Institution: University of Salford		
Unit of Assessment: 3		
Title of case study: Diagnosing breast cancer: improving policy and practice		
Period when the underpinning research was undertaken: January 2012 – December 2016		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	**Role(s) (e.g. job title):**	**Period(s) employed by submitting HEI:**
Dr Katy Szczepura	Senior Lecturer/Research Lead in Medical Imaging	May 2007 – Present
Prof. Peter Hogg	Professor in Radiography	January 1993 – August 2020
Period when the claimed impact occurred: August 2013 – December 2020		
Is this case study continued from a case study submitted in 2014? N		

1. Summary of the impact

In the early detection of benign breast conditions and malignant breast disease, mammography is regarded as the gold standard of screening methods. However, the efficacy of the method depends on the production of high-quality mammography images. After identifying inadequate breast compression and a lack of standardised positioning technique, the University of Salford Medical Imaging Research Group (MIRG) subsequently developed and published new standards, which are now embedded within United Kingdom (UK) breast services for approximately 2,000,000 women per annum. This has had a positive effect on clients' experiences, with a reduction in pain levels during mammography and improvements in detecting benign and malignant disease. The research has also led providers outside of the UK (Norway, Netherlands) to update their practice and policy, resulting in standardisation of approach and improved client experiences for another 500,000 women. Additionally, Volpara Health Technologies (New Zealand) has developed a commercial application from MIRG research that improves practice: this software is sold in 38 countries, improving the experience and outcome for 10,000,000 women globally.

2. Underpinning research

Since 2012, the Medical Imaging Research Group (MIRG) led by Szczepura and Hogg has assessed viable and effective positioning methods and compression standards for mammography.

Among the first and most detailed studies of positioning and breast compression within Europe, these outputs **[3.1 – 3.6]** provided key insights and new standards for women attending breast services. MIRG focussed on two specific areas within this non-standardised approach in clinical practice: i) compression force and ii) positioning technique. These were the first comprehensive studies providing key insights into the issues surrounding compression and positioning variability. As detailed below, research outputs demonstrate how the combination of underpinning expertise, with extensive empirical research, has improved clinical practice through the implementation of new standards and education. As further evidence of Salford's contribution to the field, Hogg co-edited the first 'Holistic Approach to Mammography' textbook in 2015 **[3.7]**.

i) Standards for applied compression force

The amount of compression force applied to the breast is dependent upon the mammographer. This has a direct impact on client experience in terms of pain the client experiences during compression as well as image quality. MIRG discovered variability in applied compression force within one screening centre in the NHS and the impact of this force on the resultant breast thickness **[3.1, 3.2, 3.3]**, leading to a reduction in the radiation dose to the client. In 2015, the team conducted a multicentre study demonstrating the same variability in applied compression force by practitioners across NHS Screening Centres **[3.4]**. This revealed that clients had different amounts of compression force applied from one screening event to another, leading to variability in image quality and client experience (pain levels) between screening examinations. Szczepura and Hogg proposed new compression force standards of 9-14daN **[3.3]** where previous guidelines recommended a range 'up to 18daN'. The new standards were disseminated through a textbook **[3.7]** together with training and education seminars and conferences.

ii) Standards for positioning

Szczepura and Hogg identified that the amount of visible breast tissue on the mammogram was dependent on the mammographer who produced the image. They developed a method to improve breast position in one of the mammography projections **[3.5, 3.6]** resulting in a significantly larger surface of breast tissue on the resultant image. In addition, reducing 'pressure points' resulted in a greater volume of visible breast tissue and a subsequent reduction in client breast pain. The research team developed and introduced these new standards and disseminated them through a textbook **[3.7]** together with training and education seminars and conferences.

Both research streams culminated in research-informed educational resources and guidelines being developed for mammographers in relation to positioning and compression force standards **[3.7]**.

3. References to the research

3.1. Hauge, I.H.R., **Hogg, P.**, **Szczepura, K.**, Connolly, P., McGill, G., Mercer, C. (2012) The readout thickness versus the measured thickness for a range of screen film mammography and full-field digital mammography units, *Medical Physics*, 39(1), pp. 263-271. https://doi.org/10.1118/1.3663579 (1)

3.2. Mercer, C.E., **Hogg, P.**, Lawson, R., Diffey, J. and Denton, E.R.E. (2013). Practitioner compression force variability in mammography: a preliminary study, *The British Journal of Radiology*, 86(1022), p. 20110596. https://doi.org/10.1259/bjr.20110596 (1)

3.3. Hogg, P., Taylor, M., **Szczepura, K.**, Mercer, C. and Denton, E. (2013). Pressure and breast thickness in mammography - an exploratory calibration study, *The British journal of Radiology*, 86(1021), p. 20120222. https://doi.org/10.1259/bjr.20120222 (1)

3.4. Mercer, C.E., **Szczepura, K.**, Kelly, J., Millington, S.R., Denton, E.R.E., Borgen, R., Hilton, B., **Hogg, P.** (2015). A 6-year study of mammographic compression force: Practitioner variability within and between screening sites, *Radiography*, 21(1), pp. 68-73. https://doi.org/10.1016/j.radi.2014.07.004 (2) **(REF2)**

3.5. Hogg, P., **Szczepura, K.**, Darlington, A. and Maxwell, A. (2013) A method to measure paddle and detector pressures and footprints in mammography, *Medical Physics*, 40(4) p. 041907. https://doi.org/10.1118/1.4792720 (1)

3.6. Smith, H., **Szczepura, K.**, Mercer, C., Maxwell, A. and **Hogg, P.** (2015). Does elevating image receptor increase breast receptor footprint and improve pressure balance? *Radiography*, 21(4), pp. 359-363. https://doi.org/10.1016/j.radi.2015.02.001 (2)

3.7. Hogg, P., Kelly, J. and Mercer, C. (2015). Digital Mammography. A Holistic Approach, Springer International Publishing. ISBN: 978-3-319-04830-7. https://doi.org/10.1007/978-3-319-04831-4

(1) Double anonymised review process, with multidisciplinary, international representation on the editorial board.
(2) Double anonymised review process, with international representation on the editorial board.

4. Details of the impact

In the UK more than 2,000,000 women undergo mammography screening each year. Breast positioning and compression define the quality of those mammography images, with a direct correlation to the diagnosis of benign and malignant breast disease. When poor image quality is recognised, a new image is required either prior to reporting (a technical repeat), or after image reporting (which requires a technical recall back to the service). Currently between 2% and 3% of women attending the NHS Breast Screening Programme (NHSBSP) require technical repeats/recalls, equating to between 41,000 and 62,000 women (UK) per annum. In addition, between 47,000 and 87,000 women (UK) do not attend their next screening appointment, 3 years later, due to the pain they experienced from compression on their previous mammogram. This highlights the importance of getting it right at the first opportunity, by applying a consistent and repeatable technique that minimises pain to the client. Through extensive research and the implementation of standards following that research, work by MIRG **[3.1 – 3.7]** instigated changes in the following areas:

1. **Policy/guidance:**
    - development and implementation of new UK mammographic guidelines
    - implementation of new national guidelines in Norway
    - removal of flexible paddles in the Netherlands
2. **Practice:**
    - change to mammographic practice in the UK
    - change to mammographic practice in Norway
    - service improvements to image quality
3. **Service user experience:**
    - improvement in breast cancer detection rates and patient experience
4. **Commercial activity:**
    - support for development of software (Volpara Health Technologies, New Zealand)

4.1. Shaping policy and guidance in the UK and Europe

- MIRG research and new guidelines illustrated within the mammography textbook **[3.7]** have been an *'important catalyst for change in clinical departments nationally and internationally'* **[5.1]**. Implementation of these new guidelines proposed from Salford's research **[3.1]** has changed clinical practice, with services confirming that *'approximately **77% of practitioners conducting breast screening have adopted methods** suggested in [MIRG research]'* which impacts **approximately 1,500,000 people [5.2]**. These new techniques are related to an **improvement in image quality without technical variations [5.3]**, with one service (North Lancashire & South Cumbria Breast Service) reporting ***'an increase in cancer detection rates'*** due to the change in guidance that was introduced in 2017 **[5.2]**.

- As a result of Salford's research **[3.2]**, in 2014 BreastScreen Norway undertook a cross-sectional study of approximately 18,000 breast screening women, which confirmed Salford's findings **[5.4]**. This has subsequently led to the **national guidelines in Norway being updated to include compression force levels**, making explicit recommendations about where higher and lower compression force values should be used within practice **[5.4]**. As the Head of BreastScreen Norway confirmed in 2019: *'The outcome of this is that the **average amount of compression force used in Norway has reduced**, compared to three years ago'* **[5.4]**.

- Prompted by MIRG research on breast thickness variations **[3.1]**, a nationwide analysis was conducted by the Dutch Expert Centre for Screening in the Netherlands, published online in December 2014, revealing uncertainties and problems with use of the Hologic flexible breast compression paddle **[5.5]**. This subsequently led to a **change in policy** in 2015, which has seen the **removal of this flexible compression paddle from mammography breast screening centres across the Netherlands [5.5]**, benefitting approximately **230,000 clients per annum.**

4.2. Driving change in mammographic practice in the UK and Europe

- Adoption of new policy and guidelines has effected change in UK practice, which has cascaded through the revised educational training for all new trainees in the UK, with **over 150 apprenticeships and mammographers per annum**. A key informant survey from the three nations of Great Britain revealed that the academic textbook **[3.7]** is being used **within all academic mammography institutions** as a reference in practice. Respondents in clinical practice confirmed that the book influenced their mammography technique and patient positioning: '*This book is valuable, and we use it a lot. We use it to help educate our practitioners and it is also used as a reference text within breast screening centres, country-wide'* **[5.1]**. According to one UK Consultant Radiographer, whose service (screening between 30,000 and 40,000 women per annum) adopted Salford's standardised imaged technique for positioning and compression rates in 2017, this has *'led to a **reduction in our technical recall rate** which ultimately led to a **reduction in anxiety for the patient** who didn't need to be called back. Since then our **technical recall and repeat rates are now within the national standards**'* **[5.2]**.

- Adaptation of new policy and guidelines in Norway has led to a change in practice, with the Head of BreastScreen Norway confirming that the textbook **[3.7]** is *'**used as a reference text within Norwegian breast screening centres**'* and that *'compression force variability […] is now legitimate because it is related to the individual women and not to individual preferences of radiographers'* **[5.4]**. This has **improved outcomes for the 310,000 clients who use the service each year.**

- A change in practice in the Netherlands resulted in the **extraction of flexible paddles** from the Dutch National Breast Screening Service and **service improvements to image quality [5.5],** with former Head of the Dutch Expert Centre for Screening confirming in 2019 that by implementing MIRG research **[3.1]** the goal was to *'…increase the amount of tissue imaged in that region, to improve breast cancer detection'* **[5.5]**.

4.3. Improving user experience

- Adopting the new positioning and compression techniques based on Salford's research is having an immediate positive impact on the client. Research has resulted in an **improvement in image quality for up to 2,000,000 women in UK screening programmes [5.1, 5.2, 5.3]**. Images also contain *'more breast tissue'* **[5.3]** at higher quality, leading to improved diagnostic capability with *'**higher cancer detection rates**'* **[5.3]**. This in turn **reduces the need for as many repeat images**, while allowing for a **more consistent client experience**, with the head of a national breast screening service in the UK confirming: *'We now take a holistic approach to imaging women, and because of this I believe firmly that a better service is now offered to women in the breast screening programme'* **[5.1]**. Fewer clients are recalled as technical repeats, because *'Following [University of Salford] research [...] we reduced blurring. This resulted in less women being recalled from home as "technical recalls", thereby improving the experience of our clients'* **[5.1]**.

4.4. Supporting software development in the global marketplace

- These changes have resulted in positive impacts for small companies, their customers and stakeholders. For example, based on Salford's research **[3.2]**, Volpara Health Technologies in New Zealand introduced a new version of its software which produces metrics based upon image acquisition parameters to facilitate improvements in practitioner technique, with a direct association to the quality of the client's image and experience. As of November 2019 Volpara's software has been installed in **38 countries**, **benefitting approximately 10,000,000 clients [5.6]**. The company's Chief Executive Officer (CEO) reported MIRG research on compression force variability **[3.2]** as a driver for their software development, confirming the *'direct relationship between the research published by the University of Salford and the further development of our software'* **[5.6]**. This helped the company to market its software by *'explain[ing] what good compression might look like across the world'* **[5.6]**. The CEO confirmed that sales in their United States (US) market alone were *'having* ***dramatic effects on the breast cancer diagnosis clinics in the US****',* with Volpara's product installed in *'approximately 25% of the mammography breast screening centres'* **[5.6]** and stating that: *'Many of those US sites are now seeing* ***improved consistency in breast compression and positioning*** *because of our software'* **[5.6]**. By identifying image problems at the time of image acquisition, Volpara's product is therefore reducing the number of women recalled for repeat mammograms.

5. Sources to corroborate the impact

5.1. Report: Assessing the Impact of *Digital Mammography: A Holistic Approach* Textbook, Research Inc. (March 2020), on new guidelines as a catalyst for change in clinical departments (4.1), use of Salford's textbook to educate practitioners (4.2) and improvement in image quality and more consistent client experience (4.3)
5.2. Report: Detector Positioning Relative to the Infra-mammary Fold: An Assessment of the Impact of Work by the University of Salford, Research Inc. (May 2020), on implementation of the guidelines in the UK (4.1), technical recall and repeat rates being within the national standards (4.2) and improvement in image quality (4.3)
5.3. Video Testimonials: University Hospitals of Morecambe and Countess of Chester Hospital (December 2019), on the improvement in image quality (4.1) and more consistent client experience (4.3)
5.4. Testimonial: BreastScreen Norway (November 2019), on the update to national guidelines around compression force levels (4.1) and use of Salford's textbook as a reference text in Norwegian breast screening centres (4.2)
5.5. Testimonial: Dutch Expert Centre for Screening, Sigma Screening B.V. (December 2019), on the change of policy to remove a flexible compression paddle (4.1) and improved image quality in practice as a result (4.2)
5.6. Testimonial: Volpara Health Technologies (November 2019), on the impact of Salford's research on product development, sales and breast cancer diagnosis in the US (4.4)