**Institution: University of South Wales**

**Unit of Assessment: UoA A3**

**Title of case study:** *Safety in numbers:* towards reducing global medication dosage calculation problem-solving (MDC-PS) error through the design and application of virtual authentic learning and assessment environments.

## 1. Summary of the impact:

This case study demonstrates the impact on healthcare education in six countries across four continents (145,000 nursing students and practitioners) in the following ways/areas:

1) *Changes to undergraduate nursing curricula* in the UK, USA, Canada, Australia, Qatar and Poland and newly registered nurses' ability to calculate medication doses safely.

2) *Change to UK Nursing Regulator policy,* i.e., the UK Nursing & Midwifery Council (NMC) policy on essential skills for giving medication.

3) *Change to health care delivery organisations' continuing professional development training programme* in the UK, USA & Canada and registered nurses' ability to transform care by calculating doses and giving medicines safely.

## 2. Underpinning research:

Contributing CRICS Researchers from the Transforming Care cluster: Profs Weeks and Pontin with support from Principal Lecturer Young and Senior Lecturer Higginson.

External collaborators: Prof. John Clochesy, University South Florida, USA; Mike Sabin, NHS Education for Scotland; Prof. Diana Coben, University Waikato, New Zealand.

The *Safety in Numbers* translation research programme bridges two gaps in translating research from 'bench to bedside': Gap 1: Knowledge and technology transfer (2002-2005): The development by Authentic World Ltd (USW spinout company) of *safeMedicate®,* a virtual web-based environment for teaching/learning MDC-PS from a prototype designed by Prof. Weeks. Gap 2: International healthcare education evaluation and impact (2006-2013): The international evaluation of *safeMedicate®*, its adaptation, global uptake, and impact on the UK NMC (2010) guidance for medicines management and healthcare curricula of six countries across four continents.

**The patient-safety problem:** Medication errors are a worldwide problem (Weeks et al 2013a): 6,000 medication errors are reported monthly in the UK and in the USA around 1.5 million people are harmed ever year by medication errors. Staff incompetence, and poor training and assessment contribute to these errors.

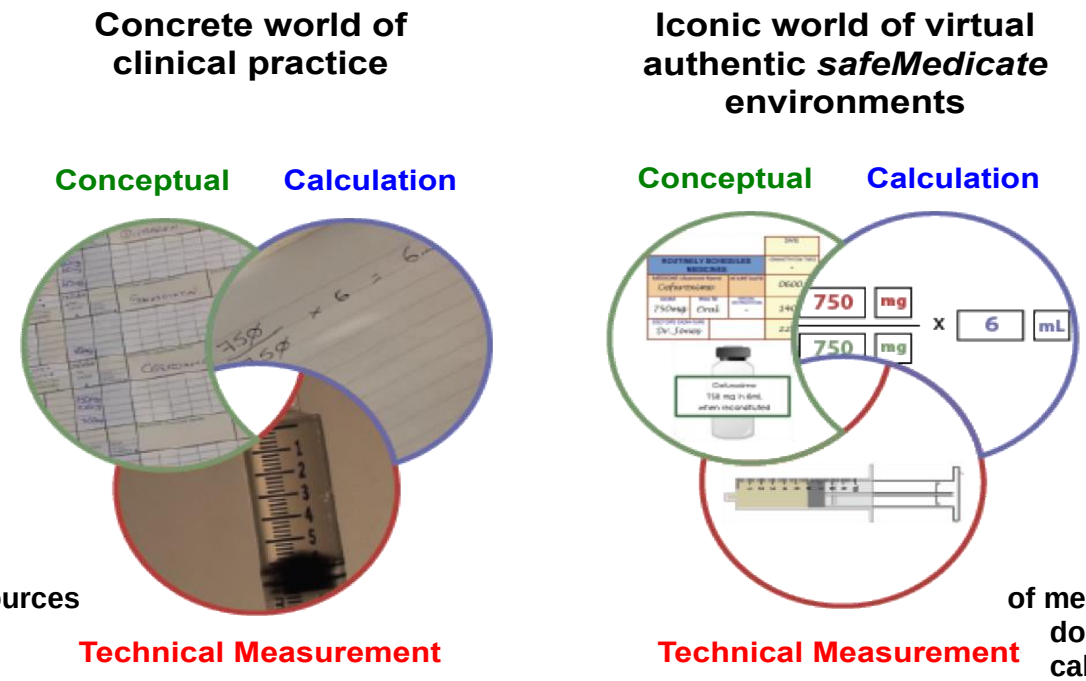
**Defining MDC-PS competence:** Weeks et al (2013b) refined the MDC-PS competence model developed by Prof. Weeks in 1992-2001 (Figure 1) to explain what is needed for people to be competent at calculating doses, giving medication, managing the process and transforming care. The model includes descriptions of authentic competence and identifies what is required to develop and integrate the learning and development of competence in 3 related domains:

1. *Conceptual competence domain*: understanding the dosage problem to be solved *in-context*.
2. *Calculation competence domain*: calculating an accurate numerical value(s) and measurement unit(s) for the medication dose or rate of medication to be administered.
3. *Technical Measurement competence domain*: measuring the correct dose or rate of medication to be administered in an appropriate way (syringe, IV pump, tablet etc).

The model changes the way that lecturers and clinical nurses teach students. It changes the way students learn to combine their understanding of medication problems with how to calculate and

measure medication doses. The model shows how to measure student competence in the concrete world of clinical practice and also the iconic world of virtual authentic environments. It challenges the 'chalk and talk' didactic approach to teaching medication dosage calculation skills that has dominated for over 70 years.

**Figure 1: Medication dosage calculation problem-solving (MDC-PS) competence model**




**Sources of medication dosage calculation errors:** Many young people have an incomplete understanding of primary and secondary school mathematics. They have 'dropped stitches' in the fabric of their knowledge and in the absence of 'picking up' the dropped stitch they are highly likely to make *calculation errors* (Weeks et al 2000; 2013b; 2013c). They also make *conceptual errors.* These come from a gap between the teaching of theory and what students experience in practice. Traditional *'chalk and talk'* methods treat students as passive receivers of abstract word based problems, e.g., *prescribed medication Morphine 2mg IM, dispensed medication Morphine 10mg/1mL for injection, what volume of medication is required?* They are taught formulae and equations that separate the calculation of doses from the real world of nursing. Because many students fail to understand medication problems *in real situations* they fail to '*see'* how expert nurses make calculations and solve problems in the real world of nursing.

**Design & evaluation of the authentic *safeMedicate*® environment:** *safeMedicate*® is a virtual computer environment. It uses real world features and expert real world practice to link with the maths used to solve dosage calculation problems and transform care. Healthcare students use a virtual world to bridge the gap between theory and practice. This helps them develop their knowledge and skills without harming real people and reduce errors in practice (Weeks et al 2001; 2013d; 2013e; Sabin et al 2013 & McDonald et al 2013). Weeks et al (2013d) evaluated the relationship between exposing nursing students to traditional teaching methods and *safeMedicate®,* and the development of their dosage calculation skills. Nursing students' calculation skills are statistically significantly different after using the authentic learning environment compared with using traditional 'chalk and talk' methods. Exposing students to authentic learning environments is an essential first step in developing their competence.

McDonald et al (2013) found that 1st year nursing students had a 33% error rate on a *safeMedicate®* numeracy test. This changed after using *safeMedicate®* linked with exposure to clinical practice. All of the students demonstrated 100% cognitive competence in the *safeMedicate®* assessments and 100% functional competence in practice based assessments. Sabin et al (2013) compared the reliability and validity of *safeMedicate®* against a commonly used simulated practice assessment, i.e. an Objective Structured Clinical Exam (OSCE). Outcome

measures showed that *safeMedicate® has* extremely high validity and reliability. The research concluded that assessments which combine a virtual environment and clinical practice are a viable, valid and reliable method for gauging student competence in calculating doses.

**3. References to the research:**

1) Weeks KW, Hutton BM, Coben D, Clochesy JM & Pontin D (2013b) Safety in Numbers 2: Competency modelling and diagnostic error assessment in medication dosage calculation problem-solving. *Nurse Education in Practice 13, Issue 2*, *March 2013*, *Pages e23-e32.*
2) Weeks KW, Clochesy JM & Hutton BM (2013d) Safety in Numbers 4: The relationship between exposure to authentic and didactic environments and nursing students' learning of medication dosage calculation problem solving knowledge and skills. *Nurse Education in Practice 13, Issue 2*, *March 2013*, *Pages e43-e54.*
3) McDonald K, Weeks KW, & Moseley L (2013) Safety in numbers 6: Tracking pre-registration nursing students' cognitive and functional competence development in medication dosage calculation problem-solving: The role of authentic learning and diagnostic assessment environments. *Nurse Education in Practice 13, Issue 2*, *March 2013*, *Pages e66-e77*
4) Weeks KW, Higginson R, Clochesy JM & Coben D (2013e) Safety in Numbers 7: *veni, vidi, duci*: a grounded theory evaluation of nursing students' medication dosage calculation problem-solving schemata construction. *Nurse Education in Practice 13, Issue 2*, *March 2013*, *Pages e78-e87*
5) Weeks KW, Lyne P & Torrance C (2000) Written drug dosage errors made by students: the threat to clinical effectiveness and the need for a new approach. *Clinical Effectiveness in Nursing* 4, 20-29
6) Weeks KW, Lyne P, Moseley L & Torrance C (2001) The strive for clinical effectiveness in medication dosage calculation problem solving skills: the role of constructivist learning theory in the design of a computer based 'Authentic World' learning environment. *Clinical Effectiveness in Nursing* 5, 18-25
**Safety in Numbers Series**: ***NB*** – due to commercial sensitivities USW placed a publication embargo between 2001-2006. Although the papers in this series are dated 2013, they report on the research, knowledge transfer, testing and evaluation of the safeMedicate®, environment carried out in the UK & USA during and following this time.

**4. Details of the impact:**

***Impact 1:*** **Changes to undergraduate nursing curricula in the UK, USA, Canada, Australia, Qatar & Poland and newly registered nurses' ability to calculate medication doses safely and to transform care*:*** More than 60% of UK university nursing departments together with significant numbers of universities in the USA, Canada, Australia, Qatar & Poland have changed their under-graduate nursing curricula. At the time of writing, approximately 145,000 students and practitioners worldwide have used the program. University nursing departments only adopt *safeMedicate®* after a thorough evaluation of the program and the supporting research by senior educators and clinicians who are highly experienced in the field of drug dosage calculation. *safeMedicate®* is funded centrally for pre-registration nursing education in Wales by NHS Wales' National Leadership & Innovation Agency for Healthcare (NLIAH).
**Evidence:** Student attrition on the University of Calgary, Canada, Bachelor of Nursing Accelerated Track (BNAT) has dramatically reduced. The BNAT student math test failure rate fell from 12% to 0% after adopting *safeMedicate®,* into the curriculum in 2009. We anticipate that students will transfer these skills into clinical practice when they become RNs and make less errors.

***Impact 2: Change to UK Nursing Regulator policy, i.e., the UK Nursing Midwifery Council (NMC) essential skills for medication administration:*** The research was reported to the NMC in 2010. They used it to inform the structure of the competence model rubric in the NMC Essential Skills Cluster (ESC) for Medicines Management (NMC 2010a) and the 'Advice and Supporting Information for Implementing NMC Standards for Pre-Registration Nursing Education' (NMC, 2010b). This is a strong example of research directly influencing policy and evidence-based regulation. Since 2012 all UK undergraduate nursing programmes must comply with the policy.

***Impact 3: Change to health care delivery organisation Continuing Professional Development Programme training in the UK, US & Canada and existing nurses' ability to calculate and administer medicines safely:*** An international partnership between *Authentic World Ltd* and USA-based *CAE Healthcare* is distributing *safeMedicate®* across four continents: http://caehealthcare.com/eng/courseware/safeMedicate .

When NHS and private healthcare organisations commit health budget money and adopt *safeMedicate®,* they change their Human Resources training policy and staff development practices. There are over 109,500 registered UK users in more than 60% of UK universities offering nursing programmes and more than 20 NHS organisations who use *safeMedicate®* as part of their staff update training. There are also over 35,500 registered users in more than 65 universities and hospital systems across 6 countries in 4 continents. We anticipate that there are reductions in MDC-PS errors in clinical areas where *safeMedicate®* is used in this way. Current international users of *safeMedicate®* include: University of Calgary, Canada; University South Florida, USA; University of Pittsburgh Medical Centre (UPMC), Shadyside School of Nursing, Pittsburgh, USA; University of Western Sydney, Australia; The Cleveland Clinic, Ohio.

**5. Sources to corroborate the impact:**

***Impact 1) Changes to undergraduate nursing curricula in UK, USA, Canada, Australia, Qatar & Poland and new nurses' ability to calculate doses safely:***

- Contact Director of Clinical Support Solutions, CAE Healthcare USA (by email)
- Contact the Nursing Instructor, University of Pittsburgh Medical Centre (UPMC), Shadyside School of Nursing, Pittsburgh, USA (by email)

***Impact 2)*** **Change to UK Nursing Regulator policy, i.e. the UK Nursing & Midwifery Council (NMC) in the essential skills for medication administration:**

- NMC, (2010a). Essential Skills Clusters and Guidance for their Use (NMC 2010). http://standards.nmc-uk.org/Documents/Annexe3_%20ESCs_16092010.pdf. *(See page 32 for the inclusion of the central premise of the safeMedicate hierarchical MDC-PS assessment rubric and definitions for MDC-PS complexity levels: unit dose, sub and multiple unit dose, SI unit conversion, complex calculations).*
- NMC, (2010b). Advice and Supporting Information for Implementing NMC Standards for Pre registration Nursing Education (NMC 2010). http://standards.nmc-uk.org/PreRegNursing/non-statutory/Documents/Advice%20and%20supporting%20information%20for%20SPNE%20201103 25.PDF *(See pages 60-61 for an acknowledgement of the NHS Education for Scotland programme of research in informing the NMC position on nursing education MDC-PS learning and assessment environment design).*

***Impact 3)*** **Change to health care delivery organisations' continuing professional development programme training in the UK, US & Canada and existing registered nurses' ability to calculate and administer medicines safely:**

- Contact by email the Associate Chief Nursing Officer of Professional Development, Cleveland Clinic Health System (CCHS), Cleveland, Ohio, USA; and see endorsement of *METI eDose®* (previous USA & Canada version of *safeMedicate®*) by The Cleveland Clinic, http://my.clevelandclinic.org/nursing-institute/career-growth-development/our-commitment-to-your-success.aspx .