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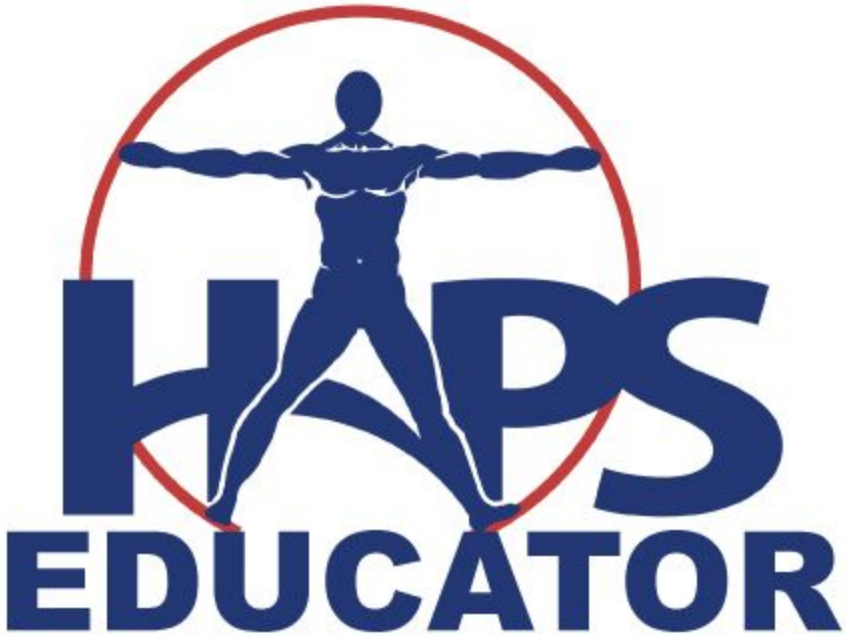

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Never Heard That Before! Bioscience Knowledge Retention in Undergraduate Nursing Education

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Abstract
Human anatomy and physiology are considered foundational courses in medical, allied health, and nursing disciplines and serve as prerequisites for future theory courses and nursing clinicals. Numerous studies have demonstrated the difficulty for medical and allied health students to acquire, transfer, retain, and apply knowledge from these courses in subsequent years of their programs. However, most knowledge retention studies of anatomy and physiology have been carried out with a focus on medical and allied health students and have rarely been assessed in nursing students. In addition, most studies of interventions in anatomy and physiology have emphasized factors affecting knowledge acquisition in the first year of nursing, and little is known about knowledge retention and application during subsequent years of nursing. This review highlights the current status of knowledge retention in nursing education, identifies potential gaps, and discusses interventional strategies to bridge the gap between the classroom and future theory courses and nursing clinicals. https://doi.org/10.21692/haps.2021.009

Key words: anatomy and physiology, knowledge retention, nursing, knowledge application, clinical application

Background
Human anatomy and physiology are considered cornerstones of any health-related profession and serve as a pre-requisite for clinical placements (Estai and Bunt 2016, McVicar et al. 2014, 2015). A strong knowledge base in these courses is crucial for nursing students to become successful practitioners after graduation (Andersson and Edberg 2010, McVicar et al. 2014, 2015). On the other hand, poor education and a lack of sufficient bioscience knowledge can result in nursing errors leading to compromised patient care and safety as well as adverse clinical outcomes (Davis 2010).

Nursing students view anatomy and physiology courses as the most difficult, content-heavy, stressful, and anxiety-provoking courses of their nursing programs (Craft et al. 2017, McVicar et al. 2015). Numerous studies have suggested that students experience great difficulty in transferring the fundamental anatomical and physiological knowledge that they gain in the first year of their programs to future theory/clinical practice (Friedel and Treagust 2005, Gunay and Kilinc 2018, Narnaware 2021, Narnaware and Neumeier 2020, Narnaware and Neumeier 2021b, Narnaware et al. 2021). A gradual loss of knowledge associated with these courses is also evident among some nursing professionals and educators (Friedel and Treagust 2005, McVicar et al. 2014).

Anatomical and physiological knowledge retention in students enrolled in nursing programs has not been assessed as extensively as that in students enrolled in medical and allied health studies and, therefore, little is known about its acquisition, transfer, and application to future theory/clinical practice (Gunay and Kilinc 2018, Narnaware 2021, Narnaware and Neumeier 2020). Any studies that have been conducted on this topic are either focused on first-year nursing students (McVicar et al. 2014, 2015) or on nurses in entry-level in nursing programs (Davis 2010, McVicar et al. 2014, 2015). In addition, most of these studies have assessed knowledge acquisition and transfer pertaining to limited body systems (Diaz-Mancha et al. 2016), so systemic, organ-by-organ anatomical knowledge transfer, and its application to gross anatomy remains to be assessed. Moreover, little is known about potential gaps and factors affecting knowledge transfer and its application to future nursing courses/clinical practice.

Therefore, the knowledge transfer, retention, and application of these courses over time in the nursing curriculum remains to be assessed. The purpose of this paper is to overview available knowledge retention studies and highlight factors affecting knowledge retention in nursing education. An additional goal is to identify potential gaps so that robust interventional strategies can be developed to bridge the gap between the classroom and future theory and clinical courses in nursing.

Knowledge Retention Studies in Undergraduate Nursing Education
Teaching and learning of anatomy and physiology in nursing programs can be viewed as problematic (Craft et al 2017, Friedel and Treagust 2005, Narnaware 2021, Narnaware et al. 2021). The nursing student's perception of these courses is that they are challenging, anxiety-provoking, difficult, and add a significant stress during their first year of nursing studies (Davis 2010; Craft et al. 2017, McVicar et al. 2015). The student's

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ability to acquire, transfer, retain, and apply aspects of anatomical and physiological knowledge to his or her second-year clinical practicum and future years of undergraduate nursing is of concern, as it is for medical and allied health students and professionals (Craft et al. 2017).

Reports related to European nurses revealed that only 9.5% received extensive bioscience education during their nursing program and 40.5% of experienced registered nurses felt that bioscience content failed to help them accomplish their roles as nurses (Davis 2010). In a recent study, Gunay and Kilinc (2018) reported that many graduate nurses felt that there was either inadequate bioscience content in their nursing programs or excessive theoretical knowledge in the first year of nursing.

On the other hand, surgical nurses in the United Kingdom (UK) understood the crucial importance of anatomy and physiology, but were unable to correlate physiological changes with their patients' conditions (McVicar et al. 2014) or adequately integrate bioscience knowledge into a clinical setting (Craft et al. 2017, Friedel and Treagust 2005). Many were frustrated with their inability to put bioscience knowledge into practice and perceived it as detrimental to overall patient care (Andersson and Edberg 2010, Davis 2010). Similar concerns were expressed by nurses trained in Australia, New Zealand and Turkey (Friedel and Treagust 2005, Gunay and Kilnc 2018).

For the past two decades, due to the introduction of a myriad of novel teaching modules, many medical and allied health programs have shifted away from the use of cadavers and prosections in favor of the newer technologies. However, the use of these newer technologies in nursing programs, particularly in the first year of nursing, and evaluation of their impact on long-term knowledge retention are rare, despite a leaning toward their adoption in nursing education (Bianchi et al. 2020, Narnaware and Neumeier 2021a, Souza et al. 2016). Moreover, the ability of these technologies to reduce cognitive load, lower exam stress and anxiety, and reduce behavioral responses that are associated with the use of cadaver dissection has not been assessed (Bianchi et al. 2020).

Although anatomy and physiology are perceived as inseparable subjects, and knowledge of these subjects is invaluable to effective clinical practice (Andersson and Edberg 2010, Culyer et al. 2018), research has described the existence of a gap between theory and practice in these crucially important subjects in the medical and allied-health curricula (McFee et al. 2018). This gap has rarely been assessed in nursing education.

As far as nursing curricula are concerned, most knowledge retention studies have focused more on anatomical knowledge retention, alone, rather than physiological knowledge retention. The reported nursing education-related studies in physiological knowledge retention have either focused on the impact of various active learning modalities (Collins et al. 2021, Majeed 2014), labs (Metz and Metz 2021), simulation (Alt-Gehrman 2019), or kinesthetic learning (Wagner 2014) on knowledge acquisition and retention (Craft et al. 2017, Culyer et al., 2018; Wagner, 2014) or academic performance (McVicar et al. 2015) in first year nursing students, or its transfer and application in intensive care units a year after students' graduation (Aari et al. 2004, Andersson and Edberg 2010). This suggests that there is a potential gap in knowledge transfer/loss, retention and application in subsequent years of nursing, but the studies needed to address this issue have not been carried out.

Most of the retention studies in nursing education have focused on the impact of the limiting factors affecting physiological knowledge acquisition/retention in first year (Dante et al. 2011, Pitt et al. 2012). Moreover, application of interventional strategies to improve knowledge acquisition and retention in physiology by first-year nursing students are limited compared to those that have been applied in anatomy (McVicar et al. 2015). Finally, these retention studies have reported physiology knowledge retention assessment in only a limited number of organ systems (Aari et al. 2004, Wagner 2014). Therefore, the assessment of base-level knowledge retention in overall organ system physiology during the first year of nursing and its transfer/loss, retention and application to subsequent years of nursing curricula warrants further exploration.

Factors Affecting Knowledge Retention Studies in Nursing Education

Like other medical and allied health care professions, nursing education continues to evolve worldwide to support professional and clinical roles and adequate anatomical and physiological knowledge is perceived as pivotal to allowing nursing students to become highly successful future nursing practitioners (Andersson and Edberg 2010, McVicar et al. 2014, 2015). At most educational institutions, these courses are being taught by employing a traditional didactic, passive teaching and learning approach (Narnaware and Neumeier 2020, Wagner 2014). It is limited to plastic models, mannequins, human skeletons, simulation, animal dissection, and the use of textbooks (Narnaware and Neumeier 2020). However, this teaching approach, coupled with the limited use of cadavers and prosections in nursing, has prevented nursing students from gaining an in-depth knowledge of the structure of the human body. It has also failed to adequately prepare them to function clinically with empathy (Washmuth et al 2019). The use of modern teaching technologies such as computer-generated three-dimensional (3-D) images and social media as well as cutting-edge teaching technologies such as a three-dimensional (3-D) virtual human cadaver (*e.g.* the Anatomage Table; www.anatomage.com), may also affect student knowledge acquisition and retention (Attardi et al. 2016, Estai and Bunt 2016, Narnaware and Neumeier 2021a, McVicar et al. 2014, 2015).

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Additional factors that have been shown to impact knowledge retention in nursing education include, but are not limited to, insufficient instructional time allotted to these courses (Al-Modhefer and Roe, 2009, Narnaware and Neumeier 2020, Narnaware 2021, Snelling et al. 2010), demographic factors (Dante et al. 2011, McVicar et al. 2014), students' prior knowledge of biology, and/or to their entry-level exam scores (McVicar et al. 2015). Their knowledge acquisition and retention may be impacted by course delivery methods and teaching strategies (Davies et al. 2000), including an excessive reliance on self-directed learning (McVicar et al. 2014, 2015), reduced use of laboratory and clinical environments (Günay and Kılınç 2018), and on the individual instructor's personal qualities, knowledge and expertise in these courses (Friedel and Treagust 2005). Finally, completely replacing cadaver and prosection use with newer technologies, particularly in the first year of nursing, could potentially have a negative impact on the student's long-term knowledge acquisition and retention (Washmuth et al. 2019).

Pedagogical Approaches to Improve Knowledge Retention in Nursing Education

The benefits of a robust interventional strategy to bridge the gap between first-year theory and clinical practice in medical and allied health students are well-documented (Manyama et al. 2016, Rutty et al. 2019). However, little is known about incorporating these strategies into nursing curricula (Davies et al. 2000, Narnaware 2021). Available strategies that have been shown to effectively to enhance long-term knowledge retention by nursing students are content reinforcement, retrieval of anatomical knowledge, and kinesthetic and active learning (Esati and Bunt 2016, McVicar et al. 2015, Narnaware et al. 2020). Also, visualization through body images (Narnaware 2018, Rutty et al. 2019), peer tutoring (Alfaro et al. 2019), and mentoring programs have been shown to be beneficial in knowledge acquisition (McVicar et al. 2014).

Various teaching and learning modalities include introducing computer-generated 3-D images, or the use of a virtual human cadaver to provide an experience similar to that obtained with a real human cadaver while helping to reduce anxiety, stress, and behavioral responses usually associated with cadaveric dissection (Bianchi et al. 2020, Narnaware and Neumeier 2021a, Washmuth et al. 2019). Also, online learning platforms such as Kahoot! quizzes (www.kahoot.com), in-class activities, group discussion, classroom presentations by students, and directing students to more online activities outside the classroom (Narnaware 2021, Narnaware & Chahal 2019, Rutty et al. 2019) and various evidence-based teaching strategies (Culyer et al. 2018) could be hugely beneficial for knowledge and long-term memory retention.

Other pedagogical approaches include allocating more teaching hours for theory classes, the introduction of labs and exams with more textbook images (Narnaware 2018), and content reinforcement (repeated knowledge assessment) (Narnaware et al. 2020). Similarly, problem-based learning (PBL) and case-based learning (CBL) with cooperative small group work and role-playing could be effective (Culyer et al. 2018). Lastly, the introduction of anatomy and physiology refresher courses at the beginning of each academic year, and access to first-year anatomy and physiology course materials could help with application and long-term memory retention. Therefore, blended, multimodal, and system-based pedagogical approaches are suggested as they have been shown to be more effective for nursing students (Estai and Bunt 2016, Souza et al. 2016).

Conclusion and Future Directions

The present review provides an initial understanding of knowledge retention of anatomy and physiology by nursing students and potential factors affecting their application to nursing education. Once areas of strengths and weaknesses in anatomical and physiological knowledge retention are identified, interventions that address those issues can be evaluated. As these findings may not be generalizable to other populations, it would be useful to conduct future studies at different nursing institutions to validate their findings in a broader context.

The perceived notion that knowledge attrition may vary significantly for the body's major organ systems would be of interest for other nursing programs and health sciences educators, as collecting this base level data could inform targeted educational interventions. The data collected will create interactive learning modules to close the gap between theory and clinical practice. The challenge for undergraduate nursing institutions committed to student success is to develop strategies aimed at addressing factors that are appropriate to specific contexts and student cohorts. While nursing educators focus on long-term knowledge retention and its application, the current trends in nursing, such as shifting from didactic, passive learning to active learning with the adoption of newer teaching technologies that foster student engagement, social interaction and communication skill development, must be kept in mind when designing nursing curricula to produce knowledgeable, confident and competent nurse practitioners (Alt-Gerhrman et al. 2019).

About the Author

Dr. Raj Narnaware is an Assistant Professor in the Department of Human Health & Sciences, Faculty of Nursing at MacEwan University, Edmonton, Alberta. He teaches human anatomy and physiology to the Bachelor of Science in Nursing (BScN) and Psychiatric Nursing (BPN) students. As a researcher, he is involved in several Scholarship of Teaching and Learning (SoTL) projects that focus on the efficacies of modern, cutting-edge teaching technologies to improve student knowledge.

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In addition, he is also involved in assessing anatomical and physiological knowledge acquisition in the first year of nursing and its transfer and application to future nursing courses and clinical experiences by developing robust interventional strategies to bridge the knowledge gap between theory and clinical.

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