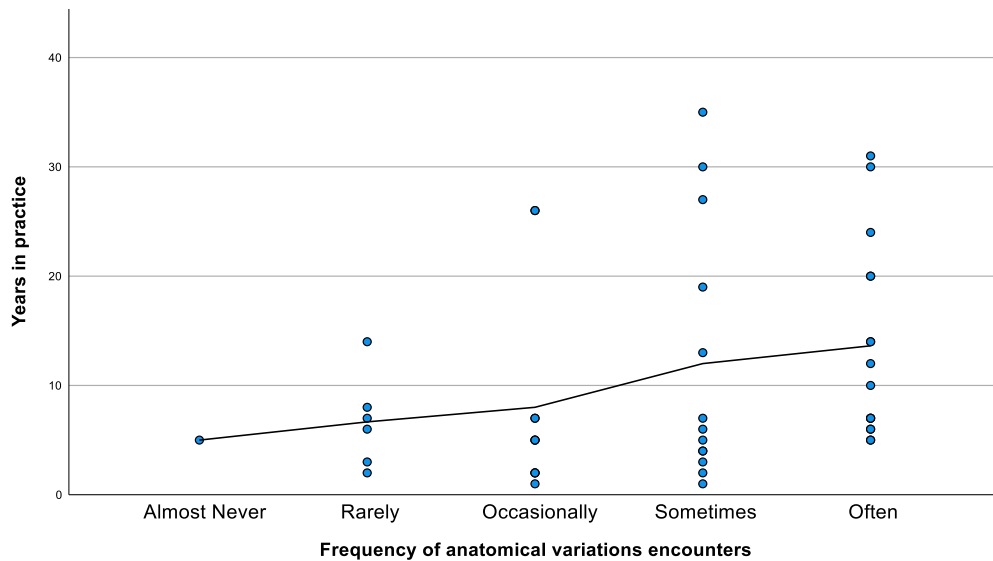


Figure 5.6.1 Relationship between years in practice and anatomical variations encountered in practice by clinicians

A significant association was found (H statistic=11.439, df= 2, n =47, p= 0.003) between sectors that have the highest frequency of variation encounters. Results indicate the private sector had a significantly higher variation encounter frequency than public (p=0.002) even though most clinicians practise in the public sector (51.9%, 27/52). In addition, clinicians working both sectors had significantly higher variation encounters than public (p=0.027), but not private (p=0.655).

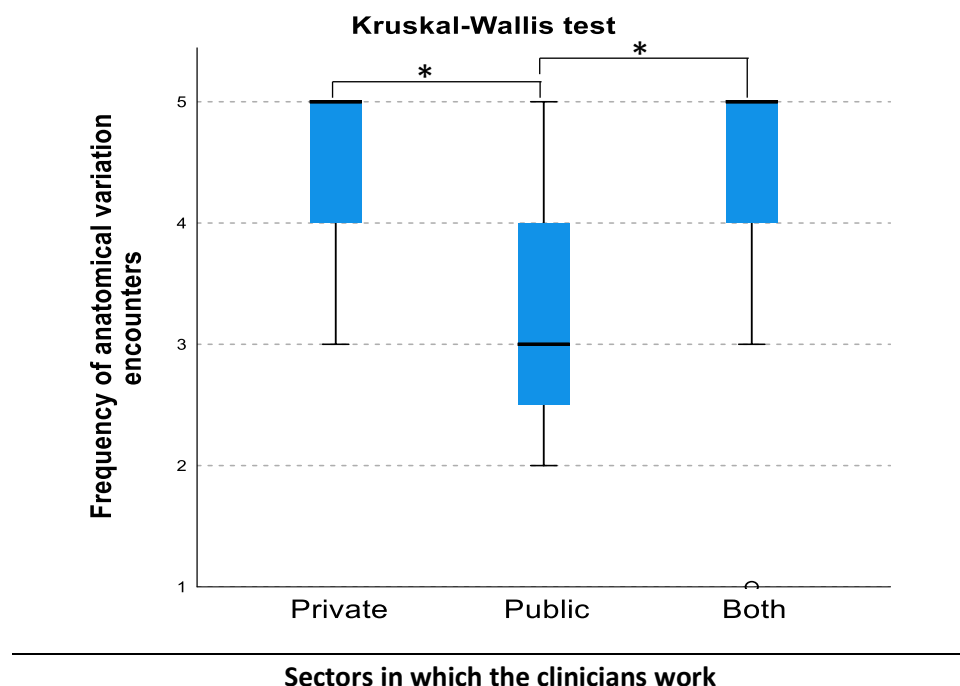


Figure 5.6.2. Associations between the frequency of anatomical variations encounters in practice and the sector in which the clinicians work in. Asterisks indicate significant differences between cohorts

5.7. Shifts in clinical intervention based on encounter with anatomical variations

Clinicians were asked which operative/ procedural stage (pre, peri or post) was most affected when anatomical variations were encountered. The stages most often affected (57.7%, 30/47) were the peri-operative/procedural stage, followed by pre-operative/procedural stage 30.8% (16/47) and the post-operative/ procedural stage (1.9%, 1/47).

Radiologists were also found to be most affected by anatomical variations in the pre-operative/procedural stage while surgeons were most affected by anatomical variations in the peri-operative/procedural stage (Mann-Whitney U value = 427.00, $p = 0.001$, $n = 47$) (Figure 5.7.1).

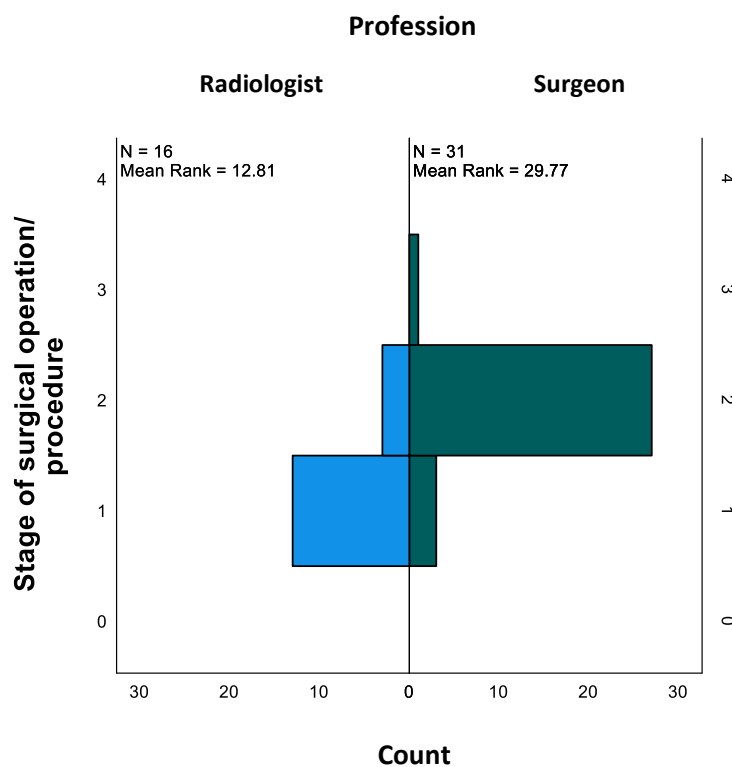


Figure 5.7.1 Graph showing the operative/procedural stage affected most by the anatomical variations between the surgeons and radiologists Key (three stages were identified): 1= Pre-operative/procedure, 2= Peri-operative/procedure, 3= post-operative/procedure

A significant difference was identified between radiologists and surgeons ($\chi^2 = 22.372$, $p = 0.001$, $N=47$) regarding the level of diagnosis or treatment affected when encountering anatomical variations. Specifically, ‘Operation duration’ was most likely affected by encountering anatomical variations among surgeons and ‘Additional diagnostics’, were more often required among radiologists when encountering anatomical variations (Table 5.7.2).

Table 5.7.2 Post hoc result of the profession of clinicians and the level of patient diagnosis/treatment most likely affected by encountering anatomical variations

Levels of patient diagnosis/treatment most likely affected by encountering anatomical variations	Profession				Total	
	Radiologist		Surgeon			
	n	%	n	%	N	%
Procedure type	3 _a	18.8	12 _a	38.7	15	31.9
Operation duration/length	0 _a	0.0	14 _b	45.2	14	29.8
Route of entry	2 _a	12.5	1 _a	3.2	3	6.4
Additional diagnostics	7 _a	43.8	1 _b	3.2	8	17.
Total	16	100	31	100	47	100

Each subscript letter denotes a subset of profession categories whose column proportions do not differ significantly from each other at the 0.05 level. If there are two different subscripts letters, then a significant difference is assumed.

5.8. Perceived value and engagement with scientific literature on anatomical variations

Clinicians were asked the frequency of engagement with literature on anatomical variations (Table 5.8.1.a). More than half of the clinicians (62%, 32/52) engage with literature on anatomical variations. Of these clinicians, the level of engagement was predominantly sometimes (28.8%, 15/52). For the remainder of the group only 7.7% (4/52) never engaged (see Table 5.8.1)

Radiologists were more likely (43.8%, 7/16) to engage with anatomical variation research articles /other academic sources engagement more (often and sometimes) than surgeons (30.6%, 11/36) (Table 5.8.1). Only surgeons (11.1%, 4/36) never engaged with variant research (Table 5.8.1).

Table 5.8.1 Frequencies of engaging in anatomical variation research between radiologists and surgeons

Frequency of anatomical variation research article/other academic sources engagement	Profession				Total	
	Radiologist		Surgeon			
	n	%	n	%	n	%
Often	1	6.3	2	5.6	3	5.8
Sometimes	6	37.5	9	25.0	15	28.8
Occasionally	5	31.3	9	25.0	14	26.9
Rarely	1	6.3	6	16.7	7	13.5
Almost Never	3	18.8	6	16.7	9	17.3
Never	0	0.0	4	11.1	4	7.7
Total	16	100	36	100	52	100

A significant weak/ positive correlation was found between the frequency of engagement of research articles or other academic sources and the frequency in which clinicians encounter anatomical variations in daily practice ($\rho = 0.375$; $p=0.009$, $n=47$).

Clinicians were asked which journal type they prefer when consulting anatomical variation studies. Most radiologists (81.3%, 13/16) prefer radiology specific, and most surgeons (63.9%, 23/36) prefer surgery specific. Surgeons mentioned that they least preferred radiology specific and radiologists least preferred surgery and general/basic science specific journal types (Table 5.8.2)

A significant difference was identified between the journal type most likely to be consulted when engaging in anatomical variation studies and the profession of the clinician (Test statistic = 38.545, $n = 52$, $p=0.001$) (Table 5.8.2).

Table 5.8.2 Frequencies of the preferred journal type for engaging in anatomical variation studies by clinicians

Journal type most likely to consult when engaging on anatomical variation studies	Profession				Total	
	Radiologist		Surgeon			
	n	%	n	%	n	%
Anatomy specific	1	6.3	4	11.1	5	17.4
Clinical medicine	1	6.3	4	11.1	5	17.4
General/basic science	0	0	3	8.3	3	8.3
Radiology specific	13	81.3	1	2.8	14	84.1
Surgery specific	0	0	23	63.9	23	63.9
Other	1	6.3	1	2.8	2	9.1
Total	16	100	36	100	52	100

Clinicians were asked the reasons why they preferred the journal type they chose (Table 5.8.2.a). Almost half the respondents (46.2%, 24/52) stated that the reason they choose that journal was because it is more clinically focused. Time efficiency was the least selected (3.8%, 2/52) reason for why respondents choose that specific journal type (Table 5.8.2.a.)

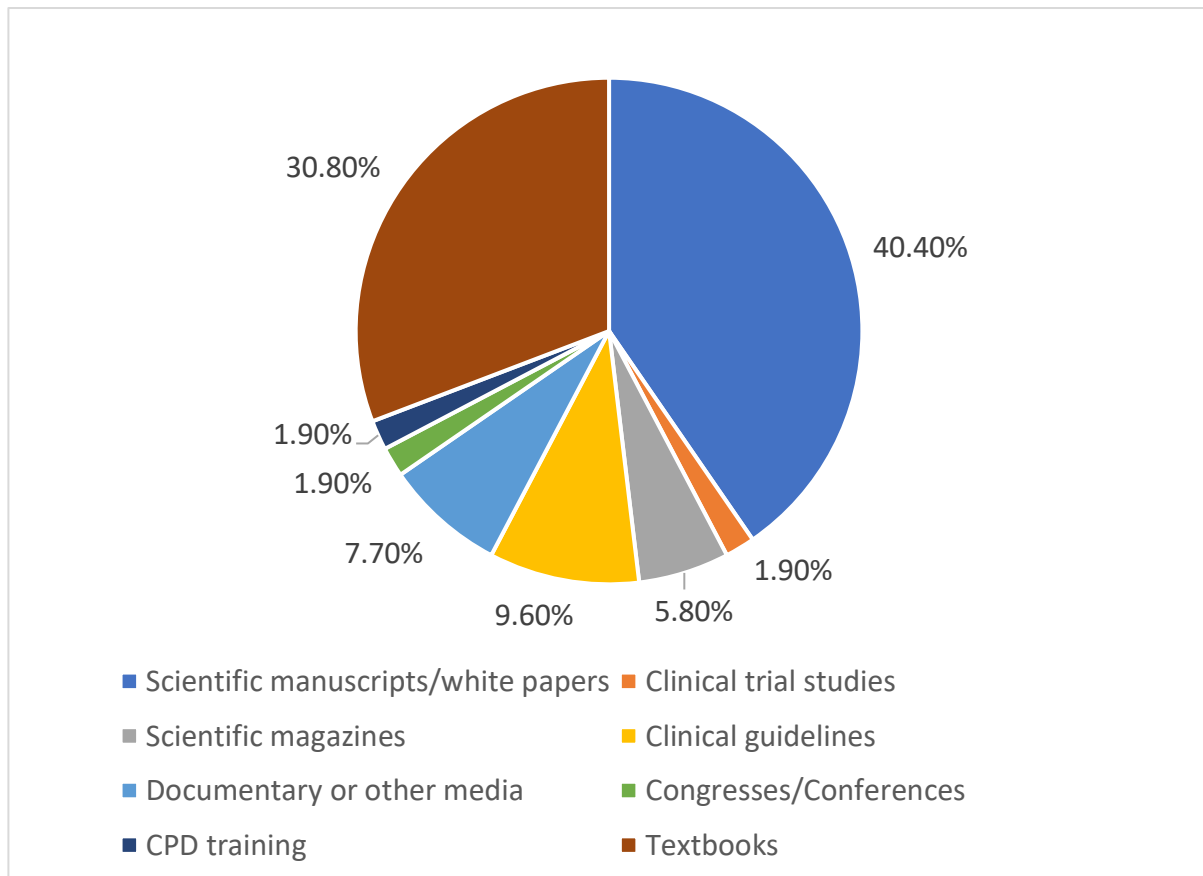
Table 5.8.2.a Frequencies of reasons why clinicians prefer that journal type

Reasons why clinicians preferred that journal type	Frequency	
	n	%
Easily understandable	12	23.1
Accessible	8	15.4
Time-efficient	2	3.8
More clinically focused	24	46.2
More anatomically based	3	5.8
Other	3	5.8

Clinicians were asked what source is commonly used when searching for information on anatomical variations (Figure 5.8.3). Scientific manuscripts (also known as white papers) (40.4%, 21/52) were the most used sources for acquiring information relating to anatomical variations. The least used sources were clinical trial studies, congresses/conferences and CPD training which had an even distribution (1.9%, 1/52)

* CPD training: Educational activities which professionals engage in to improve/develop skills for their career progression (CIPD, 2023)

Figure 5.8.3. Pie chart showing the frequency of the preferred source of acquiring information on anatomical variations by clinicians



Furthermore, a contingency table between the most utilised source of acquiring information relating to anatomical variations against the profession of the clinician (Table 5.8.4), highlighted the following result. For radiologists, textbooks (25%, 4/16), and documentaries or other media were most used (Table 5.8.4). Radiologists did not use clinical trial studies and congresses/conferences at all. Surgeons used scientific manuscripts the most (50.0%, 18/36) followed by textbooks (33.3%, 12/36). None of the surgeons used documentary/other media and CPD training as sources to learn about anatomical variations. (Table 5.8.4).

Table 5.8.4 Frequency of the different sources utilized for acquiring information relating to anatomical variations for the two different clinical professions

Source(s) utilized the most to acquire information relating to anatomical variations	Profession				Total	
	Radiologist		Surgeon			
	n	%	n	%	n	%
Scientific manuscripts/white papers	3	18.8	18	50	21	40.4
Clinical trial studies	0	0	1	2.8	1	1.9
Scientific magazines	2	12.5	1	2.8	3	5.8
Clinical guidelines	2	12.5	3	8.3	5	9.6
Documentaries or other media	4	25.0	0	0	4	7.7
Congresses/Conferences	0	0	1	2.8	1	1.9
CPD training	1	6.3	0	0	1	1.9
Textbooks	4	25.0	12	33.3	16	30.8
Total	16	100	36	100	52	100

Additionally, clinicians that prioritised scientific manuscripts were asked what specific format they preferred. Majority of the clinicians ranked original research manuscripts (81.0%, 17/21) higher as the preferred format in comparison to case reports (19.0%, 4/21).

The necessity of anatomical knowledge in clinical practice and the most utilised source to acquire information relating to anatomical variations by clinicians were compared. No significant difference was found between the two variables (value= 16.694; p= 0.799, N=52), suggesting that there was no relationship between the type of source clinicians use and how they rate how necessary anatomical knowledge is for practice.

Clinicians were asked the reason why they selected the source they did for engaging with variation studies (Table 5.8.5). Among the clinicians, 25.0% (13/52) respondents, found reliability to be the most important reason (Table 5.8.5). The least selected reason was peer advice (5.8%, 3/52) (Table 5.8.5).

Table 5.8.5 Frequency of various reasons selected by clinicians when engaging with studies relating to anatomical variations

Reason for research source chosen when engaging with studies relating to anatomical variations	Frequency	
	n	%
Reliable	13	25.0
Accessible	12	23.1
Easily understandable	10	19.2
Credible	9	17.3
Time-efficient	5	9.6
Peer advised	3	5.8
Total	52	100

Clinicians were asked what factor is deemed most important when consulting a research paper (Table 5.8.6). Most clinicians (23.1%, 12/52) considered accessibility/ availability as the most important factor when interacting with a research paper (Table 5.8.6). Impact factor was the least considered factor by clinicians (13.5%, 7/52) of when consulting research papers (Table 5.8.6).

Table 5.8.6 Frequency of various factors considered by clinicians when consulting research paper

Factors considered by clinicians when consulting a research paper	Frequency	
	n	%
Availability/ accessibility (whether open access or subscription based)	12	23.1
Clear and high-quality figures and images	11	21.2
Methodology (e.g., sample size, repeatability)	11	21.2
Source credibility (e.g., predatory journal or not)	11	21.2
Impact factor of journal	7	13.5
Total	52	100

5.8.1 Future recommendations for improving future anatomical studies

The final question of the questionnaire included an open-ended space for clinicians to provide any recommendations on improving future anatomical studies (Figure 5.8.7). Out of 52 clinicians, 14 clinicians responded. The responses given highlighted two distinct categories:

improving future anatomical studies and improving medical training (Figure 5.8.7). Within responses regarding anatomical studies, a further two themes were highlighted: research publications in relevant anatomical journals (14.3%, 2/14), and the inclusion of anatomical variation literature in UG and PG training (7%, 1/14) (Figure 5.8.7).

Within responses regarding medical anatomical training, a further four themes were highlighted: more clinical based training (35.7%, 5/14), more technology-based training i.e., apps, programs (14.3%, 2/14), more dissections exposure (14.3%, 2/14) and a compilation of most common variations per region/country included in medical training (14.3%, 2/14) (Figure 5.8.7).

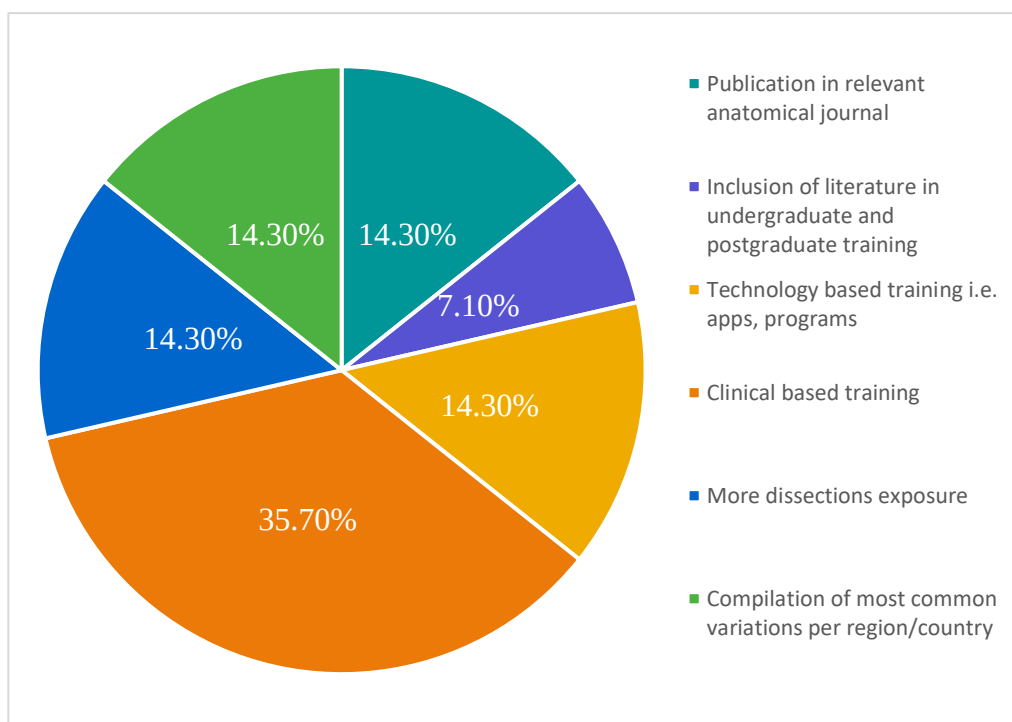


Figure 5.8.7 Recommendations by clinicians for anatomical studies and medical training. n = 14

5.9 Scoping review

The second component of the current study utilised a scoping review to assess the prevalence of repeatability and reproducibility in anatomical arterial variant studies of the abdomen. This review covered abdominal arterial variations between 2006-2023. PubMed and Web of Science were used as the databases to conduct the searches. In phase one, a total of 6003 potential abstracts were identified (Figure 5.9), according to the key words, from the databases PubMed (2938 abstracts) and Web of Science (3050 abstracts) (Figure 5.9). After initial search and removal of duplicates across both databases, 2647 abstracts were included for phase two. In phase two, 622 papers were selected for inclusion in the scoping review based on the full manuscript. Due to inaccessible papers (n=95), and reassessment of the articles based on the content and exclusion criteria (n=45), data was extracted from a final total of 487 sources (Figure 5.9)

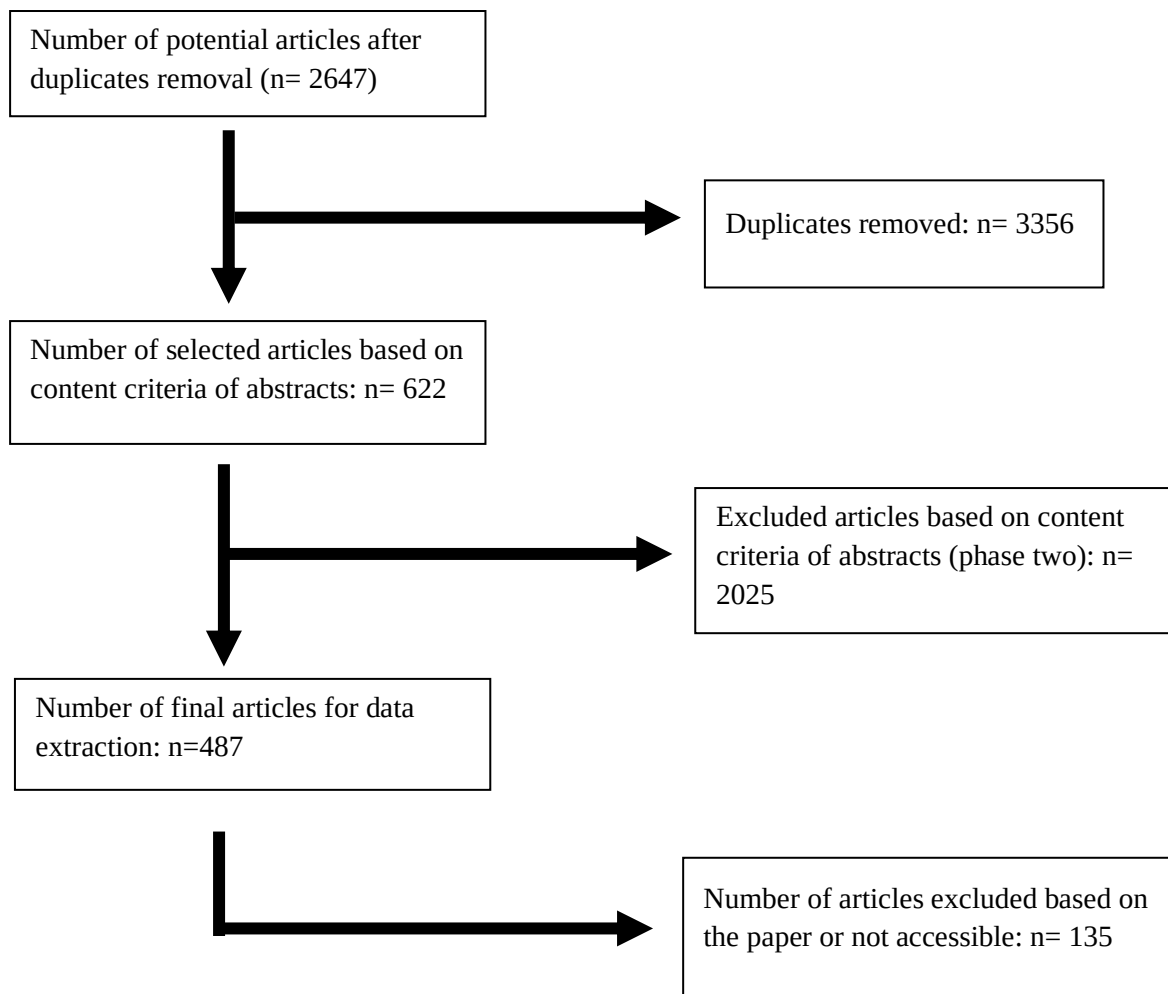


Figure 5.9. Source inclusion and exclusion process at the various stages of the scoping review

Considering the prevalence of the different evidence source types, most of the studies were case reports (56.5%, 275/487), while original research manuscripts were 43.5% (212/487). Amongst the original research manuscripts (212/487), there were 92.5% (196/212) retrospective studies and 7.5% (16/212) prospective studies.

Under the theme of journal, most studies were published in medical journals (37.4%, 182/487) (Table 5.10). The least studies were published in three journals in the 0% range, which was scientific (0.8%, 4/487), life science (0.4%, 2/487) and biomedical engineering (0.2%, 1/487) (Table 5.10).

Furthermore, the different types of evidence source type were assessed to see which source type was prevalent and published in various journal themes (Table 5.10). Most case reports (37.8%, 104/275) and original research manuscripts (36.8%, 78/212) were published in medical themed journals. Original research manuscripts were least published in scientific (1.9%, 4/212, biomedical engineering (0.5%, 1/212) and life science (0%, 0/212) themed journals (Table 5.10). This was the same for case reports with 0.7% (2/275) life science and 0% (0/275) for biomedical engineering and scientific themed journals (Table 5.10).

Table 5.10 Frequency of evidence source types published under various themes in journals

Theme of Journal	Evidence source type				Total	
	Case report		Original research manuscript			
	n	%	n	%	n	%
Anatomical	68	24.7	41	19.3	109	22.4
Biomedical engineering	0	0.0	1	0.5	1	0.2
Life Science	2	0.7	0	0	2	0.4
Medical	104	37.8	78	36.8	182	37.4
Medical Science	14	5.1	8	3.8	22	4.5
Radiological	15	5.5	39	18.4	54	11.1
Scientific	0	0.0	4	1.9	4	0.8
Surgical	42	15.3	22	10.4	64	13.1
Surgical and Radiological	30	10.9	19	9.0	49	10.1
Total	275	100	212	100	487	100

Among the studies included in the scoping review, three categories were identified, namely living, cadaveric and a combination of cadaveric and living. Majority of the variation studies made use of a living patient sample (58.5%, 285/487) and 40.5% (197/487) cadaveric studies. The least observed sample type was the combination of cadaveric and living patient samples (1.0%, 5/487).

Furthermore, the different types of samples were assessed to see which source type was prevalent for each sample type (Table 5.11). Out of the cadaveric sample, majority were case reports (68%, 134/197) with (32%, 63/197) in original research manuscripts. For the living patient sample, there was a near-even distribution between original research manuscripts (50.5%, 144/285) and case reports (49.5%, 141/285) (Table 5.11).

Table 5.11 Frequency of types of samples observed across evidence source types in the included abdominal arterial variation studies

Evidence source type		Both		Cadaveric		Living		Total	
		n	%	n	%	n	%	n	%
	Case report	0	0	134	68	141	49.5	275	56.5
	Original research manuscripts	5	100	63	32.0	144	50.5	196	40.2
Total		5	100	197	100	285	100	487	100

Most cadaveric studies were published in medical journals (41.1%, 81/197) (Table 5.12). For the living patient studies, most were published under medical journals 35.4% (101/285) followed by surgical journals 18.9% (54/285) (Table 5.12). Less cadaveric studies were published in radiological (1.0%, 2/197), scientific (1.0%, 2/197), life science (0.5%, 1/197) and biomedical engineering (0%, 0/197) (Table 5.12). Less living patient studies were also published in scientific (0.7%, 2/285), biomedical engineering (0.4%, 1/285) and life science (0.4%, 1/285)_theme journals (Table 5.12).

Table 5.12 Frequency of types of samples observed across evidence journal themes in the included abdominal arterial variation studies

Theme of journal	Sample type						Total	
	Both		Cadaveric		Living			
	n	%	n	%	n	%	n	%
Anatomical	2	40.0	67	34.0	40	14.1	109	22.4
Biomedical engineering	0	0	0	0	1	0.4	1	0.2
Life Science	0	0	1	0.5	1	0.4	2	0.4
Medical	0	0	81	41.1	101	35.4	182	37.4
Medical Science	0	0	15	7.6	7	2.5	22	4.5
Radiological	1	20.0	2	1.0	51	17.9	54	11.1
Scientific	0	0.0	2	1.0	2	0.7	4	0.8
Surgical	0	0.0	10	5.1	54	18.9	64	13.1
Surgical and Radiological	2	40.0	19	9.6	28	9.8	49	10.1
Total	5	100	197	100	285	100	487	100

When reviewing the prevalence for the use of reliability techniques, 75.4% (367/487) of the studies did not report any. The remaining 24.6% (120/487) of studies conducted and reported some form of reliability testing (Table 5.13). The source type exhibiting the highest degree of included reliability testing were original research manuscripts (80%, 96/120) of which 72.5% (87/120) were retrospective studies and 7.5% (9/120) were prospective studies (Table 5.13). Few case reports had reproducibility and/or repeatability (20.0%, 24/120).

Table 5.13 Frequency of reproducibility/repeatability observed across evidence source types in the included abdominal arterial variation studies

Evidence source type	Reproducibility/ Repeatability				Total	
	Absent		Present			
	n	%	n	%	n	%
Case report	251	68.4	24	20.0	275	56.5
Original research manuscript	116	31.6	96	80	212	43.5
Total	367	100	120	100	487	100

Reproducibility/repeatability was most prevalent in living sample population studies (86.7%, 104/120) while only 10.8% (13/120) was observed for cadaveric sample type studies (Table 5.14).

Table 5.14 Frequency of reproducibility/repeatability observed across evidence source types in the included abdominal arterial variation studies

Sample type	Reproducibility/ Repeatability				Total	
	Absent		Present			
	n	%	n	%	n	%
Living	181	49.3	104	86.7	285	58.5
Cadaveric	184	50.1	13	10.8	197	40.5
Both	2	0.5	3	2.5	5	1.0
Total	367	100	120	100	487	100

Reliability was also investigated across themes in journals (Table 5.15). Medical themed journals published the most studies that included reproducibility/repeatability (31.7%, 38/120). The journal theme with the lowest inclusion was life science and scientific journals (0.8%, 1/120). Biomedical engineering journals had no study with repeatability/ reproducibility (Table 5.15).

Table 5.15 Frequency of reproducibility/repeatability observed across journal themes in the included abdominal arterial variation studies

Reproducibility/R epeatability	Anatomical		Biomedical engineering		Life Science		Medical		Medical Science		Radiological		Scientific		Surgical		Surgical and Radiological		Total	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Absent	95	88.0	1	100	1	50.0	144	79.1	16	72.7	23	42.6	3	75.0	48	75.0	36	73.5	367	75.4
Present	14	12.0	0	0.0	1	50.0	38	20.9	6	27.3	31	57.4	1	25.0	16	25.0	13	26.5	120	24.6
Total	108	100	1	100	2	100	182	100	22	100	54	100	4	100	64	100	49	100	487	100

CHAPTER 5

6. **Discussion**

The aim of the current study was to investigate the perceptions of clinicians (surgeons & radiologists) on the relevance of anatomical knowledge and exposure to anatomical variants. Secondly, to assess the use of reliability testing (i.e. repeatability and reproducibility measures) across different types of abdominal arterial variant studies. General findings indicate that South African clinicians deem anatomical knowledge important and are exposed to anatomical variants quite often in clinical practice. However, a low number of clinicians engaged with anatomical variation research often, which is concerning considering the frequency of variations that they encountered in clinical practice.

Concerning the scoping review, most of the studies included did not conduct or report reliability techniques (repeatability and reproducibility) and of those that did, they were predominantly from original research manuscripts when compared to case reports.

6.1 Significance of anatomical knowledge to clinicians and medical students

Anatomical knowledge is the foundation for learning about human pathophysiology, patient examination & diagnosis (Koppes *et al.*, 2022). Anatomical learning also promotes collegial communication and facilitates the initial learning of anatomical structures (Almizani *et al.*, 2022). Most clinicians consider anatomical knowledge most crucial for clinical practice in general (Sbayeh *et al.*, 2016; Rajprasath *et al.*, 2019; Singh *et al.*, 2022; Kowalczyk *et al.*, 2022) and South African clinicians in this current study share this sentiment. However, this sentiment does not extend into all parts of the world, as in the United Kingdom less than 50% of senior (consultants and above) surgeons regard anatomical knowledge very important or essential (Tibrewal, 2006). In the current study, majority of the clinicians were at a senior position, had written their college exams and notably over 90% of them agreed strongly on the necessity of anatomical knowledge.

However, despite the varying levels of the importance of anatomical knowledge to clinicians globally, senior clinicians find incoming medical trainees to have limited anatomical knowledge (Waterston and Stewart, 2005; Raikos and Smith, 2015; Tayyem *et al.*, 2019). A recent South African study reported that senior clinicians identified that medical students, in their clinical years, were lacking in anatomical competence for the clinical setting (Lunn-

Collier *et al.*, 2022). Consequently, medical students regard their own anatomical knowledge inadequate (Triepels *et al.*, 2018, Farey *et al.*, 2018, Tayyem *et al.*, 2019).

Poor anatomical knowledge could have adverse effects on the patient (Macmillan, 2023). Inadequate investigation or poor anatomical knowledge by surgeons on anatomical abnormalities results in challenging surgeries or revisions of the surgical procedure (Macmillan, 2023) and thus increases the risk on patients' lives (Cheng *et al.*, 2018). Additionally, this results in prolonged, complex surgical procedures that utilises more resources e.g. a need for more blood as longer surgeries often have increased blood loss (Shtarbanov *et al.*, 2023). Therefore, revision surgeries also increase the financial burden of the hospital and on the patient (Birkmeyer, 2001).

Thus, good anatomical knowledge, is important and can lead to dire clinical consequences for patients. Concurrently anatomical knowledge acquisition through the different tools of knowledge dissemination during medical education and training of clinicians is equally important.

6.2 Medical education/training of clinicians

Human dissection, prosection, plastinated human specimens, plastic models, and computer-based software have been outlined as tools for undergraduate anatomical training (Craig *et al.*, 2010, Memon, 2018, Rockarts *et al.*, 2020, Smith *et al.*, 2021). Certain countries prioritise specific tools over others. Australia and New Zealand use prosection and plastic models for teaching gross anatomy more frequently than dissection (Craig *et al.*, 2010; Hutchinson *et al.*, 2019). Canada uses prosection the most for anatomical learning in comparison to other tools (Rockarts *et al.*, 2020). The UK and Ireland commonly use dissection and prosection in their anatomy curriculum relative to other anatomical modes (Smith *et al.*, 2021) while the USA utilizes dissection the most (Memon, 2018). Within Africa, dissection is the primary anatomical learning tool (Memon, 2018) and the best resource to teach anatomy to medical students (Anyanwu, 2010, Ghazanfar *et al.*, 2018, Asante *et al.*, 2021, Kalthur, Pandey and Prabhath, 2022) and for majority of our clinicians in the current study, dissection was the primary anatomical tool for their undergraduate anatomical learning.

This is important to note as undergraduate medical training has been under scrutiny across anatomical curricula in recent years (Tayyem *et al.*, 2019, Shin *et al.*, 2022, Chang Chan *et al.*, 2022). Majority (89.8%) of pre-clinical year students and interns in Netherlands stated that dissection was extremely essential for anatomical knowledge (Mutalik and Belsare, 2016).

However, this teaching method and general morphological anatomy teaching hours appear to be on the decline in medical schools (Craig *et al.*, 2010, Bergman *et al.*, 2013; Singh *et al.*, 2015; McBride and Drake, 2018; Rockarts *et al.*, 2020; Smith *et al.*, 2021). It has been observed that anatomical knowledge is not assessed enough during undergraduate medical students' clinical years (Turney, 2007; Fitzgerald *et al.*, 2008)

However, the South African clinicians in this study felt adequately prepared for clinical practice based on their undergraduate medical training and most of the clinicians had been trained in South Africa for their undergraduate medical training. The clinicians in the current study further explained that their undergraduate training was sufficient. In US medical schools, most anatomy instructors stated that since the start of the COVID-19 pandemic, there was a further reduction in dissection hours and interactive learning for anatomy (Shin *et al.*, 2022). Additionally, more than half of Australasian medical schools did not have a precise assessment structure for morphological anatomy (Craig *et al.*, 2010). Most medical students in an Australian study stated that there was a severe lack of anatomical knowledge assessment during their medical training (Farey *et al.*, 2018). However, for South African clinicians in the current study, this may not be the case as most attributed their clinical preparedness to sufficient dissection exposure in undergraduate training.

Plastinated specimens are another noteworthy source of learning anatomy (Riederer, 2014). In the current study, this mode of anatomical training was the second most used tool by clinicians in undergraduate medical training. Most Saudi Arabian and Singaporean medical students concurred highly and ranked plastinated specimens the preferred anatomical tool (Atwa, Dafalla and Kamal, 2021; Radzi *et al.*, 2022) while Turkish medical students deemed the resource the least preferable for lab related activities (Karaer and Barut, 2017). Plastinated specimens may be the best alternative for anatomical learning after dissection as they represent real individuals and have great anatomical detail (Radzi *et al.*, 2022).

Computerized anatomical programs in anatomical learning are on the rise (Craig *et al.*, 2010; Smith *et al.*, 2021). Over 40% of clinicians indicated that they were never exposed to computer software in undergraduate training. As the average years of practice for clinicians in the current study was greater than 10, most of them would have been trained when dissection was still the more common tool for anatomical education. Therefore, majority of the clinicians questioned in the current study may not have had access to during their undergraduate and possibly postgraduate training to these recent software as they were trained prior to the widespread use.

The rapid growth in technological advancements, has seen a substantial increase in the access and use of computer-based anatomical learning tools (Zargaran *et al.*, 2020; Lottering *et al.*, 2022). However in general, there is a vast disparity in access to computer-based resources also reflected on current South African undergraduate students (Lazarus, Sookrajh and Satyapal, 2017). Many mobile devices cannot facilitate the use of the programs; therefore, students may not have consistent access to this anatomical learning tool (Lazarus, Sookrajh and Satyapal, 2017) even when it is now deemed ubiquitous.

The second least used anatomical tool in the current study was plastic, anatomically relevant models. However recently, students from Turkey, Netherlands and India regard 3-D plastic models and images as the ideal tool for enhancing their anatomical knowledge (Mutalik and Belsare, 2016; Karaer and Barut, 2017; Triepels *et al.*, 2018). There appears to be a shift of appreciation for 3-D models for understanding anatomy better in medical undergraduate training. Non-human dissection was the least used anatomical tool in undergraduate and postgraduate medical training and is usually primarily used in biological education (Osenkowski *et al.*, 2015; Kaiser *et al.*, 2023)

It has been observed that towards the end of undergraduate training, students are not as exposed to anatomical sessions which affects the clinicians' readiness for postgraduate training (Standring, 2009). South African postgraduate medical training is facilitated at the medical schools where undergraduate medical training takes place (Shabalala, 2019). The decline in cadavers in medical school in the last 20-30 years (Mwachaka, Mandela and Saidi, 2016, Memon, 2018) has been attributed due to the high financial costs of procuring, facilitating, and maintaining cadaveric dissection as a learning tool (Varner, Dixon, and Simons, 2021). This may also affect the availability of dissection as a teaching tool in postgraduate anatomical courses. Particularly since there has also been an increase in the student to cadaver ratio in undergraduate medical training (Mwachaka, Mandela and Saidi, 2016). In the current study, most clinicians were never exposed to human dissection more during their postgraduate studies. Moreover, over 70% of clinicians had never been exposed to plastinated human specimens either. This is to be expected as availability of cadavers for dissection may extend to plastination and consequently be scarce as well. The fact that clinicians were more often exposed to plastic, anatomical models highlight this possible scarcity.

Postgraduate medical training courses incorporate better anatomical training for clinicians (Memon, 2018). This is important as majority of Dutch postgraduate medical students stated

that anatomical training was more important in postgraduate medical training (Triepels *et al.*, 2018). South African surgical training has three main exams for the College Exam Fellowship and the primary exam includes anatomy as a core subject for assessment (Degiannis *et al.*, 2008). This emphasises how anatomical knowledge is relevant up to the level of surgical specialisation.

How surgeons are trained varies across the world (Whewell *et al.*, 2020). The UK, Ireland, Australia, and New Zealand often have longer periods of postgraduate training (Whewell *et al.*, 2020) in comparison to South Africa. Surgeons trained in the UK and Ireland were also observed to conduct more surgical procedures than other countries (Whewell *et al.*, 2020). However, despite the differences in length of training hours, majority of South African clinicians still regard their postgraduate training sufficient. This is despite an observation that South African surgeons who qualified after 1990 felt more confident in their knowledge compared to surgeons who qualified after 2000 (De Beer, Karusseit and Pienaar, 2014).

Even though it is seen that clinicians benefit from specialist anatomical training in their postgraduate studies, many countries do not have anatomy as one of their mandatory courses during postgraduate training (Whewell *et al.*, 2020). In the current study, more clinicians experienced increased preparedness based on their postgraduate anatomical training (86.5%) compared to undergraduate anatomical training (69.2%). Moreover, 47.6% of clinicians felt adequately prepared for clinical practice due to more exposure to anatomical variations during their postgraduate training. Interestingly, only one clinician (4%) felt adequately prepared due to variant anatomy exposure during their undergraduate training

Surgical trainees are considered to not have sufficient anatomy and anatomical variations knowledge (Raikos and Smith, 2015, Ttayem *et al.*, 2019). This corroborates the findings on the gradual decline of adequate anatomical knowledge training since the increase in the use of computer-based programs, software, and digital media for learning anatomy globally (Kuyatt and Baker, 2014, Lottering *et al.*, 2022, Amr Maani *et al.*, 2023). However, this does not necessarily benefit learning of anatomical variants as most software options available present strictly normal anatomy and do not discuss variants, at the exception of extremely common cases (e.g., Visible Body software (Argosy Publishing, Inc, 2019)). As mentioned, cadaver-based teaching (i.e. human dissection) has been shown to be the best and preferred teaching method of exposing medical students to variations dissection (Rizzolo, 2002, Granger, 2004, Raikos and Smith, 2015, Goldberg and Royer, 2016).

Majority of clinicians indicated they had been exposed to anatomical variation in both their undergraduate and postgraduate training. A further 13.5% clinicians were exposed to anatomical variations only in undergraduate training. Considering how dissection and plastinated specimens are considered to facilitate more exposure to and understanding of anatomical variations by students and anatomical educators (Chapman *et al.*, 2013, Riederer, 2014), this corroborates that most clinicians in the current study may have been exposed to anatomical variations possibly through these anatomical tools.

Inadequate or no knowledge of variations as a practicing clinician can be a product of little exposure to anatomical variations in undergraduate training (Bergman, 2011). The inclusion of 3D models or physical preserved cadaveric specimens could enhance the exposure of anatomical variations to medical students (Moore, Wilson, and Rice, 2017).

Medical students could benefit in being more aware of variability of humans prior to residency training (Moore, Wilson, and Rice, 2017). This could be achieved through the inclusion of models or specimens with variations present. Practical assessments including anatomical variations would be effective tool to test a students' understanding of typical and atypical anatomy (Moore, Wilson, and Rice, 2017). Most clinicians in the current study suggested more clinical based training be included in medical training. Piromchai *et al.*, 2017 observed that frequent surgical simulations enhanced surgical skills and increased the success rates of surgical operations. Clinicians recommended more clinical training be implemented in anatomical medical education. This corroborates with a study which states that, most students and interns also expressed the need for radiological (68%) and living anatomy (89.8%) based training (Mutalik and Belsare, 2016).

Anatomy educators could utilise medical imaging in their lectures to improve students' capabilities in recognizing anatomical structures (de Barros *et al.*, 2001; Khalil *et al.*, 2005). Additionally, it is advised that anatomical variation 3D models should be learnt in conjunction with cadaveric dissection (Aziz and Mansor, 2006; Moore, Wilson, and Rice, 2017).

Another recommendation is a catalogue of specialty or profession specific common anatomical variations (Raikos and Smith, 2015). This aids in the understanding of the important, relevant, and anatomical variations that affect medical practice (Raikos and Smith, 2015). Additionally, since 2005, Rowland *et al.*, (2010) observed that there was a decrease in practical assessing

methods such as anatomy spot tests, coupled with an increase in the more aggressive method of theory-based assessment of medical students.

Raikos and Smith, (2015) indicated that senior (<75%) surgeons and radiologists in charge of surgical and radiological trainees think it is important to teach anatomical variations in postgraduate training. Additionally, the clinicians in the current study recommended that variations studies be taught throughout undergraduate and postgraduate training as depicted by the following statement:

“Consistent teaching throughout undergraduate and postgraduate training”-Respondent A.

There is insufficient literature that assesses medical curricula which implement anatomical variations globally (Moore, Wilson, and Rice, 2017). Only one study (Raikos and Smith, 2015) and this current study to date documents or assesses the integration of anatomical variations in undergraduate and postgraduate training. Moreover, there are no studies that have documented how the variation incorporated learning would compare to medical curricula that includes little or no anatomical variations.

6.3 Exposure of anatomical variations in clinical practice and intervention shift: radiologists vs surgeons

Generally, most clinicians had recently encountered an anatomical variation. Furthermore, South African clinicians were exposed to variants in their practice more regularly, than compared to Australian and Canadian clinicians in a similar study (Raikos and Smith, 2015).

“Clinical judgement is directly proportional to medical experience” (Tayyem *et al.*, 2019, p.1476) which in the current study’s context, continual exposure and learning of anatomical variations can lead to more identification of variations. The current study identified a weak but significant correlation between years in practice and frequency of anatomical variation encounters. This result suggested that the more years of experience a clinician may have the more likely to identify anatomical variants more frequently. Again, considering the average years of experience of the clinicians in the current study being 10.67 and most of the clinicians occupying a senior position, the assumption would be that a lot of clinicians would have had an adequate amount of exposure to anatomical variations.

When we separate exposure to variants by profession, more radiologists were exposed to anatomical variations than surgeons in the current study. Clinicians have mentioned that anatomical knowledge is majorly integrated into radiology (Smith and Mathias, 2010), which

is an expectation when considering the diagnostic and interventional requirements of their profession.

Diagnostic radiologists use imaging technology to diagnose various injuries and medical conditions while interventional radiologists in addition use imaging to treat the various medical conditions (Vernon, 2023). Oncology radiologists however specialise in using radiation for cancer treatment and various other medical conditions (Vernon, 2023). Most of the clinicians were diagnostic radiologists. Aligning with their job description; it is likely that diagnostic radiologist would be more likely to encounter anatomical abnormalities.

However, generally surgeons seldom consult radiologists (Royal, Siegel and Murphy, 1993; Kwee, Almaghrabi and Kwee, 2023) even though radiologists are more likely to be the first point of contact for abnormalities and surgeons need diagnostic tests to decide whether to operate or not (Timothy, 2023). In the current study radiologists were most affected by anatomical variations in the pre-operative/procedural stage while surgeons were affected by variations in the peri-operative stage. As mentioned, this aligns with radiologists' role to interpret diagnostic images and perform procedures which involve image guidance (Dhanoa *et al.*, 2013).

For radiologists, anatomical knowledge is particularly important for interpreting cases of variations on radiological images (Singh *et al.*, 2022). This forms part of diagnosing patient conditions and is imperative in planning the next steps of possible surgical intervention (Singh *et al.*, 2022). Therefore, intrinsic knowledge of normal and abnormal anatomy serves as an important role in patient treatment (Singh *et al.*, 2022) and if lacking, leads to high diagnostic error rates amongst radiologists (Berlin, 2014). Normally the error rates are between 3-4% in radiological research studies with both normal and abnormal anatomy (Alexander *et al.*, 2020) but the diagnostic error rate can increase to as high as 30% if all the images being interpreted have abnormalities in the radiological images (Berlin, 2014).

Pre-operative planning is the protocol for pre-surgical preparation of a patient, and involves pre-operative imaging involving x-rays, ultrasound, computed tomography (CT) scans, magnetic resonance imaging (MRI) and additional imaging modalities of which radiologist specialise in (Healthdirect, 2019; Sharma, 2023). Radiologists are imperative in recognising typical anatomy and anatomical variations in preoperative planning (Singh *et al.*, 2011). This may be the main reason why radiologists were most affected by anatomical variations in the pre-operative/procedural stage. Moreover, in cases of abnormal incidental findings, many

radiologists need to conduct more examinations or imaging modalities to confirm the abnormality e.g. a CT may be ordered after an abnormality is identified on a radiograph (Lumbreras, Donat and Hernández-Aguado, 2010). Therefore, it is sensible that most radiologists in the current study would employ additional diagnostics when an anatomical variation was encountered.

Surgeons were most affected by anatomical variations in the peri-operative/procedural stage. Intraoperative adverse events (IAE) are described as complications that emerge during surgical procedures and are underreported in surgical literature (Cacciamani *et al.*, 2022). IAE include anatomical variations that were unidentified during the preoperative stage (Cacciamani *et al.*, 2022). Reporting these intraoperative findings and stage-specific adverse medical events is important for enhancing surgeons' awareness to these complications (Cacciamani *et al.*, 2022)

For surgeons, anatomical variations had a large impact on the duration of operations. Surgical operational delays incur financial costs (Wong *et al.*, 2010). This is because for many surgical operations, the operating team are paid hourly (Wong *et al.*, 2010)

In one study, not consulting radiologists is prevalent amongst academic hospitals (Kwee, Almaghrabi and Kwee, 2023). However, in non-academic hospitals, clinicians have been noted to rely extensively on radiologists (Kwee, Almaghrabi and Kwee, 2023). All academic hospitals in South Africa are primarily public hospitals (Department of Health, 2012). Frequency of anatomical variation exposure to clinicians could differ between the private or the public sector due to differences in surgical resources (Dell, Kahn, and Klopfer, 2018). In the current study clinicians that work in the private sector observed more anatomical variations than the public sector clinicians. Surgeons in public hospitals may not depend on radiological imaging due to resource and time constraints and only encounter variations when a surgical operation is conducted. European orthopaedic surgeons reported that they rarely read radiology reports due to lack of time (Donners *et al.*, 2021) however clinicians in Australia were more likely to underscore the importance of medical imaging in clinical practice (Kwee, Almaghrabi and Kwee, 2023). Due to high volume of patients per surgeon (Dell and Kahn, 2018), many patients may not reach a radiologist for comprehensive imaging. Many cases with anatomical variations may go unnoticed due to the fewer resources assigned to individuals who are treated at a public hospital (Dell and Kahn, 2018). The lack of consultation between radiologists and surgeons can result in many anatomical variations being missed prior to further medical interventions.

More than 70% patients from a private surgical training institution in South Africa stated that they think doctors should undergo surgical training at private hospitals (Lutrin *et al.*, 2022). This affinity to private based surgeons may be because majority of the patients reportedly are seen by more than one doctor (Lutrin *et al.*, 2022). A multiple attending clinicians' system has been observed to in Japan to increase the level of high-quality medical care (Park *et al.*, 2023). Patients being observed by more than once clinician, creates an unconscious repeatability process which may multiply opportunities between different clinicians for detection on anatomical variations in private clinical practice.

However, in South African public hospitals, there is often 3.58 specialist and non-specialist surgeons responsible for 100 000 people (Dell and Kahn, 2018). The probability of a multiple diagnosis system may not be applicable which results in less anatomical variations being detected as seen in the current study. Additionally, the private health sector in South Africa has more than two-fold hospital beds than the public hospital beds (Dell, Kahn, and Klopper, 2018). This is even though the public sector has significantly lower number of surgeons per capita (Dell, Kahn, and Klopper, 2018). There is no study that has specifically questioned surgeons and radiologists on the possible differences in exposure to anatomical variations based on the type of sector. However, the study can assume the amount of time spent on patients by the clinicians in the current study may be limited due to the stipulated reasons which thus more variations are undetected in resource depleted hospitals commonly found in the public health sector.

Among clinicians, including trainees and specialists like surgeons and clinicians arterial and circulatory variations are the most prevalent type encountered by surgeons (Raikos and Smith, 2015; Beser, 2018; Buongiorno *et al.*, 2020; Kowalczyk and Majewski; 2021) This was in seen in this current study, where the clinicians, stated that arterial (50%) and circulatory (48.4%) variations were the most encountered. However, despite the high level of encounters, there is a lack of training and education in vascular surgery observed by South African surgeons (De Beer, Karusseit and Pienaar, 2014). Moreover, there is notably a lower vascular surgeon to patient ratio in South Africa (Tiwari, Chikte and Chu, 2021). The least encountered variations by clinicians and trainees are usually muscular variations (Raikos and Smith, 2015, Buongiorno *et al.*, 2020) as also confirmed by the clinicians in the current study.

6.4 Perceived value and engagement with variant literature

The interaction of clinicians with anatomical variation literature is particularly important to establish the relevance of these studies to clinicians. Only one other study (Raikos and Smith, 2015) has explored this interaction. In the current study, the frequency of engagement of literature on anatomical variations by clinicians was examined.

Most clinicians from the current study had little to no engagement with variant research. Furthermore, it was observed that surgeons engaged with variant literature less than radiologists. In general, surgeons increasingly neglect their research interactions as their career progresses (Ko *et al.*, 2000, Chokshi *et al.*, 2009). Most surgeons cited a lack of time and motivation to interact with basic research even though they considered it important (Rangel, Efron, and Moss, 2002; Jarry *et al.*, 2022). Despite this, 87.9% of clinicians in one study mentioned their interest in engaging with research, while 64.7% of clinicians corroborated that time was the biggest hurdle in active research interaction (Ciemins *et al.*, 2019). An experienced surgeon attested to this, as she mentioned that with the workload that is imminent with every year of surgical specialisation, there was less time for reading of journals (Wong, 2020). If this is the case for interacting with generalised medical research, then it can be expected that surgeons would not find time to engage with variation research. One study mentioned the importance of anatomical journal engagement so clinicians and students can be updated consistently about structural variability (Youssef, 2022)

In the current study, when consulting variant literature most surgeons preferred surgical journals while majority of radiologists preferred radiology specific journals. While surgeons have been shown to engage most in peer-reviewed surgical journals (Schein *et al.*, 2000, Jones, Hanney and Buxton, 2006). no research investigating the journal theme preferences of radiologists has been conducted. However, radiologists tend to publish research findings more often (64.3 - 74.6%) in radiological journals than in non-radiological journals (Eun Joo Yun *et al.*, 2013). As such, it is reasonable to have a broader reach to the target audience of anatomical variant research, it would be more effective to publish in specialty aligned journals. This was supported by the following recommendation:

“Publication in relevant/specialty-specific surgical journal”- Respondent B

The reasoning is relevant as clinicians mentioned that they would engage with their selected specific journal because it was more clinically focused. This was corroborated in the following statement:

“I think that publications in clinical journals are more likely to be read”- Respondent C

However, it has been observed that some clinicians only read the popular medical journals even though these journals lack clinical research (Ioannidis, 2016). The study mentioned often clinical research is overlooked as it is published in other journals (Ioannidis, 2016). It appears clinicians would appreciate more clinically relevant or specialty specific research/ sources when sourcing variant information.

In the current study, the most used resources to learn about anatomical variations were scientific manuscripts (40.4%) and textbooks (30.8%). Contrary to the study by Raikos and Smith, (2015) where clinicians regarded surgical specialty textbooks and dissection courses as the preferred method for the trainees to learn about anatomical variations and published papers were the least preferred method. However, in the current study, it was noted that clinicians who encountered variants in clinical practice more often were also more likely to consult the literature. This finding may likely be due to the clinicians need to study and confirm any suspected variant morphology encountered and inform themselves on the potential implications for patient treatment and prognosis (Kowalczyk and Majewski, 2021). Conversely, it could be the inverse relationship, where clinicians that tended to engage with variant anatomy literature were more likely to be knowledgeable enough to accurately identify them, as a form of additional self-directed on-the-job training.

Clinicians were asked the reasons for selecting their preferred source for interacting with anatomical variations. Most clinicians found reliability to be most important reason, while accessibility was ranked second most important. Reliability, inclusive of repeatability and reproducibility, is considered important in radiological studies and has been identified to increase the quality of radiological manuscripts (Bannas and Reeder, 2017). Research which is considered good quality should be reliable with properly planned methods (Ahmed and Ishtiaq, 2021). Thus, clinicians from this study must regard only good quality research for accessing variant information.

Credibility (17.3%), time efficiency (9.6%) and peer advice (5.8%) were the least selected reasons for choosing the preferred source type by the participants of this study. Raikos and Smith, (2015) and Kowalczyk *et al.*, (2022) did not assess these factors. Based on the author's

knowledge, there are no studies that investigate these factors specifically in the context of relevance to anatomical variations. However, it is concerning that clinicians do not consider credibility when interacting with variant research as it is important to acquire information from credible, updated medical research to avoid confusion for the best health care to patients (Skelly, 2014).

In general clinicians do not have easy access to the latest research-based evidence (Straus and Haynes, 2009). This may be why most clinicians in the current study selected availability/accessibility as the factor they consider most when consulting a research paper. This may be why clinicians opt for textbooks rather than research papers as they are more readily available (Straus and Haynes, 2009). Surgeons overall are more likely to interact with free, handout journals in terms of reading medical literature (Schein *et al.*, 2000; Wong, 2020) even if the research paper may be of low quality (Krueger, Hsu, and Belmont, 2016).

Therefore, the source credibility, clear & high-quality figures & images and methodology may be equally the second most considered factors by clinicians as indicated in the current study. This was supported in the following statement:

“More diagrams / images and more related to practical clinical practice and real impact”- Respondent D

However, there is a slight contradiction in answers given by clinicians prior when only a few clinicians considered the credibility of the research source they chose to interact on variant research. It is possible clinicians may disregard credibility only when interacting with variant research if it does not apply to their field however general research enquiries may be more targeted and therefore, the clinicians would seek out more credible research papers.

Impact factor was the least considered factor by clinicians when consulting a research paper in the current study even though in general, surgeons consider a high impact factor to be most important (Schein *et al.*, 2000). Raikos and Smith, (2015) and Kowalczyk *et al.*, (2022) did not assess these factors. The enquiry was to ascertain characteristics that influence clinicians' engagement with variant research and thus may inform anatomists on what is more relevant about variant research to clinicians

6.5 Insights from an overview of the research in abdominal anatomical variants

The opinions of surgeons and radiologists on the impact of variant anatomy in clinical practice and their engagement with the relevant literature are vital to understand both for improving

clinical practice, but also to improve quality and reach of research on anatomical variants. The scoping review was intended to provide an overview of the variant anatomy literature in the specific context of abdominal arterial variants, selected as a region of wide interest and variability. The scoping review was able to yield some insight into the publication practices and the quality of the research on anatomical variants, to relate to the insights provided by the surgeons and radiologists questioned. As it was focused on the abdominal region, the inferences made on the topic are specific to this region and may or may not be reflected in other anatomical regions.

As observed in the current study, arterial variations are frequently encountered in South African clinical practice and most reported as most prevalent in literature (Raikos and Smith, 2015; Beser, 2018; Buongiorno *et al.*, 2020; Kowalczyk and Majewski; 2021). Therefore, the current study reported on abdominal arterial variations as the type of variation is relevant to clinical practice.

Most abdominal arterial variant in the current study studies were described in case reports when compared to original research manuscripts. Case reports are ranked as the least reliable method of reporting medical findings (Daramola and Rhee, 2011, Harrod, 2023). Case reports are the initial line of reporting a finding in clinical settings (Harrod, 2023) so there is usually a lack of structure in the report (Nissen and Wynn, 2014). This may explain why most of the South African clinicians in the current study preferred original research manuscripts as the most preferred format rather than case reports. Case reports also tend to focus on the rarer abnormalities rather than on more prevalent, general clinical problems and conditions which may be more important for clinicians (Nissen and Wynn, 2014). This demonstrates a huge disjunct between the needs of clinicians in terms of the sourced material used for finding information on anatomical variants. However, clinicians and more specifically surgeons are considered to prefer to publish case reports as it allows them a more flexible structure to report their findings (Agha and Rosin, 2010). This was observed in the current study finding that more case reports were published in medical, anatomical, and surgical journals.

Literature is saturated with a surplus of case reports, which usually entail incidental findings (Nissen and Wynn, 2014). Case reports involve less effort and have lower costs in comparison to more formal and planned studies (Nissen and Wynn, 2014). Case reports are also more likely to be published faster (Nissen and Wynn, 2014). For anatomists and clinicians trying to inform the medical and scientific world of abnormalities (Nissen and Wynn, 2014), this may be the desirable form for reporting on anatomical variation finding. Additionally, many journals still

find case reports relevant to the continuous clinical advancement of various clinical conditions (Ortega-Loubon, Colicchio and Correa, 2017) and as such may readily accept more case reports.

6.6 Reliability testing concerning anatomical variant studies: abdominal arterial variants

Reliability testing techniques are common practice when conducting evidenced based research but its application to anatomical variant studies seems to have been neglected according to anecdotal evidence. In fact, no study to date has scrutinised the application of this important tool for quality assurance. It is advised for clinicians to consider the reliability of a research study when evaluating research findings (Garfinkel, 1975; Straus and Sackett, 1998).

It is interesting to note that South African clinicians indicated reliability to be most important reason, when sourcing information from research papers while accessibility was ranked second most important. Reliability is considered important in radiological studies (Bannas and Reeder, 2017). For example, a lot of radiological studies which were in the form of original research manuscripts in the scoping review used at least two radiologists to classify abdominal arterial variations (Werder *et al.*, 2006; De Cecco *et al.*, 2009; Ugurel *et al.*, 2010; Wang *et al.*, 2014; Farghadani *et al.*, 2016). In one case, if the two radiologists were not in agreement, a third radiologist was consulted to verify an arterial variation on an angiogram (De Cecco *et al.*, 2009). In one study, a radiologist and surgeon reviewed CT images (Bouali *et al.*, 2011). In general, an overwhelming number of case reports did not test the reliability of their findings (Vishnumaya *et al.*, 2008; Kardile, 2013; Hazzard *et al.*, 2016; Ramakrishnan, Viswakumar and Goriparthi, 2020; Doustmohammadi *et al.*, 2023). The current scoping review revealed that majority of research studies did not utilise these reliability techniques which is in direct contradiction to what clinicians identify as the most important aspect of research studies.

Fewer case reports included reliability testing measures than original research studies (both retrospective and prospective). This is likely a result of case reports using involving a single or very few patients or individuals and discuss rare variants that are hard to confirm the reliability of in such a small sample. In addition, case reports usually have no control group (Sayre *et al.*, 2017) and without a comparison group, it makes the outcome challenging to be reliable. Case reports are known to have a higher risk of bias in medical literature (Murad *et al.*, 2018). Increased bias may compromise both reliability and validity of findings (Jarry *et al.*, 2022).

It has been observed that reliability is often unreported in medical sciences by researchers (Ahmed and Ishtiaq, 2021). It has been alluded that researchers (anatomists and clinicians) do not conduct these methodological techniques correctly or at all (Ahmed and Ishtiaq, 2021).

Radiological themed journals published the most studies with either repeatability/reproducibility present. Radiologists often perform many measurements during diagnosis (Cohen *et al.*, 2016; Oberkamp *et al.*, 2016) and require precise and reproducible results when a diagnostic procedure is needed. As mentioned earlier in the study radiologists are more likely to confirm a finding using additional diagnostic testing when confirming a variation. This may increase the rate of radiological repeatability even though many radiological studies are primarily known to lack reproducibility (Wright *et al.*, 2020; Peng *et al.*, 2021).

Anecdotally, clinicians mostly conducted studies on living patients whereas while living patients sample studies were mostly conducted by clinicians and cadaveric studies where usually conducted by anatomists. Anecdotally in the current study, there were a lot of cadaveric studies where variations were encountered during routine dissection with health sciences students. However a several studies on anatomical variations are routinely found in dissection sessions (Alraddadi, 2021). Many of the case reports in the current study were reported on incidental findings during routine dissection (Nayak *et al.*, 2008; Kayalvizhi, Monisha, and Usha, 2011; Eid *et al.*, 2022)

Planned studies under original research manuscripts usually conducted reliability than case reports which were often based on incidental findings. Planned studies with living patients typically displayed more reliability (Wu *et al.*, 2013; Johnson *et al.*, 2013; Mao *et al.*, 2022) than unplanned studies.

Clinical research that involves many patients often has real life implications on patient treatment and subsequent longevity of human lives (Rahman, 2017). Inadequate internal reliability in a study does not depict a realistic deduction of the results and thus no conclusion can be applied in real life cases (Ahmed and Ishtiaq, 2021). Therefore, living human led research may involve an increased level of reliability testing rather than non-living centred studies. In the current study, it was observed that more studies with living humans as the sample had more reliability testing. Ultimately it seems researchers, may not regard reliability or its importance with most of the studies they conduct.

7. **Limitations**

For the questionnaire, the number of raters for statistical validation was restricted to the minimum number of raters. This was despite numerous efforts to recruit raters and participants via email. There was a low number of respondents, and this is particularly true for clinicians due to heavy workload and time constraints. Therefore, there might be a response bias based on the clinicians who participated. The findings of the current study therefore do not reflect the perceptions of all SA clinicians and inferences should be restricted to the specific sample. Additionally, one society (Radiological) changed its policy to no longer distribute questionnaires due to members' frustration and survey fatigue. Furthermore, selection bias may have occurred as certain specialist will provide perspectives and information, according to their specific field, as well as the increased likelihood of clinicians with a vested interest in anatomical variants being more likely to respond to this particular questionnaire.

For the scoping review, due to the high volume of arterial variation studies, the study's timeline was adjusted to include 2006 – 2023. There were papers which were relevant to the topic of the scoping review that were inaccessible due to fees being incurred or the papers not being attached to any database. Future studies should review abdominal arterial variant research within a longer timeframe to obtain a true representation of reliability in abdominal arterial variations.

8. **Recommendations**

Studies should investigate the barriers preventing clinicians from engaging in anatomical variation research. Clinicians should encourage to host lectures on living patient anatomy to medical students to help improve their anatomical knowledge competence in South Africa. Studies thereafter should investigate on how this affects South African medical students and how they learn anatomy. Efforts for collaboration between anatomists and clinicians should be made to encourage research on anatomical variations. This would help in keeping anatomist s update about daily practice exposure and clinicians updated about the prevalence and trends amongst cadaveric populations. This ensures continual monitoring of areas to improve between clinicians and anatomists. There should be a progressive effort to collate relevant anatomical variations for different surgical and radiological specialties through research especially regionally. Additionally, reliability should be implemented in variation studies despite the source type. Reliability promotes trustworthy results and therefore makes the conclusions deduced from research applicable to clinical practice. A larger timeframe would also be

suggested for a future study to get a more comprehensive account of reliability in variation studies.

CHAPTER 6

9. **Conclusion**

The current study showed that anatomical knowledge is necessary for clinical practice and that anatomical variations are relevant to clinical practice in South Africa. Different tools for training in basic anatomical knowledge had been used throughout undergraduate and postgraduate training by the surveyed clinicians, with dissection, plastinated specimens, and plastic models being preferred. Other studies highlighted that clinicians preferred using dissection and prosection for learning about anatomical variants, however, the current study found that clinicians preferred to learn from scientific manuscripts instead. Despite this preference, clinicians rarely engaged with variation research despite regular anatomical variations being encountered in daily practice. Particularly as lack of anatomical variant knowledge can pose severe life-threatening risks to patients and increase the risk of medical malpractice. Anatomists should also be aware that clinicians preferred specialty/role specific journals when consulting information regarding anatomical variants, as such, researchers should aim to publish in these journals for greater impact.

Furthermore, the scoping review highlighted how reliability measures are often not utilised in abdominal arterial research, which was used in the current study as a general example of anatomical variant research. Awareness of the underuse of reliability testing techniques should be emphasised with anatomists and clinicians. As these poor research practices may have real life adverse consequences to clinical practice. In addition, researchers should be motivated to improve their own research, by implementing reliability testing regularly throughout anatomical variant research. In particular as the surveyed clinicians prioritised reliability the most when selecting their preferred sources on anatomical variants.

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Participant Information Sheet

Study Title

The relevance of anatomical variations to South African clinicians: a questionnaire & scoping review.

Good day! My name is Ozyl Marufu, and I am a Master of Science in Medicine student within the School of Anatomical Sciences at the University of Witwatersrand, Johannesburg.

I would like to invite you as a clinician (surgeon or radiologist) to participate in my study. The aim of this study is to investigate the relevance of anatomical variations in clinical practice within South Africa. It is well known that extensive anatomical knowledge, is associated with better clinical outcomes. I would like to investigate if the same holds true for anatomical variations within clinical practice with a dedicated focus on the perceptions of South African surgeons and radiologists.

Research study details

The research is a cross sectional, prospective study (administered electronically via REDCap questionnaire) and is quantitative in nature. The survey will approximately take 10-15 minutes. To investigate, the following information will be asked of you, should you agree to participate:

1. Medical education background
2. Exposure to anatomical variations during medical training, post medical training and current clinical practice.
3. The type of sources you use to access information on anatomical variations.

The broad objectives of the study are:

- To explore the exposure of anatomical variation to clinicians and how the encounters may affect clinical practice.
- To determine the preferred sources (for example scientific manuscripts, peers or word of mouth, scientific magazines, social media etc.) of anatomical variations by clinicians
- To identify the association between clinicians' experience, education, and training to their exposure of anatomical variations.

This survey forms part of my postgraduate research project for my master's degree. The results of this research, if successful will be published in an internationally recognized, peer reviewed research journals and disseminated through presentations, conferences within the clinical and academic community.

By agreeing to participate you will contribute to assembling information on the overall relevance of anatomical variations in South African clinical practice and training. Furthermore, the few studies that do address this important topic are specific to the North America, Australia, and Europe with minimal contributions from Africa. Your valued input and participation will provide a unique insight into the relevance of these variants in the South African clinical arena.

Risks of being involved in the study:

There are no direct/indirect risks to you participating in the study.

Benefits of being in the study

There are no direct/indirect benefits to you participating in the study.

Participation

Your participation in this study is completely voluntary. You are free to withdraw at any point of the study until the anonymized submission.

Confidentiality and anonymity

Your questionnaire responses will be collected anonymously through REDCap and assigned a unique identifier record number. Hence, there is no direct identifying information required for you to answer in this questionnaire. Your response will be assigned a generic number and will

be processed as such in the results. The information will only be available to the principal investigator and supervisors.

The data collection period will be from April to December 2023.

In addition, no individual will be identifiable by name out of any possible dissertation, publication, or conference.

The only exceptions- and all of them are rare- would normally be

1. Personal information may be disclosed if required by law
2. The Human Research Ethics Committees of the University may exceptionally require personal data to respond to a formal complaint or for a compliance audit

You can reach out to me should you require additional information:

Miss Ozyl Marufu, Principal Investigator, cell phone number: 0676585583, or by e-mail: 1356799@students.wits.ac.za

Dr Brendon Billings, (Primary)

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Dr Nicholas Bacci,

Supervisor, phone number: 0117172204, or by e-mail: Nicholas.Bacci@wits.ac.za

Dr Joshua Davimes

Supervisor, phone number: 0117171337, or by e-mail: Joshua.Davimes@wits.ac.za

Outputs

The output of this study will be through a dissertation and possible publication and conferences. Should you wish to read the dissertation, please feel free to contact me, and I will send a copy to you via email.

Contact details of HREC administrator and Chairperson

The study has been approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg('Committee'). A principal function of this

Committee is to safeguard the rights and dignity of all human subjects who agree to participate in a research project and the integrity of the research.

Should there be any concerns or complaints pertaining to ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (Medical), email hrec-medical@wits.ac.za or the chairperson of this committee:

Professor CB Penny, Chairperson of the Human Research Ethics Committee (Medical) at the University of Witwatersrand, on telephone no. 011 717 2301, or by e-mail at Clement.Penny@wits.ac.za.

Ms. Z Ndlovu or Mr Rhulani Mkansi, Committee Secretariat, telephone nos.: 011 717 2700 or 1234, or by e-mail at: Zanele.Ndlovu@wits.ac.za or Rhulani.Mkansi@wits.ac.za

Thank you for taking time to read my participant information sheet.

Date: February 2023

The relevance of anatomical variations to South African clinicians

Good day! My name is Ozyl Marufu, and I am a Master of Science in Medicine student in the School of Anatomical Sciences at the University of Witwatersrand, Johannesburg. Your participation in the below questionnaire would be most appreciated.

I am undertaking this study to investigate the relevance of anatomical variations in clinical practice within South Africa. We aim to gather data from clinicians (e.g., specifically surgeons and radiologists) on all their exposure, training, and experience of anatomical variations during their clinical practice. This is in the hope that the data will help investigate their importance to clinicians in a South African clinical environment.

Your participation in this would be most appreciated. The questionnaire should take about 10-15 minutes to complete. There is no cost to participating in this questionnaire. There will be no direct benefits or disadvantages incurred by participating in this questionnaire. By participating, you will assist in gathering information on the relevance of anatomical variations to clinicians in the country. Participants' responses will be anonymous as no personal identifying information will be requested. The information given will be de-identified and handled confidentially. The questionnaire is available electronically. However, you are welcome to have a follow-up interview if conditions allow and if you are comfortable to do so.

By completing this questionnaire, you are providing informed consent. You acknowledge that you have read the above information. You acknowledge and understand that there is no immediate benefit nor penalty for completing this questionnaire. You may exit the questionnaire at any point, or you may withdraw from the study by emailing the study researchers (see the contact details listed below).

Should there be any concerns or complaints pertaining to this study's ethical procedures, you are welcome to contact the University Human Research Ethics Committee (Medical) (HREC), email hrec-medical@wits.ac.za : hrec-medical@wits.ac.za. The ethics clearance number for this study is MED23-02-037.

For contacts in the HREC:

Professor CB Penny, Chairperson of the Human Research Ethics Committee (Medical) at the University of Witwatersrand, on telephone no. 011 717 2301, or by e-mail at Clement.Penny@wits.ac.za.

Ms. Z Ndlovu or Mr. Rhulani Mkansi, Committee Secretariat, telephone nos.: 011 717 2700 or 1234, or by e-mail at: Zanele.Ndlovu@wits.ac.za or Rhulani.Mkansi@wits.ac.za

Study investigators:

The study is being undertaken by the following individuals:

Miss Ozyl Marufu, Principal Investigator, cell phone number: 0676585583, or by e-mail: 1356799@students.wits.ac.za

Dr Brendon Billings, Primary Supervisor, phone number: 0117172057, or by e-mail: Brendon.Billings@wits.ac.za

Dr Nicholas Bacci, Co-Supervisor, phone number: 0117172204, or by e-mail: Nicholas.Bacci@wits.ac.za

Dr Joshua Davimes, Co-Supervisor, phone number: 0117171337, or by e-mail: Joshua.Davimes@wits.ac.za

Do you want to continue and begin the survey?

- ☐ Yes
☐ No

Professional Details

Definitions:

Public sector: being employed by the government.

Private sector: being employed by an individual, self employed or a separate company; not government employed.

- | | | |
|-------|--|--|
| 1 | What qualifications do you hold? | ☐ Fellowship for specialty (College exams)
☐ Doctorate in Medicine
☐ Master of Medicine
☐ Undergraduate Medical degree (MBBCh or equivalent)
☐ Undergraduate Dentistry degree (BDS or equivalent)
☐ Other |
| <hr/> | | |
| 1.2 | If you hold other qualifications not listed above, please specify | <div style="border-bottom: 1px solid black; width: 100%;"></div> |
| <hr/> | | |
| 2. | Which country did you acquire your undergraduate degree qualification? | ☐ South Africa
☐ Other African Country
☐ Country outside Africa |
| <hr/> | | |
| 2.2 | Please specify other African countries, with the exclusion of South Africa, in which you acquired your qualifications: | <div style="border-bottom: 1px solid black; width: 100%;"></div> |
| <hr/> | | |
| 2.3 | Please specify the country outside Africa in which you acquired your qualifications: | <div style="border-bottom: 1px solid black; width: 100%;"></div> |
| <hr/> | | |
| 3. | Current Position | ☐ Junior Registrar
☐ Senior Registrar
☐ Medical Officer
☐ Consultant
☐ Senior Consultant
☐ Professor
☐ Other |
| <hr/> | | |
| 3.2 | Please specify other position: | <div style="border-bottom: 1px solid black; width: 100%;"></div> |

4.

What is your main specialization (in which you work in)?

☐ All fields of Surgery

☐ All fields of Radiology

☐ General Surgery

☐ Vascular Surgery

☐ Trauma Surgery

☐ Urology

☐ Plastic Surgery

☐ Urology Surgery

☐ Orthopaedic Surgery

☐ Pediatric Surgery

☐ Oncology Surgery

☐ Ear, Nose and Throat Surgery

☐ Maxillofacial Surgery

☐ Neurosurgery

☐ Cardiothoracic surgery

☐ Thoracic surgery

☐ Cardiac surgery

☐ Diagnostic Radiology

☐ Interventional Radiology

☐ Oncology Radiology

☐ Other

4.2

Please specify other specialization:

5.

Years in practice as a surgeon/radiologist:

6.

Province in which you are currently practicing

☐ Gauteng

☐ North-West

☐ KwaZulu-Natal

☐ Eastern Cape

☐ Western Cape

☐ Northern Cape

☐ Limpopo

☐ Mpumalanga

☐ Free State

7.

In which sector do you currently work:

☐ Private

☐ Public

☐ Both

8. Prior Training and Exposure (UNDERGRADUATE)

How frequently were you exposed to the following anatomical training and tools during your UNDERGRADUATE medical degree?

Definitions:
Plastinated human specimens: Three-dimensional, dry and durable specimens from real human bodies used for anatomical study.
Plastic, anatomically relevant models: Factory made, non-biological three-dimensional idealized representations of anatomical structures.

	Often (more than once per week)	Sometimes (more than once per month)	Occasionally (more than once every six months)	Rarely (more than once per year)	Never (no previous exposure)
Human cadaver dissections	☐	☐	☐	☐	☐
Non-human (animal) dissections	☐	☐	☐	☐	☐
Plastinated human specimens	☐	☐	☐	☐	☐
Plastic, anatomically relevant models	☐	☐	☐	☐	☐
Computer software programs on anatomy	☐	☐	☐	☐	☐

8.2. If applicable, can you recount how many total hours you spent in cadaveric dissection during undergraduate study? _____

9. Prior Training and Exposure (POSTGRADUATE)

How frequently were you exposed to the following anatomical training and tools during your POSTGRADUATE medical degree or specialist training?

	Often (more than once per week)	Sometimes (more than once per month)	Occasionally (more than once every six months)	Rarely (more than once per year)	Never (no previous exposure)
Human cadaver dissections	☐	☐	☐	☐	☐
Non-human (animal) dissections	☐	☐	☐	☐	☐
Plastinated human specimens	☐	☐	☐	☐	☐
Plastic, anatomically relevant models	☐	☐	☐	☐	☐
Computer software programs on anatomy	☐	☐	☐	☐	☐

9.2. If applicable, can you recount how many total hours you spent in cadaveric dissection during postgraduate study?

Prior Training and Exposure

Definition:

Anatomical variation: anatomical structures which may appear different morphologically but generally exhibit typical physiological functioning.

-
10. In your undergraduate or postgraduate anatomical training, were you taught about any anatomical variations?
- ☐ Yes, in undergraduate training
☐ Yes, in postgraduate training
☐ Yes, in both undergraduate and postgraduate training
☐ No, none in both undergraduate and postgraduate training
-
11. In which phase of your career (after undergraduate training) did you start to encounter anatomical variations?
- ☐ Junior Registrar
☐ Senior Registrar
☐ Medical Officer
☐ Consultant
☐ Senior Consultant
☐ Professor
☐ Other
-
- 11.2 Please specify other phase of your career where you have encountered variations:
- _____
-
12. Do you find anatomical knowledge necessary for your clinical practice?
- ☐ Strongly agree
☐ Agree
☐ Neutral
☐ Disagree
☐ Strongly Disagree
-
13. Do you feel you were adequately prepared for clinical practice based on your undergraduate anatomical training?
- ☐ Yes
☐ No
-
- 13.2 Please elaborate further on your answer above:
- _____
-
14. Do you feel you were adequately prepared for clinical practice based on your postgraduate anatomical training?
- ☐ Yes
☐ No
-
- 14.2. Please elaborate further on your answer above:
- _____

Current Exposure to Anatomical Variations

15. In your current position, have you encountered anatomical variations? ☐ Yes
☐ No
-
16. How frequently do you encounter anatomical variations in your daily practice? ☐ Often (more than once per week)
☐ Sometimes (more than once per month)
☐ Occasionally (more than once every six months)
☐ Rarely (more than once per year)
☐ Almost Never (once per year)
☐ Never
-
17. Where do you most encounter anatomical variations? ☐ During surgery/procedure
☐ During diagnostic workup
-
18. Which class of anatomical variant have you encountered the most often during your years of practice? ☐ Arterial
☐ Venous
☐ Nervous
☐ Muscular
☐ Skeletal
☐ Organ
☐ Lymphatic
-
- 18.2 Please specify the name of the variant you encounter the most: _____

Intervention Shift Based on Encounter with Anatomical Variations

19. Which stage of surgical operative/procedural process was most affected by encountering the anatomical variations in general?

☐ Pre-operative/procedure
☐ Peri-operative/procedure
☐ Post-operative/procedure
20. Which of the following levels of patient diagnosis/treatment was most likely affected by encountering anatomical variations?

☐ Procedure type
☐ Operation duration
☐ Route of entry
☐ Additional diagnostics
☐ Other
- 20.2. Please specify the other level of patient diagnosis/treatment that would most likely be affected by encountering anatomical variations:

Perceived Value and Engagement with Literature on Anatomical Variations

Definition:

White papers: a research-based report which defines/explains a presenting author's body and perspective.

-
21. How often do you engage with research articles or other academic sources on anatomical variations?
- ☐ Often (more than once per week)
 - ☐ Sometimes (more than once per month)
 - ☐ Occasionally (more than once every few months)
 - ☐ Rarely (more than once per year)
 - ☐ Almost Never (once per year)
 - ☐ Never
-
22. Which journal type are you most likely to consult when engaging on anatomical variation studies?
- ☐ Anatomy specific
 - ☐ Clinical medicine specific
 - ☐ General/basic science
 - ☐ Radiology specific
 - ☐ Surgery specific
 - ☐ Other
-
- 22.2. Please specify the other journal type you are most likely to consult when engaging on anatomical variation studies:
- _____
-
23. Why do you prefer that journal type?
- ☐ Easily understandable
 - ☐ Accessible
 - ☐ Time-efficient
 - ☐ More clinically focused
 - ☐ More anatomically based
 - ☐ Other
-
- 23.2. Please specify the other reason you prefer the journal type:
- _____
-
24. Which source(s) do you utilize the most to acquire information relating to anatomical variations?
- ☐ Scientific manuscripts/white papers
 - ☐ Peers or word of mouth
 - ☐ Clinical trial studies
 - ☐ Scientific magazines
 - ☐ Clinical guidelines
 - ☐ Documentary or other media
 - ☐ Social media (Reddit, Twitter, YouTube, TikTok etc.)
 - ☐ Congresses/Conferences
 - ☐ CPD training
 - ☐ Textbooks
-
25. With regards to scientific manuscripts/ white papers, which format do you engage with most?
- ☐ Case reports
 - ☐ Original research manuscripts
 - ☐ Peer-reviewed conference proceedings
 - ☐ Other
-

Please specify other format:

-
26. Why do you prefer the research source you have chosen when engaging with studies relating to anatomical variations?
- ☐ Easily understandable
 - ☐ Accessible
 - ☐ Time-efficient
 - ☐ Reliable
 - ☐ Credible
 - ☐ Legally comprehensive
 - ☐ Peer advised
 - ☐ Ranking
 - ☐ Other
-
- 26.2 Please specify other reason why you choose that specific research source:
- _____
-
27. What criteria do you consider most important or most valuable when consulting a research paper?
- ☐ Source credibility(e.g. predator journal or not)
 - ☐ Publishing company ranking
 - ☐ Impact factor of journal
 - ☐ Clear and high-quality figures and images
 - ☐ Methodology (e.g., sample size, repeatability)
 - ☐ Availability/ accessibility (whether open access or subscription based)

The Future of Anatomical Variation Research Studies for Clinicians

28. Do you have any recommendations on how anatomical variation studies can be improved to better suit clinical practice, if there are any?

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

R14/49 Miss Ozyl Tinetairo Marufu

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)**CLEARANCE CERTIFICATE NO. M230269 MED23-02-037**

NAME: Miss Ozyl Tinetairo Marufu
(Principal Investigator)
DEPARTMENT: School of Anatomical Sciences

PROJECT TITLE: The Relevance of Anatomical Variations to South African Clinicians: A Questionnaire & Scoping Review

DATE CONSIDERED: 24/02/2023

DECISION: Approved unconditionally

CONDITIONS:

SUPERVISOR: Dr B. Billings, Dr N. Bacci and Dr J. Davimes

APPROVED BY:


Dr C Penny, Chairperson, HREC (Medical)

DATE OF APPROVAL: 11/04/2023

EXPIRY DATE: 11/04/2028

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report** in January each year until study is closed. Failure to submit annual report will result in ethics clearance certificate suspension. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed February and will therefore be due in the mo.

month of February each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical). Login to upload signed copy of this ethics clearance certificate prior to commencing with the study

<https://www.witsethics.co.za/login.aspx>


Principal Investigator Signature

21/04/2023
Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG



HUMAN RESEARCH ETHICS
COMMITTEE (MEDICAL)

DECLARATION:

Adherence to HREC (Medical) Ethics Application Terms and Conditions

I, the undersigned, hereby declare that I have not collected data/ done secondary data analysis or any other form of research, prior to obtaining clearance certificate from the HREC (Medical) for study no: MED23-02-037.

I have read and understood the terms and conditions on page 8-9 of the HREC (Medical) application form. I confirm that it is my responsibility to ensure that I have received final HREC (Medical) Clearance before commencing any research.

Ozyl Tinetariro Marufu

A handwritten signature in black ink, appearing to read 'Ozyl Marufu'.

Name, Surname and Signature

Student/Staff no if applicable: 1356799

Date: 21/04/2023

Dr Brendon K. Billings

A handwritten signature in blue ink, appearing to read 'Dr Brendon K. Billings'.

Name, Surname and Signature

Supervisor (if applicable)

Date: 21/04/2023

 UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG	HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
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2023/09/07

Ms OT Marufu
School of Anatomical Sciences
Medical School
University

Sent by e-mail to: 1356799@students.wits.ac.za

Dear Ms Marufu

Re: Protocol Ref No: M230269
Protocol Title: *The relevance of anatomical variations to South African clinicians: a questionnaire and scoping review*
Principal Investigator: Ms OT Marufu

Thank you for your letter of 2023/08/31.

We note and approve of your proposal to widen your distributive network, subject to the undernoted observations:

1. to radiologists and surgeons in private or state practice, subject to permission from the Head of the practice or the CEO respectively
2. to clinicians affiliated to South African Universities, noting that the two categories are not mutually exclusive - here I refer to joint staff; in the case of Wits staff, you will need permission from the Registrar and similar arrangements presumably exist at all other institutions

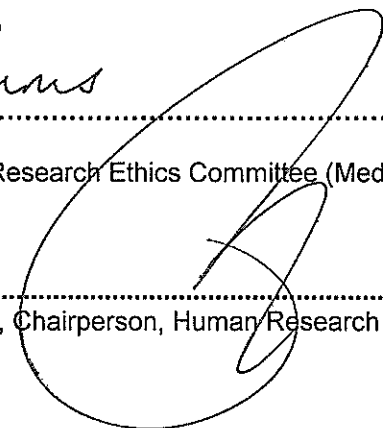
Thank you for keeping us informed.

Yours Sincerely



.....
Mr I Burns
For the Human Research Ethics Committee (Medical)

.....
Professor P Ruff, Chairperson, Human Research Ethics Committee (Medical)



Appendix E

Table 1. Career phase clinicians started to encounter anatomical variations

In which phase of your career (after undergraduate training) did you start to encounter anatomical variations?	Frequency	
	N	%
Junior Registrar	28	53.8
Medical Officer	18	34.6
Senior Registrar	15	28.8
Consultant	4	7.7
Other	1	1.9
Senior Consultant	1	1.9
Professor	1	1.9

Appendix F

Table 2 Range of Cronbach alpha values and the interpretation thereof.

Range of values	Interpretation
0.93–0.94	Excellent
0.91–0.93	Strong
0.84–0.90	Reliable
0.81	Robust
0.76–0.95	Fairly high
0.73–0.95	High
0.71–0.91	Good
0.70–0.77	Relatively high
0.68	Slightly low
0.67–0.87	Reasonable
0.64–0.85	Adequate
0.61–0.65	Moderate
0.58–0.97	Satisfactory
0.45–0.98	Acceptable
0.45–0.96	Sufficient
0.4–0.55	Not satisfactory
0.11	Low

Appendix G

Table 3 Fisher-Freeman-Halton Exact Test results testing the most frequently used source and the necessity of anatomical knowledge as indicated by the clinicians.

Which source(s) do you utilize the most to acquire information relating to anatomical variations?		Do you find anatomical knowledge necessary for your clinical practice?			Total
		Strongly agree	Agree	Neutral	
	'Scientific manuscripts/white papers	19	1	1	21
	Clinical trial studies	1	0	0	1
	Scientific magazines	3	0	0	3
	Clinical guidelines	5	0	0	5
	Documentary or other media	4	0	0	4
	Congresses/Conferences	1	0	0	1
	CPD training	1	0	0	1
	Textbooks	13	3	0	16
Total		47	4	1	52

Appendix H

Table 4 Post hoc data for the Fisher-Freeman-Halton Exact test

Chi-Square Tests					
	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	5.709 ^a	14	.973	.729	
Likelihood Ratio	6.501	14	.952	.668	
Fisher-Freeman-Halton Exact Test	16.694			.799	
Linear-by-Linear Association	.069 ^b	1	.792	.836	.426
N of Valid Cases	52				

Appendix I

Table 5 Normality results from the Shapiro Wilks test

Survey Question	Sample Size	p-value	Normality
What qualifications do you hold?	52	0.001	Not normally distributed
Which country did you acquire undergraduate degree qualification?	52	0.001	Not normally distributed
Current position	52	0.001	Not normally distributed
What is your specialisation?	52	0.001	Not normally distributed
Years in practice as a surgeon/radiologist?	52	0.001	Not normally distributed
Province in which you are currently practicing	52	0.001	Not normally distributed
In which sector do you currently work	52	0.001	Not normally distributed
Human cadaver dissections UG	52	0.001	Not normally distributed
Non-human (animal) dissections UG	52	0.001	Not normally distributed
Plastinated human specimens UG	52	0.001	Not normally distributed
Plastic anatomically relevant models UG	52	0.001	Not normally distributed
Computer software programs on anatomy UG	52	0.001	Not normally distributed
Human cadaver dissection PG	52	0.001	Not normally distributed

Non-human (animal) dissections PG	52	0.001	Not normally distributed
Plastinated human specimens PG	52	0.001	Not normally distributed
Plastic, anatomically relevant models PG	52	0.001	Not normally distributed
Computer software programs on anatomy PG	52	0.001	Not normally distributed
In your undergraduate or postgraduate anatomical training, were you taught about any anatomical variations?	52	0.001	Not normally distributed
In which phase of your career after undergraduate training?	52	0.001	Not normally distributed
Do you find anatomical knowledge necessary for your clinical practice?	52	0.001	Not normally distributed
Do you feel you were adequately prepared for clinical practice based on your undergraduate training?	52	0.001	Not normally distributed
Do you feel were adequately prepared for clinical practice based on your postgraduate training?	52	0.001	Not normally distributed
In your current position have you encountered variations?	52	0.001	Not normally distributed

How frequently do you encounter anatomical variations in your daily practice?	52	0.001	Not normally distributed
Where do you most encounter variations?	52	0.001	Not normally distributed
Which class of anatomical variant have you encountered the most often during your years of practice?	52	0.001	Not normally distributed
Which stage of surgical operation/ procedural process was most affected by encountering the anatomical variations in general?	52	0.001	Not normally distributed
Which of the following levels of patient diagnosis/treatment was most likely affected by encountering anatomical variations?	52	0.001	Not normally distributed
How often do you engage with research articles or other academic sources in anatomical variations?	52	0.001	Not normally distributed
Which journal type are you most likely to consult when engaging on anatomical	52	0.001	Not normally distributed

Why do you prefer that journal type?	52	0.001	Not normally distributed
Which source (s) do you utilize the most to acquire information relating to anatomical variations?	52	0.001	Not normally distributed
With regards to scientific manuscripts white papers which format do you engage with most	52	0.001	Not normally distributed
Why do you prefer the research source you have chosen when engaging with studies relating to anatomical variations	52	0.001	Not normally distributed
What criteria do you consider most important or most valuable when consulting a research paper	52	0.001	Not normally distributed

Appendix J

Table 6 ICC, McNemar and Mantel-Haenszel values between the two sets of responses from the clinicians.

Question	Test statistic	Df	P-value	Interpretation
In your undergraduate or postgraduate anatomical training, were you taught about any anatomical variations? (multiple options, categorical)	Mantel Haenszel X^2 = 0.1938	1	0.6598	H_0 = there is no consistent difference in proportions of answers; $p > 0.05$ = there is no significant difference in answers between test & retest.
In which phase of your career (after undergraduate training) did you start to encounter anatomical variations? (multiple options, categorical)	Mantel Haenszel X^2 = 0.5625	1	0.4533	H_0 = there is no consistent difference in proportions of answers; $p > 0.05$ = there is no significant difference in answers between test & retest.
Which class of anatomical variant have you encountered the most often during your years of practice? (multiple options, categorical)	Mantel Haenszel X^2 = 5.0331e	1	1	H_0 = there is no consistent difference in proportions of answers; $p > 0.05$ = there is no significant difference in answers between test & retest.
Which stage of surgical operative/procedural process was most affected by encountering the anatomical variations in general? (multiple options, categorical)	Mantel Haenszel X^2	N/A	-	Test would not compute with too few entries per option; however, responses were a perfect match between test and retest.

Which of the following levels of patient diagnosis/treatment was most likely affected by encountering anatomical variations? (multiple options, categorical)	Mantel Haenszel X^2	N/A	-	Test would not compute with too few entries per option, disagreement on two options
Which journal type are you most likely to consult when engaging on anatomical variation studies? (multiple options, categorical)	Mantel-Haenszel X^2	N/A	-	H_0 = there is no consistent difference in proportions of answers; $p > 0.05$ = there is no significant difference in answers between test & retest but 3 disagreements
Why do you prefer that journal type? (multiple options, categorical)	Mantel Haenszel X^2	N/A	-	H_0 = there is no consistent difference in proportions of answers; $p > 0.05$ = there is no significant difference in answers between test & retest.
Which source(s) do you utilize the most to acquire information relating to anatomical variations? (multiple options, categorical)	Mantel Haenszel X^2	N/A	-	. H_0 = there is no consistent difference in proportions of answers; $p > 0.05$ = there is no significant difference in answers between test & retest.
With regards to scientific manuscripts/ white papers, which format do you engage with most? (multiple options, categorical)	Mantel Haenszel X^2	N/A	-	H_0 = there is no consistent difference in proportions of answers; $p > 0.05$ = there is no significant difference in answers between test & retest.
Why do you prefer the research source you have chosen when engaging with studies relating to anatomical variations? (multiple options, categorical)	Mantel Haenszel X^2	N/A	-	H_0 = there is no consistent difference in proportions of answers; $p > 0.05$ = there is no significant difference in answers between test & retest.
What criteria do you consider most important or most valuable when consulting a research paper? (multiple options, categorical)	Mantel-Haenszel X^2 = 1.0417	N/A	-	H_0 = there is no consistent difference in proportions of answers; $p > 0.05$ = there is no significant difference in answers between test & retest.
How frequently were you exposed to the following anatomical training and tools during your UNDERGRADUATE medical degree? (cadaver) (Likert scale)	ICC = 0.890 (CI 95% lower bound - 0.615; upper bound 0.972)	9	<0.001	Good reliability. P-value: <0.05, significant correlation

How frequently were you exposed to the following anatomical training and tools during your UNDERGRADUATE medical degree? (non-human) (Likert scale)	ICC = 0.757 (CI 95% lower bound - 0.262; upper bound 0.934)	9	0.005	Good reliability. P-value: <0.05, significant correlation
How frequently were you exposed to the following anatomical training and tools during your UNDERGRADUATE medical degree? (plastinated specimen) (Likert scale)	ICC = 0.708 (CI 95% lower bound 0.164; upper bound 0.919)	9	0.010	Moderate reliability. P-value: <0.05, significant correlation
How frequently were you exposed to the following anatomical training and tools during your UNDERGRADUATE medical degree? (plastic models) (Likert scale)	ICC = 0.699 (CI 95% lower bound - 0.193; upper bound 0.915)	9	0.004	Moderate reliability. P-value: <0.05, significant correlation
How frequently were you exposed to the following anatomical training and tools during your UNDERGRADUATE medical degree? (computer software) (Likert scale)	ICC = 0.949 (CI 95% lower bound - 0.811; upper bound 0.987)	9	<0.001	Excellent reliability. P-value: <0.05, significant correlation
How frequently were you exposed to the following anatomical training and tools during your POSTGRADUATE medical degree or specialist training? (cadaver) (Likert scale)	ICC = 0.740 (CI 95% lower bound - 0.224; upper bound 0.929)	9	0.006	Moderate reliability. P-value: <0.05, significant correlation
How frequently were you exposed to the following anatomical training and tools during your POSTGRADUATE medical degree or specialist training? (non-human) (Likert scale)	ICC = -0.203 (CI 95% lower bound - 0.846; upper bound 0.499)	9	0.701	ICC value set to zero. Limited scale variance (Bartko, 1976). P-value: >0.05, no significant correlation
How frequently were you exposed to the following anatomical training and tools during your	ICC = 0.447 (CI 95% lower bound -	9	0.097	Poor reliability. P-value: >0.05, no significant correlation

POSTGRADUATE medical degree or specialist training? (plastinated specimen) (Likert scale)	0.267; upper bound 0.831)			
How frequently were you exposed to the following anatomical training and tools during your POSTGRADUATE medical degree or specialist training? (plastic models) (Likert scale)	ICC = 0.441 (CI 95% lower bound - 0.285; upper bound 0.829)	9	0.102	Poor reliability. P-value: >0.05, no significant correlation
How frequently were you exposed to the following anatomical training and tools during your POSTGRADUATE medical degree or specialist training? (computer software) (Likert scale)	ICC = 0.841 (CI 95% lower bound 0.474; upper bound 0.958)	9	<0.001	Good reliability. P-value: <0.05, significant correlation
Do you find anatomical knowledge necessary for your clinical practice? (Likert scale)	ICC = -0.098 (CI 95% lower bound - 0.760; upper bound 0.564)	9	0.603	ICC value set to zero. Limited scale variance (Bartko, 1976). P-value: >0.05, no significant correlation
How frequently do you encounter anatomical variations in your daily practice? (Likert scale)	ICC = 0.760 (CI 95% lower bound 0.277; upper bound 0.935)	9	0.004	Good reliability. P-value: <0.05, significant correlation
How often do you engage with research articles or other academic sources on anatomical variations? (Likert scale)	ICC = 0.736 (CI 95% lower bound 0.174; upper bound 0.930)	9	0.001	Moderate reliability. P-value: <0.05, significant correlation
Do you feel you were adequately prepared for clinical practice based on your undergraduate anatomical training? (two categorical options)	McNemar test: N/A			Perfect match, test did not compute.
Do you feel you were adequately prepared for clinical practice based on your postgraduate anatomical training?	McNemar test: N/A			Perfect match, test did not compute.

(two categorical options)		
In your current position, have you encountered Yes anatomical variations? (two categorical options)	McNemar test: N/A	Perfect match, test did not compute.
Where do you most encounter anatomical variations? (two categorical options)	McNemar test: N/A	Perfect match, test did not compute.

Table 7 Number of final articles derived from all journals included within the scoping review

Journal name	Number of articles derived
Vascular	2
Surgery and Radiology	1
Springerplus	1
Jornal Vascular Brasileiro	1
Polish Journal of Radiology	2
Hepatogastroenterology	1
International Journal of Surgery	1
Turkish Journal of Gastroenterology	1
European Radiology	4
Surgical and Radiologic Anatomy	27
Annals of Anatomy-Anatomischer Anzeiger	1
Journal of Ayub Medical College Abbottabad	1
Morphologie	3
Journal of Research in Medical Sciences	1
Journal of the Pakistan Medical Association	1
British Journal of Radiology	1
Folia Morphologica	13
Journal of The College of Physicians and Surgeons Pakistan	2
Diagnostics	3
Abdominal Imaging	4
Medical Image Analysis	1
International Journal of Surgery	1
Journal of Clinical and Diagnostic Research	7
Journal of the Pancreas	1
Journal of the Anatomical Society of India	4
Cureus Journal of Medical Science	3
Clinical & Translational Oncology	1
Chinese Medical Journal	1
European Journal of Anatomy	4
American Journal of Roentgenology	3
Diagnostic and Interventional Radiology	2
Pakistan Journal of Medical & Health Sciences	1
International Journal of Morphology	1
Clinical Anatomy	10
Anatomical Science International	2
Abdominal Radiology	4
Medical Bulletin of Sisli Etfal Hospital	1
Urology Research and Practice	1
African Journal of Urology	1
Journal of Computer Assisted Tomography	2
Cureus	5
Transplantation Proceedings	3
Annals of Biomedical Engineering	1

Journal of Clinical Medicine Research	1
Turkish Journal of Medical Sciences	1
European Journal of Therapeutics	1
Annals of Vascular Surgery	4
Archives of Biological Sciences	1
Advances in Therapy	1
Abcd-Arquivos Brasileiros De Cirurgia Digestiva-Brazilian Archives of Digestive Surgery	1
Medicina-Lithuania	1
Journal of the Medical Association of Thailand	2
International Journal of Medical Toxicology and Forensic Medicine	1
American Journal of Surgery	1
Chirurgia	1
South African Journal of Radiology	1
Advances in Clinical and Experimental Medicine	1
European Journal of Vascular and Endovascular Surgery	2
Clinical Radiology	1
Anatomy & Cell Biology	1
Korean Journal of Radiology	1
Indian Journal of Radiology and Imaging	1
Renal Failure	1
Nigerian Journal of Clinical Practice	1
European Review for Medical and Pharmacological Sciences	1
Journal of Clinical Ultrasound	1
Romanian Journal of Morphology and Embryology	12
Frontiers in Pediatrics	1
World Journal of Surgery	1
Genitourinary Imaging	1
Radiology Research and Practice	1
Journal of Cancer	1
BMC Medical Imaging	2
Kathmandu University Medical Journal	1
Magnetic Resonance Imaging	1
Asian Biomedicine	1
BMC Surgery	1
Radiologia Medica	1
Radiology	1
Circulation Journal	1
Radiologia Brasileira	1
Liver Transplantation	2
Clinical Imaging	1
International Journal of Colorectal Disease	1
ANZ Journal of Surgery	1
Asian Journal of Endoscopic Surgery	2
Molecular and Clinical Oncology	1
Radiology Case Reports	6
Interactive Cardiovascular and Thoracic Surgery	1
Case Reports in Medicine	1

Surgery Journal	1
Annals of Thoracic Surgery	1
Journal of Surgical Case Reports	1
International Journal of Surgery Case Reports	3
Saudi Journal of Kidney Diseases and Transplantation	1
Frontiers in Oncology	1
Frontiers in Surgery	1
Journal of the Louisiana State Medical Society	1
World Journal of Clinical Cases	3
Australasian Radiology	1
American Journal of Mens Health	1
Archives of Medical Science	1
Journal of Interventional Medicine	1
American Journal of Case Reports	1
International Journal of Surgery Case Reports	4
Italian Journal of Anatomy and Embryology	1
Journal of Minimally Invasive Surgery	1
Annali Italiani di Chirurgia	1
CVIR Endovascular	2
Journal of Vascular Surgery Cases, Innovations and Techniques	1
Cirugia Española (English Edition)	1
Journal of Surgical Case Reports	1
Journal of Gastrointestinal and Liver Diseases	1
Surgery Today	1
Journal of Radiology Case Reports	2
Asian Journal of Surgery	2
Diagnostic and Therapeutic Endoscopy	1
Medicine (Baltimore)	2
Asian Journal of Endoscopic Surgery	1
Journal of Minimal Access Surgery	1
Medical Principles and Practice	2
Journal of the Korean Surgical Society	1
Progres en Urologie	1
Journal of Vascular Surgery	1
Romanian Journal of Military Medicine	1
Cardiovascular Revascularization Medicine	1
Surgical Oncology-Oxford	1
Medicina-Lithuania	1
The Annals of The Royal College of Surgeons of England	1
Visceral Medicine	1
Pediatric Radiology	1
Medicine	2
Wiener Klinische Wochenschrift	1
World Journal of Surgical Oncology	1
International Journal of Clinical and Experimental Medicine	2
Clinical Journal of Gastroenterology	1
BMC Gastroenterology	1
Ochsner Journal	1

Transplant International	1
BMJ Case Reports	2
Korean Journal of Thoracic and Cardiovascular Surgery	1
Texas Heart Institute Journal	1
Trauma Monthly	1
Artery Research	1
CardioVascular and Interventional Radiology	2
World Journal of Gastroenterology	1
Qatar Medical Journal	1
Vascular and Endovascular Surgery	2
General Thoracic and Cardiovascular Surgery	1
Annals of Translational Medicine	1
American Journal of Case Reports	1
Gut Liver	1
Vojnosanitetski Pregled	1
Clinical Case Reports	1