Nurse Education in Practice 34 (2019) 7–11

Contents lists available at ScienceDirect

Nurse Education in Practice

journal homepage: www.elsevier.com/locate/nepr

Enhanced bioscience content is urgently needed in UK pre-registration nursing curricula

C. Perkins

Birmingham City University, Westbourne Road, Edgbaston, Birmingham, B15 3TN, United Kingdom

ARTICLE INFO

Keywords:
Bioscience
Pre-registration
Nursing
Modern
Learning and teaching
Assessment

ABSTRACT

Achieving adequate bioscience learning and assessment in pre registration nursing programs has been problematic for many decades. This has been discussed extensively in national and international health care literature. Despite this, the quantity and quality of bioscience content appears currently in many UK registered nursing programs, to be in a period of decline.

Sub optimal bioscience knowledge of registered nurses has been consistently correlated with avoidable morbidity and mortality. An increasing evidence base indicates that a higher level of educated registered nurse, leads to improved health outcomes. It is therefore clear that continuing to fail to address the bioscience problem in nursing education has the potential to incur considerable adverse impact on the UK populations' health.

The recent publication of new Nursing and Midwifery Council (NMC) standards of proficiency for registered nurses, and standards for pre-registration nursing programs require nurse education providers across the UK, to write new curriculum. The purpose of this discussion paper is to present the case for enhanced bioscience content within these.

1. Introduction

Few would disagree that an understanding of anatomy, physiology and pathophysiology, together referred to as bioscience, is essential for registered nursing practice (Clifton and McKillup, 2016). The term bioscience is often expanded to include pharmacology, microbiology, biochemistry, genetics and immunology (European Directive 2005/36/EC, Smales, 2010). This wider definition is used in this paper.

Registered nurses need to have sufficient understanding of bioscience to underpin safe and effective clinical practice (Fawcett et al., 2016). Bioscience content in pre-registration nursing curriculum has however, been declining through recent decades (Davis, 2010; Fawcett et al., 2016).

2. Quantifying the bioscience problem

Results from a survey involving ten Approved Education Institutions (AEI) in the UK indicated that on average, hours of taught bioscience currently represent only 0.4–2.4% of total time of pre-registration nursing programs (Taylor et al., 2015). This finding that the amount of bioscience teaching in UK pre registration nursing programs is minimal, and varies widely across different AEI's, has been mirrored by others (Wharrad et al., 1994; Morrison-Griffiths et al., 2002). This appears to be consistent with the practice placement environment (McVicar et al., 2010; Perkins and Kisiel, 2013). Logan and Angel (2011) concur that there has been a gradual devaluing of bioscience knowledge, in both clinical practice and practice education, for many years.

Over 40% of registered nurses in Davis' (2010) study stated bioscience content had not prepared them for their roles on registration. From their survey of 245 third year nursing students, Fell and James (2012) found that approximately one half said there was inadequate physiology content in their pre-registration program. The findings of Davis' (2010) and Fell and James' (2012) work correlate with the work of Friedel and Treagust (2005), who found that there was insufficient bioscience in nursing programs.

Health care colleagues and patients have also raised concerns. Studies have found that doctors and service users both expect a higher level of bioscience knowledge in registered nurses than they actually have (Jordan et al., 2000; Friedel and Treagust, 2005; Davis, 2010; Moleseworth and Lewitt,.2016). Also that student nurses themselves think that they should know more than they actually do (Moleseworth and Lewitt,.2016).

3. Evolution of the bioscience problem

It is beyond the scope of this paper to provide detailed chronology of the decline in bioscience content in UK pre-registration nursing curriculum. It is however important to consider the history of it, to

E-mail address: Claire.perkins@bcu.ac.uk.

https://doi.org/10.1016/j.nepr.2018.10.008
Received 11 July 2018; Received in revised form 12 October 2018; Accepted 17 October 2018

appreciate the gravity of this problem.

It is widely acknowledged that the reduction of bioscience content began in the early 1980's, when nursing education moved away from the 'medical model', towards much greater emphasis on the social and behavioral sciences (Davis, 2010). This stemmed from a desire to identify the unique contribution of nursing as an emerging profession, and distance itself from medicine (Clarke, 1995). It became commonplace to acknowledge, tacit, intuitive, 'knowing' knowledge and focus on the psycho-social aspects of care, with minimal emphasis on bioscience. In the mid 1990's it was identified that both nurse lecturers and mentors lacked bioscience knowledge (Clarke, 1995). Bradley et al. (2006) later published findings of wide variability in the bioscience knowledge of nurse lecturers.

The majority of nurses and nurse educators currently registered with the Nursing and Midwifery Council (NMC), trained during this extensive time period. This explains why, despite decades of identification and evaluation of the impact of the bioscience problem, arguably no progress has been made.

Providing a contemporary illustration of the ongoing issue, Large and Aldridge (2018) discuss the value of nurse intuition, in the context of ensuring timely recognition of acute health deterioration. They recommend the addition of a *'nurse worry'* indicator to existing published escalation tools, suggesting that this could help reduce poor outcomes by "enabling nurses to escalate patients about whom they may be unable to communicate quantifiably to medical staff" (Large and Aldridge, p 28).

Within this paper, it is argued that a more effective approach would be to enable registered nurses to quantifiably communicate concerns about a patient's health, to multi-disciplinary colleagues. A graduate healthcare professional should be equipped to do this. Clancey et al. (2000) identified that staff nurses lack confidence in expressing bioscience knowledge to patients, and to other health care professionals. Andrew et al. (2015) however found that preparing students with a strong understanding of bioscience leads to registered nurses who are confident in applying their knowledge to practice.

4. The case for enhanced bioscience curriculum content

4.1. Improved patient outcomes

With the advent of greater scrutiny of health outcomes by bodies such as National Confidential Enquiry into Patient Outcome and Death (NCEPOD) and the Parliamentary and Health Service Ombudsman (PHSO), examples of the avoidable health harm that has occurred as a result of health care professionals' inadequate application of bioscience knowledge are regularly published (Table 1). Some reports draw alarming specific conclusions such as 38% of cardiac arrests in hospital are likely to have been avoidable if health care professionals had interpreted patient assessment data more effectively (NCEPOD, 2012).

This correlates with a growing evidence base that illustrates the link between the level of bioscience knowledge of registered nurses, and patient care outcomes (Jordan et al., 1999; Gresty and Cotton, 2003; Aitken et al., 2003; Friedal and Treagust, 2005; Prowse and Heath, 2005). Cho et al. (2015) published evidence of a statistically significant link between the level of nurse education and patient mortality. Aiken et al. (2014) demonstrated that where there are higher proportions of nurses educated to degree level, there are lower mortality and failure to rescue rates.

Bioscience knowledge can be argued to be an integral component of improving a wide variety of health outcomes. Research has illustrated how an increased depth of biological science knowledge can impact positively on the healing time of wounds (Redmond et al., 2015). Stern et al. (2017) published evidence of an increased understanding of pain in health care professionals, resulting in an improvement in pain outcomes, and decrease in utilization of unnecessary services.

One in five patients receiving intravenous fluid and electrolyte therapy in the UK currently suffer avoidable complications and morbidity (NICE, 2017). Registered nurses administer and evaluate this therapy. Improved understanding of the physiological principles and the pathophysiological changes that affect fluid balance in disease states would seem likely to reduce this harm. NICE (2013) estimate that the costs to the NHS of Acute Kidney Injury (AKI), a largely avoidable yet increasingly prevalent condition in primary, secondary and tertiary care, are £434 to £620 million a year. If registered nurses had enhanced bioscience understanding of renal function, this could similarly reduce. Case studies that illustrate this have been published in nursing literature for many years (Perkins and Kisiel, 2005; Dirkes, 2015).

Cox et al. (2014) concluded that urgent review of microbiology education was required in nursing education to ensure appropriate implementation of infection control practice. Student nurse respondents in Vaismoradi et al.'s. (2014) study, felt their education programs were leaving them vulnerable to drug errors. In the UK, medication errors account for approximately 20% of deaths due to all types of adverse events in hospitals, cost the NHS £500 million annually, and avoidable increases in hospital stay (Leufer and Clearly-Holdforth, 2013).

4.1.1. Core of the registered nurses role-impact on health

Many nurse educators trained during the post 'medical model' era have developed differing views on the role of a nurse, and arguably justified reduced bioscience learning accordingly. As Lord Willis (2012) highlights, there is indeed wide opinion and varied perceptions about what the registered nursing role entails. However whichever definition you prefer (Table 2), it appears unambiguous that the central purpose of registered nursing is to positively impact upon health. It is hard to imagine how a health care professional could achieve this, without a robust bioscience understanding of it. Not only of physical health, but mental and social health too. There have recently been significant advances in medical science research in identifying a biological basis of many forms of mental illness (Fawcett et al., 2016).

An important focus of modern nursing is to empower patients to achieve health, and prevent future illness (NMC, 2018a). A registered nurse who encounters a patient in primary care, with co-existing chronic cardiac, renal disease and depression will require robust bioscience understanding of the combined health problems and treatments, to enable safe and effective dietary, exercise, medication and condition monitoring advice, and treatment to be given.

Table 1
Publications, which demonstrate avoidable harm within the UK health service.

National Confidential Enquiry Patient Outcome Death (NCEPOD) (2017)	Non Invasive Ventilation: Inspiring Change
NCEPOD (2016)	Acute Pancreatitis
NCEPOD (2015)	Just Say Sepsis
NCEPOD (2014)	Time To Get Control: Gastrointestinal Hemorrhage
NCEPOD (2012)	Time To Intervene: Cardiac Arrest Procedures
NCEPOD (2010)	Elective & Emergency Surgery In The Elderly: An Age Old Problem
NCEPOD (2009)	Acute Kidney Injury: Adding Insult To Injury
Parliamentary Health Service Ombudsman (PHSO) (2016)	A Report Of Investigations Into Unsafe Discharges From Hospital
PHSO (2014)	Complaints About Acute Trusts 2014-15
PHSO (2013)	Time To Act: Severe Sepsis; Rapid Diagnosis and Treatment Saves Lives

Table 2
Definitions of nursing.

Royal College of Nursing RCN (2014)	The use of clinical judgment in the provision of care to enable people to improve, maintain, or recover health, to cope with health problems, and to achieve the best possible quality of life, whatever their disease or disability, until death.
American Nurses Association ANA (2018)	Nursing is the protection, promotion, and optimization of health and abilities, prevention of illness and injury, alleviation of suffering through the diagnosis and treatment of human response, and advocacy in the care of individuals, families, communities, and populations
International Council Nurses ICN (2009)	Nursing encompasses autonomous and collaborative care of individuals of all ages, families, groups and communities, sick or well and in all settings. Nursing includes the promotion of health, prevention of illness, and the care of ill, disabled and dying people. Advocacy, promotion of a safe environment, research, participation in shaping health policy and in patient and health systems management, and education are also key nursing roles.

Table 3
Examples of nursing procedures that a newly registered nurse must be able to demonstrate proficiency in (NMC, 2018a), that have clear bioscience requirement.

1.2.1, 1.2.1 and 1.2.3	Take history, observe, recognize and accurately assess people of all ages for symptoms and signs of physical ill health, physical distress, deterioration and sepsis
2.1	Take, record and **interpret vital signs** manually and via technological devices
2.2	Undertake venepuncture and cannulation and blood sampling, **interpreting normal and common abnormal blood profiles and venous blood gases**
2.3	Set up and manage routine electrocardiogram (ECG) investigations and **interpret normal and commonly encountered abnormal traces**
2.4	Manage and **monitor blood component transfusions**
2.5	Manage and **interpret cardiac monitors, infusion pumps, blood glucose monitors and other monitoring devices**
2.7	Undertake *a* **whole body systems assessment, including respiratory, circulatory, neurological, musculoskeletal, cardiovascular and skin status**
2.8	Undertake chest auscultation *and* **interpret findings**
2.9	Collect and observe sputum, urine, stool and vomit specimens, **undertaking routine analysis and interpreting findings.**
2.10	Measure and **interpret blood glucose levels**
2.12	Undertake, respond to and **interpret neurological observations and assessments**
2.13	**Identify and respond to signs of deterioration and sepsis**
3.1	Observe and **assess comfort and pain levels** and rest and sleep patterns
4.8	Assess, respond and **effectively manage pyrexia and hypothermia**
5.1	**Observe, assess and optimize nutrition and hydration status** and determine the need for intervention and support
5.4	Record fluid intake and output and **identify, respond to and manage dehydration or fluid retention**
8.1	Observe and **assess the need for intervention and respond to restlessness, agitation and breathlessness** using appropriate interventions
8.2	Manage the administration of oxygen **using a range of routes and best practice approaches.**
8.3	Take and **interpret peak flow and oximetry measurements**
9.9	Safely assess and **manage invasive medical devices and lines**
10.1	**Identify, assess and respond appropriately to uncontrolled symptoms and signs of distress including pain, nausea, thirst, constipation, restlessness, agitation, anxiety and depression.**
10.2	Manage and **monitor effectiveness of symptom relief medication**, infusion pumps and other devices
11.6	Exercise **professional accountability in ensuring the safe administration of medicines** to those receiving care
11.10	**Recognize and respond to adverse or abnormal reactions to medications.**

Changing patient demographics require nurses to have increased bioscience knowledge. More of the UK population now have multiple and complex health conditions (CoDH, 2016). The population is an ageing one, with mental health problems affecting one in four (BMA, 2017). This increase in complexity is causing for example, many of the Track and Trigger Scoring (TTS) tools utilized by nurses to identify health deterioration, to lack sensitivity and relevance to many individual patients (Grant and Crimmons, 2018). As a result, nurses are increasingly required to utilize their bioscience based interpretation skills, to identify instances of concern (Grant, 2018).

Many patients in modern society have also evolved from being passive to active recipients of health information, wishing to be collaborative partners; challenging and seeking deeper rationales for the advice they receive (McMullan, 2006). McMullan (2006) found that some health professionals feel threatened by the detailed level of understanding that patients often have, about their health,. Student nurses in Fell et al.'s., (2016) study illustrated that it can be stressful to be unable to answer patient's questions, and meet their expectations.

4.1.2. Increased student satisfaction

Evidence suggests student nurses want increased learning of bioscience (Nicoll and Butler, 1996; Davis, 2010; Ashelford et al., 2014). Lecturers in Taylor et al.'s., (2015) study reported that students enjoy the subject, and consider bioscience learning to be of high value to patient care. Nursing students expressed a high level of interest in understanding how the human body works, in Clifton and McKillups (2016) study. Danielson and Berntsson (2007) found from their sample of registered nurses working in a variety of settings, that nurses considered the knowledge most needed in relation to their work was related to bioscience. Students consistently request more time and greater priority for bioscience in their program (Taylor et al., 2015).

Bioscience knowledge has also been found to increase student's confidence to undertake their role, and challenge practice if necessary (Fell et al., 2016). The majority of participants in Khan and Hood's (2018) study agreed that pharmacology education was crucial for practice. Student nurses in Clifton and McKillup's (2016) study rated the three bioscience courses, within their top four preferences of the fourteen courses they studied.

It seems odd therefore that the majority of AEI's in the UK are providing such small proportions of bioscience provision, often delivered as isolated subjects, frequently in Year 1 of registered nursing programs. In a climate where registered nursing applications are falling (RCN, 2018) it is important for AEI's to be aware that registered nurse applicants may choose to study where a higher level of bioscience curriculum is offered.

4.1.3. New NMC standards

As the responsibility associated with registered nursing is currently increasing, the requirement for qualified nurses to have a better understanding of bioscience has never been more important (Fell et al., 2016). Lord Willis (2012) identified that “more registered nurses will need to acquire advanced knowledge and practice skills, such as prescribing, diagnostic and clinical decision making skills, undertaking diagnostic tests, administration of IV fluids, enteral feeding and complex pain relief interventions, whilst working within a patients home,” (p 22). This modern view is reflected within the new standards of

Table 4
Examples of proficiency statements for registered nurses (NMC, 2018a) that have clear bioscience requirement.

1.10	… be capable of explaining the rationale that influences their judgments and decisions, in routine, complex and challenging situations.
1.18	Demonstrate the knowledge and confidence to contribute effectively and proactively in an interdisciplinary team
2.11	Promote health and prevent ill health by understanding and explaining to people the principles of pathogenesis, immunology …. . …
3.1	Demonstrate and apply knowledge of human development from conception to death …. *when undertaking full and accurate person-centered nursing assessments and developing appropriate care plans*
3.2	Demonstrate and apply knowledge of body systems and homeostasis, human anatomy and physiology, biology, genomics, pharmacology and social and behavioral sciences … (see 3.1)
3.3	Demonstrate and apply knowledge of all commonly encountered mental, physical, behavioral and cognitive health conditions, medication usage … (see 3.1)
3.5	Demonstrate the ability to accurately process all information gathered during the assessment process to identify needs for individualized nursing care and develop person-centered evidence-based plans for nursing interventions with agreed goals.
3.12	Interpret results from routine investigations, taking prompt action when required by implementing appropriate interventions, requesting additional investigations or escalating to others.
4.4	Demonstrate the knowledge and skills required to support people with commonly encountered mental health, behavioral, cognitive and learning challenges
4.5	Demonstrate the knowledge and skills required to support people with commonly encountered physical health conditions, their medication usage and treatments
4.8	Demonstrate the knowledge and skills required to identify and initiate appropriate interventions to support people with commonly encountered symptoms including anxiety, confusion, discomfort and pain
4.10	Demonstrate the knowledge and ability to respond proactively and promptly to signs of deterioration or distress in mental, physical, cognitive or behavioral health, and use this knowledge to make sound clinical decisions.
4.15	Demonstrate knowledge of pharmacology and the ability to recognize the effects of medicines, allergies, drug sensitivities, side effects, contraindications, incompatibilities, adverse reactions, prescribing errors and the impact of poly pharmacy and over the counter medication usage.

proficiency recently published by the NMC (2018a).

It is clear within these standards that additional depth of bioscience content to existing curricula provision must occur, to ensure that future registered nurses are proficient in procedures such as those shown in Table 3, and achieve proficiencies such as those in Table 4. The NMC (2018 a,b) have required this from all fields of nursing. This heralds an era of increasing awareness that it is not safe and effective to aim to effect positive health impact in anything less than the whole person.

The challenges of achieving adequate bioscience in nursing curricula have been well documented (Bradley et al., 2006; Craft et al., 2013; Taylor et al., 2015; Jensen et al., 2018). It is disappointing in light of this that the NMC have not given the clear minimum outcome guidance for bioscience by the point of registration that Taylor et al. (2015) advocate, despite key developments such as the bioscience learning outcome framework published by BINE (2016). In light of the training histories of many of the nurse educators who will be clinically and academically assessing the new NMC (2018a) proficiencies, considerable risk exists that standards will continue to decline.

It is beyond the scope of this discussion paper to propose specific detail about what future enhanced bioscience curricula should involve. Initial recommendations however are presented in Table 5, which are supported by relevant evidence.

5. Conclusion

Concern about the level of registered nurses bioscience knowledge and understanding has been raised for many years (Wilson, 1975; Clarke, 1995; Clancey et al., 2000; Fawcett et al., 2016). It has been illustrated that the current pattern of decline of bioscience content in UK pre-registration nursing curricula is detrimental for both the UK population, and the nursing profession. It is urgent that this is now addressed.

With ever increasing professional autonomy, the need for registered nurses to be able to make the practical application of bioscience in the clinical environment has never been greater (Fawcett et al., 2016). A deep understanding of bioscience and the ability to draw on this information in the context of nursing clinical practice is integral to achieving high standards of patient care (Christensen et al., 2015). This will have the additional benefit of being more in tune with nursing students' expectations (Taylor et al., 2015).

Today's population has more complex needs and higher expectations than ever before (Lord Willis, 2012). Modern registered nursing practice requires robust bioscience knowledge that informs clinical decision making that avoids health harm, and maximizes health impact. The safety and long-term viability of our health service depend upon this.

Table 5
Recommendations for enhanced bioscience in UK pre-registration nursing curricula.

1. Increased depth of content and frequency of bioscience learning, throughout the curricula	The NMC (2018a) summary statements for the 7 domains, indicate that; • an increased depth of bioscience knowledge is required for 2,3,4 and 6, but less so for 1,5, and 7. • an appropriate depth of bioscience learning and teaching should therefore occur in approximately 60% of the curriculum. • A wide range of teaching, learning and assessment strategies should occur in all years of the program (Taylor et al., 2015)
2. Ensure bioscience content is always clinically applied.	• Bioscience content is most effectively delivered and assessed through clinically applied approaches, such as those discussed by Johnston et al. (2015) and Craft et al., 2016. • The incomplete holism problem that Wynne et al., 1997 described of bioscience in nurse education, still needs to be addressed.
3. Enhance the methods of delivery of bioscience content	• Delivery methods of bioscience content need to be reviewed. • Some delivery methods can cause information to become disconnected, and students to employ rote-learning as a coping mechanism, in order to achieve assessment outcomes (Craft et al., 2016).
4 Ensure sufficient level of teaching expertise	• Nurse educators must further develop their bioscience knowledge as required, to effectively enable enhanced bioscience content that is integrated throughout new curricula (Ralph et al., 2017). • Pathophysiology team teaching involving a bio scientist and nurse educator has been demonstrated to be an effective way of ensuring expertise (Christensen et al., 2015).
5. Enhance the methods of bioscience assessment within the AEI	• Bioscience assessment within the AEI needs to be rigorous. • Clinically based mentors may not have sufficient bioscience knowledge to assess applied bioscience knowledge sufficiently (McVicar et al., 2010; Logan and Angel., 2011; Andrew et al., 2015). • Bioscience knowledge expectations should be made explicit within placement documentation, to ensure this is prioritized and valued.

Ethical approval details

Not Applicable.

Conflicts of interest

None.

Role of the funding source

No funding has been received in relation to the submitted manuscript.

References

Aiken, L., Clarke, S., Cheung, R., Sloane, D., Silber, J., 2003. Educational levels of hospital nurses and surgical patient mortality. J. Am. Med. Assoc. 290 (12), 1617–1623 24 September.
Aiken, L., Sloane, D., Bruyneel, L., et al., 2014. Nurse staffing and education and hospital mortality in nine European countries: a retrospective observational study. Lancet 383 (24 Mar), 1824–1830.
American Nurses Association, 2018. Nursing Scope of Practice. ANA, America Last accessed: 11/7/18. https://www.nursingworld.org/practice-policy/scope-of-practice/.
Andrew, S., McVicar, A., Zanganeh, M., Henderson, N., 2015. Self-efficacy and relevance of bioscience for nursing, midwifery and healthcare students. J. Clin. Nurs. 24, 2965–2972.
Ashelford, S., Taylor, V., Middleton-Green, L., Flynn, L., O'Donnell, P., Waskett, C., 2014. Evaluation of Student Nurses' Perceptions of Learning and Integrating Bioscience Knowledge in Pre-registration Nursing Programmes and Year 1 Post Graduation/ Registration. Abstract NET2014 Conference. Cambridge.
Bioscience In Nurse Education, 2016. Quality Assurance Framework for Biosciences Education in Nursing. BINE, UK Accessed 29/8/18. https://www.heacademy.ac.uk/system/files/bine_biosciences_qa_framework_b-qaf_july_16.pdf.
British Medical Association, 2017. Breaking Down Barriers; the Challenge of Improving Mental Health Outcomes. BMA, London.
Bradley, E., Blackshaw, C., Nolan, P., 2006. Nurse lecturers' observations on aspects of nurse prescribing training. Nurse Educ. Today 26 (7), 538–544.
Cho, E., Sloane, D., Kim, E.-Y., Kim, S., Choi, M., Young Too, I., Sun Lee, H., Aiken, L., 2015. Effects of nurse staffing, work environments, and education on patient mortality: an observational study. Int. J. Nurs. Stud. 52, 535–542.
Christensen, M., Craft, J., Wirihana, L., Gordon, C., 2015. Pathophysiology team teaching: bio scientist contribution to knowledge integration in a nursing subject. J. Clin. Nurs. 24, 3739–3741.
Clancey, J., McVicar, A., Bird, D., 2000. Getting it right? An exploration of issues relating to the biological sciences in nurse education and nursing practice. J. Adv. Nurs. 32, 1522–1532.
Clarke, M., 1995. Nursing and the biological sciences. J. Adv. Nurs. 22, 405–406.
Clifton, D., McKillup, S., 2016. Why such success? Nursing students show consistently high satisfaction with bioscience courses at a regional university. Aust. J. Adv. Nurs. 33 (3), 21–28.
Council of Deans Health, 2016. Education the Future Nurse- a Paper for Discussion. CoDH. Shape of Caring Advisory Group, London.
Cox, J., Simpson, M., Letts, W., Cavanagh, H., 2014. Putting it in to practice: infection control professionals' perspectives on early career nursing graduates' microbiology and infection control practice. Contemp. Nurse 49, 83–92.
Craft, J., Hudson, P., Plemder, M., Wirhana, L., Gordon, C., 2013. Commencing nursing students' perceptions and anxiety of bioscience. Nurse Educ. Today 33 (11), 1399–1405.
Craft, J., Hudson, B., Plenderleith, M., Gordon, C., 2016. Registered nurses' reflections on bioscience courses during the undergraduate nursing programme: an exploratory study. J. Clin. Nurs. 26, 1669–1680.
Danielson, E., Berntsson, L., 2007. Registered nurses' perceptions of educational preparation for professional work and development in their profession. Nurse Educ. Today 27 (8), 900–908.
Davis, G., 2010. What is provided and what the registered nurse needs- bioscience learning through the pre-registration curriculum. Nurse Educ. Today 30, 707–712.
Dirkes, S., 2015. Acute kidney injury; causes, phases and early detection. Am. Nurse Today 10 (7), 20–24.
European Parliament, 2005. Directive 2005/36/EC of the European Parliament and of the Council of 7 September 2005 on the Recognition of Professional Qualifications. Last Accessed 11/7/18. https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2005:255:0022:0142:en:PDF.
Fawcett, T., Waugh, A., Smith, G., 2016. Editorial: the Primacy of the biosciences: a forgotten priority in nurse education? J. Clin. Nurs. 25, 2680–2682.
Fell, P., James, P., 2012. Body of evidence. Nurs. Stand. 27 (14), p64.
Fell, P., Dobbins, K., Dee, P., 2016. Bioscience learning in clinical placement: the experiences of pre-registration nursing students. J. Clin. Nurs. 25, 2694–2705.
Friedel, J.M., Treagust, D.F., 2005. Learning bioscience in nursing education: perceptions of the intended and the prescribed curriculum. Learn. Heatlh Soc. Care 4, 203–216.
Grant, S., 2018. Limitations of track and trigger systems and the National Early Warning Score. Part 1: areas of contention. Br. J. Nurs. 27 (11), 624–631.
Grant, S., Crimmons, K., 2018. Limitations of track and trigger systems and the National Early Warning. Part 2: sensitivity versus specificity. Br. J. Nurs. 27 (12), 705–710.
Gresty, K., Cotton, D., 2003. Supporting bioscience in the nursing curriculum: development and evaluation of an online resource. J. Adv. Nurs. 44 (4), 339–349.
International Council of Nurses, 2009. Definition of nursing. Geneva, Switzerland. [Accessed 11 July 18]. Available from: http://www.icn.ch/who-we-are/icn-definition-of-nursing/.
Jensen, K., Knutstad, U., Fawcett, T., 2018. The challenge of the biosciences in nurse education: a literature review. J. Clin. Nurs. 27, 1793–1802.
Johnston, A., Hamil, J., Barton, M., Baldwin, S., Percival, J., Williams-Pritchard, G., Todorovic, M., 2015. Student learning styles in anatomy and physiology courses: meeting the needs of nursing students. Nurse Educ. Pract. 15, pp1–6.
Jordan, S., Davies, S., Green, B., 1999. The biosciences in the pre-registration nursing curriculum: staff and student's perceptions of difficulties and relevance. Nurse Educ. Today 19 (3), 215–226.
Jordan, S., Philpin, S., Davies, S., Andrade, M., 2000. The biological sciences in mental health nursing: stakeholder's perspectives. J. Adv. Nurs. 32, 881–891.
Khan, E., Hood, P., 2018. Nurses' perspectives on pharmacology: why, what and at which point of the curricula should education be delivered? Br. J. Nurs. 27 (10), 546–553.
Large, C., Aldridge, M., 2018. Non-technical skills required to recognise and escalate patient deterioration in acute hospital settings. Nurs. Manag. 25 (2), 24–30.
Leufer, T., Cleary-Holdforth, 2013. Let's do no harm: medication errors in nursing: Part 1. Nurse Educ. Pract. 13, 213–216.
Logan, P.A., Angel, L., 2011. Nursing as a scientific undertaking and the intersection with science in undergraduate studies: implications for nursing management. J. Nurs. Manag. 19, 407–417.
Lord Willis, P., 2012. Raising the Bar. Shape of Caring: a Review of the Future Education and Training of Registered Nurses and Care Assistants. Health Education England, London.
McMullan, M., 2006. Patients using the Internet to obtain health information: how this affects the patient-health professional relationship. Patient Educ. Counsel. 63 (1), 24–28.
McVicar, A., Clancy, J., Mayes, N., 2010. An exploratory study of the application of biosciences in practice, and implications for pre-qualifying education. Nurse Educ. Today 30, 615–622.
Moleseworth, M., Lewitt, M., 2016. Preregistration nursing students' perspectives on the learning, teaching and application of bioscience knowledge within practice. J. Clin. Nurs. 25, 725–732.
Morrison-Griffiths, S., Snowden, M., Pirmohamed, M., 2002. Pre-registration nurse education in pharmacology: is it adequate for the roles that nurses are expected to fulfill? Nurse Educ. Today 22 (6), 447–456.
National Confidential Enquiry into Patient Outcome and Death, 2012. Cardiac Arrest Procedures: Time to Intervene. NCEPOD, London.
National Institute for Health and Care Excellent, 2013. Acute Kidney Injury: Prevention, Detection and Management. NICE, London.
National Institute for Health and Care Excellent, 2017. Intravenous Fluid Therapy in Adults in Hospital. NICE, London.
Nicholl, L., Butler, M., 1996. The study of biology as a cause of anxiety in student nurses undertaking the common foundation programme. J. Adv. Nurs. 24, 615–624.
Nursing and Midwifery Council, 2018a. Standards of Proficiency for Registered Nurses. NMC, London.
Nursing and Midwifery Council, 2018b. Standards for Pre-registration Nursing Programs. NMC, London.
Perkins, C., Kisiel, M., 2005. Utilising physiological knowledge to care for acute renal failure. Br. J. Nurs. 14 (14), 768–773.
Perkins, C., Kisiel, M., 2013. Developing the recognition and response skills of student nurses. Br. J. Nurs. 22 (12), pp715–724.
Prowse, M., Heath, V., 2005. Working collaboratively in health care contexts: the influence of bio scientific knowledge on patient outcomes. Nurse Educ. Today 25, 132–139.
Ralph, N., Birks, M., Chun Tie, Y., Hillman, E., 2017. How should science be taught to nurses?; Preferences of registered nurses and science teaching academics. Collegian 24, 585–591.
Royal College of Nursing, 2014. Defining Nursing. RCN, London.
Royal College of Nursing, 2018. Left to Chance: the Health and Care Nursing Workforce Supply in England. Policy Report. RCN, London.
Redmond, C., Davies, C., Cornally, D., Fegan, M., O'Toole, M., 2015. Teaching and learning in the Biosciences; the development of an educational programme to assist student nurses in their assessment and management of patients with wounds. J. Clin. Nurs. 25, 2706–2712.
Smales, K., 2010. Learning and applying biosciences to clinical practice in nursing. Nurs. Stand. 24, 35–39.
Stern, N., Weber, L., Van Wagner, C., Neihus, R., Halpenin, K., Spineli, K., Cruz, L., 2017. Pain education in primary care and rehab services improves patient outcomes. J. Pain 18 (4) pS50.
Taylor, V., Ashelford, S., Fell, P., Goacher, P., 2015. Biosciences in nurse education: is the curriculum fit for practice? Lecturer's views and recommendations from across the UK. J. Clin. Nurs. 24, 1–10.
Vaismoradi, M., Jordan, S., Turunen, H., Bondas, R., 2014. Nursing student's perspectives of the cause of medication errors. Nurse Educ. Today 34, 434–440.
Wharrad, H., Allcock, N., Chappie, M., 1994. A survey of the teaching and learning of biological sciences on undergraduate nursing courses. Nurse Educ. Today 14 (6), 436–442.
Wilson, K., 1975. Study of the Biological Sciences in Relation to Nursing. Churchill Livingstone, Edinburgh.
Wynne, N., Brand, S., Smith, R., 1997. Incomplete holism in pre-registration nurse education: the position of the biological sciences. J. Adv. Nurs. 26, 470–474.