

Research Title

Risks and benefits to Radiographers working beyond standard hours in healthcare provision

Author

Jason Elliott, Clinical and Academic Lecturer in Diagnostic Radiography & Imaging, School of Healthcare Sciences, Cardiff University

This PhD Study is in Progress (2022-2026)

Background

The nature of healthcare work involves working outside of the normal day-night routine, to meet round-the-clock patient care demands (NHS Employers 2018). In 2020, there were 37,000 diagnostic radiographers registered in the UK with the Health and Care Professions Council (HCPC) (HCPC, 2020). Diagnostic radiographers have a very specific set of tasks and skills (Harvey-Lloyd 2018), some overlapping with other healthcare professionals in terms of patient care skills and technical knowledge (HCPC 2018). However, a large proportion of the work involves uniquely undertaking imaging with ionising radiation (IRMER 2017), therefore is subject to multiple safety procedures and checks (Harvey Lloyd 2018). This is required around the clock to manage demand for emergency imaging (Ooi et al 2021). If working hours include or are primarily in the evenings and at night, while the circadian and homeostatic brain systems are promoting sleep (Richardson 2013), it can lead to the natural circadian rhythm being disrupted – impairing alertness and disturbing subsequent sleeping routines (Akerstedt and Wright 2009).

Within the NHS Diagnostic radiographers often work outside of the normal working day (Working Time Regulations 1998) to provide the service across the 24 hour period (Department of Health, 2012). This is often a mixed pattern of shifts that overlap, some of which may fall outside of the Working Time Regulations (1998) either due to participation in multiple rota systems or balancing mix of skills (Hawke 2011) and to manage a national vacancy rate of 10.5% in the workforce (Society and College of Radiographers 2021). This has been exacerbated by an increased demand for diagnostic imaging (Singh et al 2017) without an increase in capacity via extra equipment and mix of staff skills (Richards et al 2020) and the COVID19 pandemic (Akudjedu et al 2020, Commons Select Committee 2021). This leads to an existing workforce with stretched resources, rather than being enhanced and empowered (Department of Health 2017) to meet demand and avoid adverse outcomes related to delayed diagnosis (Parliamentary and Health Ombudsman 2021).

The corresponding fatigue and associated symptoms that radiographers may be experiencing (Drake et al 2004, Raj et al 2006) have been termed Shift Work Disorder in other workers, particularly nurses (Asaoka et al 2013). This effect has been shown to increase when patterns are disrupted to allow less than eleven hours rest in between shifts (Eldevik et al, 2013). This leaves them prone to sickness absence (Singh et al 2017), low motivation and potential errors when compared to failure rates in other similar professions such as nursing (Elliott & Williamson 2019). Patients (and staff) are subsequently at risk of consequence due to health hazards from ionising radiation or extremely strong magnetic fields (IRMER 2017). The Health and Safety at Work Act (1974) should limit this, but lack of understanding and awareness (Bishop & Elliott 2019) means this is often not adhered to and further increases the likelihood of fatigue (Akerstedt & Wright 2009). Additional exploration of varying shift patterns has been undertaken in research to observe efficiency and consequence (Hawke 2011, Ooi et al 2021) without addressing the effects on staff wellbeing. Nightingale et al (2021) identify the working patterns in radiography as a major factor in staff retention, but do not explore the effects of this on the individual practitioner's fatigue levels or wellbeing.

While shift work related fatigue has been attributed to major industrial accidents (Harrington 2001) and aviation related incidents (Bendak & Rashid 2020), safety measures relating to work hours are often routinely applied (Gabriel et al 2018, Holley Sundaram and Wood 2003) – but this is not routine in healthcare. Shift work fatigue is more prevalent in out-of-hours work for healthcare professionals (Hanecke et al 1998). The suggestion of “attentional failures” in medical professionals is double in junior doctors with unrestricted working practice (Lockley et al 2004) with fatigue impairing function and cognition (Papp et al 2004) cited as a major factor. Routine difficult tasks become more erroneous (Hughes and Rogers 2004) due to fatigue in cognition, or “decision fatigue” (Reiner & Krupinski 2012). In human factors reviews of medical imaging error (Lacson et al 2019) most errors were found in communication or practice – relating to procedural error such as those safety checks described previously (IRMER 2017). There is no additional information available pertaining to radiographers as a professional group (Elliott & Williamson 2019) despite evidence from other health care professional groups (Suzuki et al 2004, Barker & Nussbaum 2010, Chang et al 2011). This work is arguably transferable to radiographers due to equivalent professional registration, range of care and technical skills including cannulation (Lo et al 2011), and expectation of round-the-clock service delivery. Additional scoping studies (Bishop & Elliott 2019, Amin & Elliott 2021) show some limited evidence of detrimental health effects on radiographers more generally due to shift patterns. There remains a lack of investigation into radiographer wellbeing and fatigue due to these demands on the current resource and structure.

Study Objectives

To identify the primary factors contributing to the complex working environment for radiographers relating to a 24 hour service delivery, and identify effects on wellbeing and safety

Defining the factors that make radiology a complex working environment as demand and resource

Investigating the associated effects of shift work on wellbeing and fatigue in radiographers

Correlating adverse event data

Methodology

The Job-Demands-Resources (JDR) theory is useful in predicting and defining levels of burnout and performance particularly in healthcare (Bakker & Demerouti 2004; Demerouti & Bakker 2011). This can be applied to study of the radiographer population as in other healthcare professions (Schaufeli 2017, Tomo & De Simone 2019). In the JDR model, the investigation of workload, shift prevalence and pressure can investigate strain levels from demand (Schaufeli & Toons 2014) and the moderation of job resources (that is, staff and skills mix within the shiftwork pattern adding to compensatory rest) can demonstrate burnout and engagement/performance levels – critical to the safe and effective care of service users (Harvey-Lloyd 2018).

The study is overall a mixed methods study, with an explanatory sequential format (Polgar & Thomas 2004): the quantitative questionnaire preceding semi-structured qualitative interviews. The JDR theory framework (Bakker & Demerouti 2004) will be applied to investigate the demand and resource situation on employee wellbeing; with the qualitative element explaining and triangulating results from the quantitative data (Locke & Lees 2021)

Setting & Population

All UK radiographers would be invited to participate in the questionnaire via social media and the Society & College of Radiographers, so the study would be representative of a broad sample of diagnostic radiographers across the country.

The participants would be included if they undertake shiftwork or participate in out of hours rotas.

The selection of participants chosen for the qualitative study would be random from questionnaire participants who indicate willingness to be interviewed, allowing for a broad cross-demographic approach - as to maintain a representative view of the UK radiography population.

1. Literature review into Diagnostic Radiography as a complex environment – working patterns, staffing levels, skills & tasks, parallel overlapping rota systems, workload and variation between centres. Review of other wellbeing research in other healthcare roles that pertains to JDR theory by defining the job demands (workloads and structure) and resources (staffing, shift patterns to meet demand)

Additional investigation into error prevalence in via information from Health Inspectorate Wales, Care Quality Commission and NHS Resolution; reviewed in relation to aviation and industrial incidents.

2. UK Wide questionnaire survey on shift patterns, stress, fatigue and wellbeing

All radiographers across the UK will be invited to take part through professional body and social media. Participant Information would be provided on the electronic survey, and consent obtained before admission to the study. A simple power calculation puts required sample size over 381 participants. Additionally, participants would indicate whether they would be willing to be contacted to participate in the qualitative element of the research.

Staff would identify their age, experience, level participation in mixed shift patterns and/or out-of-hours work so that comparisons can be made and form a discussion over the demands, resources and subsequent impact of shift work.

Questions related to Demand and Resource availability using the Job Demands and Resource Scale (Jackson & Rothmann 2005), perceived fatigue levels using the Oldenburg Burnout Inventory (Demerouti & Bakker 2008), and overall wellbeing via the Warwick Edinburgh Mental Wellbeing Scale (Tennant et al 2007).

3. Qualitative study into fatigue in radiographers, Semi-structured interviews of selected questionnaire participants.

A selection of around 40 participants in stage 2, 10% of the proposed questionnaire sample size, would be invited to interview. This would allow participants an opportunity to discuss further their answers in context of personal experiences and impacts on their health.

Following consent, a semi-structured interview would be conducted, exploring the

participants individual situation and discuss the impact to them as a result of their working patterns – including coping mechanisms, symptoms of fatigue. The interview would be recorded, transcribed and its accuracy agreed with the participant prior to inclusion in thematic analysis.

Data Analysis - Questionnaire

Descriptive graphics for presentation of general trends and results information, box plots and confidence intervals for wellbeing scores dependent on location/shift pattern frequency, comparison of personal coping mechanisms.

Comparative analysis between shift/non-shift groups and analysis of variance based on experience, overall working hours on average, type of working environment. Potential causal analysis can be undertaken on:

- demand and resource values from the JDRS
- OBI scores
- WEMWBS scores

using a multiple linear regression model such as least squares. Statistical significance of any calculable results using ANOVA or suitable alternative.

Data analysis – qualitative

All interviews would be transcribed, and then subsequently approved by the interviewee prior to analysis. NVivo software would be used to assist in the analysis process.

Braun & Clarke's (2006) thematic analysis would be undertaken, using the following principles:

1. Data familiarisation and immersion
2. Investigation of interesting features and themes, application of initial coding
3. Collating further responses into codes and application across the transcript
4. Review of themes and information, further investigation and correlation
5. Themes finally defined and report of overall results generated

References

- Akerstedt T, Wright KP, 2009; Sleep Loss and Fatigue in Shift Work Disorder. *Sleep Med Clin*, 2009 Jun, 1(4), 257-71.
- Akudjedu T, Lawal O, Sharma M, Elliott J et al 2020; Impact of the COVID-19 pandemic on radiography practice: findings from a UK radiography workforce survey. *BJR Open*, 2020, 2(1), 20200023.
- Amin NO, Elliott J, 2020; Effect of Shift Work on Personal Health and Service Quality Among Radiographers in the Western Province of the KSA: A Quantitative Study. MSc Dissertation, Cardiff University
- Asaoka S, Aritake S, Komada Y et al, 2013; Factors associated with shift work disorder in nurses working with rapid-rotation schedules in Japan: the nurses' sleep health project. *Chronobiol Int*, 2013 May, 30(4); 628-36.
- Bakker AB, Demerouti E, 2004; Using the job demands-resources model to predict burnout and performance. *Human Resource Management*, 2004 Apr, 43(1), 83-104.
- Barker LM, Nussbaum MA, 2010; Fatigue, Performance and the Work Environment: a survey of registered nurses. *Journal of Advanced Nursing*, 2010, 67(6), 1370-1382.
- Bendak S, Rashid HSJ, 2018; Fatigue in aviation: a systematic review of the literature. *International Journal of Industrial Ergonomics*; 2020 March, 76, 102928.
- Bishop A, Elliott J, Floyd M 2019; What are the effects of night work on radiographers working in the south of Wales? BSc Dissertation, Cardiff University
- Braun V, Clarke V, 2006; Using Thematic Analysis in Psychology. *Qualitative Research in Psychology*, 2006, 2, 77-101.
- Chang YS, Wu YH, Chung YH et al, 2004; Impairment of perceptual and motor abilities at the end of a night shift is greater in nurses working fast rotating shifts. *Sleep Medicine*, 2004, 12, 866-869.
- Chernoff P, Adeokun C, O'Sullivan I et al, 2018; Burnout in the Emergency Department hospital staff at Cork University Hospital. *Irish Journal of Medical Science*, 2018 Jul, 188, 667-74.
- Commons Select Committee, 2021; Coronavirus: Lessons Learned To date. London, House of Commons.
- Demerouti E, Bakker AB, 2008; The Oldenburg Burnout Inventory: A Good Alternative to Measure Burnout and Engagement. *Handbook of Stress and Burnout in Healthcare*, 65-78.
- Department of Health, 2012; Implementing 7 Day working in Imaging Departments: Good Practice Guidance A Report from the National Imaging Clinical Advisory Group. London, Department of Health.
- Department of Health, 2017; NHS National Staff Survey [online]. Accessed via <http://www.nhsstaffsurveys.com/Page/1010/Home/NHS-Staff-Survey-2015/>

- Drake CL, Roberts T, Richardson G et al, 2004; Shift Work Disorder: Prevalence and Consequences Beyond that of Symptomatic Day Workers. *Sleep*, December 2004, 27(8), 1453-62.
- Eldevik MF, Flo E, Moen E et al, 2013; Insomnia, excessive sleepiness, excessive fatigue, anxiety, depression and shift work disorder in nurses having less than 11 hours in-between shifts. *PLoS One* 2013 Aug, 15(8), e70882.
- EFRS, 2019; Patient safety in medical imaging: A joint paper of the European Society of Radiology (ESR) and the European Federation of Radiographer Societies (EFRS). *Radiography*, 2019 May, 25(2), E26-38.
- Elliott J, Williamson K 2019; The radiology impact of Healthcare errors during shiftwork. *Radiography*, 2020 Aug; 26(3); 248-53.
- Gabriel J, 2018; Industrial Fatigue: A Workman's Great Enemy. *IOSR Journal of Business and Management*; 2018 Oct, 20(10), 9-14.
- Hanecke K, Tiedemann S, Nachreiner F et al, 1998; Accident risk as a function of hour at work and time of day as determined from accident data and exposure models for the German working population. *Scand J Work Environ Health* 1998, 24(3), 43-48.
- Harvey-Lloyd JM, 2018; Being and Becoming a Diagnostic Radiographer. PhD Thesis, University of Brighton.
- Hawke FA, 2011; Development of a work pattern model to meet the changing service requirements with respect to patient and staff needs in Scottish radiology departments. PhD Thesis, Glasgow Caledonian University.
- Health And Safety At Work Act, 1974.
- Health and Care Professions Council, 2014; Standards of Performance, Conduct and Ethics: Radiographers. London, Health and Care Professions Council.
- Holley DC, Sundaram B, Wood DK 2003; Shift work and Aviation safety. *Clinics in Occupational and Environmental Medicine*, 2003 May, 3(2); 231-62.
- Hughes RG, Rogers AE, 2004; First, Do No Harm: Are you Tired? *AJN*, 2004 March, 104(3), 36-38.
- Ionising Radiation (Medical Exposure) Regulations, 2017.
- Jackson, L.T.B. & Rothmann, S. (2005). Work-related well-being of educators in a district of the North West Province. *Perspectives in Education*, 23, 107-122
- Lacson R, Cochon L, Ip I et al, 2019; Classifying Safety Events Related to Diagnostic Imaging From a Safety Reporting System Using a Human Factors Framework. *Journal of the American College of Radiology*, 2019 March; 16(3), 282-8.
- Lo WY, Chiou ST, Huang N et al, 2016; Long work hours and chronic insomnia are associated with needlestick and sharps injuries in hospital nurses in Taiwan: A National Survey. *International Journal of Nursing Studies*, 2016, 64, 130-136.

- Locke R, Lees A, 2021. Mixed Methods Research in Wellbeing And Health. London, Routledge.
- Lockley SW, Cronin JW, Evans EE et al, 2004; Effect of reducing interns' weekly work hours on sleep and attentional failures. *N Engl J Med*, 2004 Oct 28, 351(18), 1829-37.
- Martin CJ, Vassileva J, Vano E et al, 2017; Unintended and accidental medical radiation exposures in radiology: guidelines on investigation and prevention. *Journal of Radiological Protection*; 2017 Oct, 37(4), 883.
- NHS Employers, 2008; Terms And Conditions of Service (Agenda For Change) Handbook (online) available from <https://www.nhsemployers.org/sites/default/files/2021-06/TCS-handbook-version-280208.pdf>
- NHS Resolution, 2021; Claims made to NHS Radiology (online) available from <https://resolution.nhs.uk/foi-disclosure-log/radiology/> (accessed 19/10/2021)
- Nielsen HB, Dyreborg J, Hansen AM et al, 2019; Shift work and risk of occupational, transport and leisure-time injury. A register-based case-crossover study of Danish hospital workers. *Safety Science*, 2019 Dec, 120, 728-34.
- Nightingale J, Burton J, Appleyard R et al, 2021; Retention of radiographers: A qualitative exploration of factors influencing decisions to leave or remain within the NHS. *Radiography*, 2021 Aug, 27(3), 795-802.
- Ooi JWL, Er ATW, Lee WC et al 2021; The 12-hour shift: radiographers' perspectives and its applicability during a pandemic. *Radiography*, 2021 May. 27(2), 512-8.
- Papp KK, Stoller EP, Sage P et al, 2004; The effects of sleep loss and fatigue on resident-physicians; a multi-institutional, mixed-method study. *Acad Med*, 2004 May, 79(5), 394-406.
- Parliamentary and Health Ombudsman, 2021; Unlocking Solutions in Imaging: Working together to learn from failings in the NHS [online] available from gov.uk/official-documents
- Pereira JM, Silva C, Freitas D, 2021; Burnout among Portuguese radiographers during the COVID19 pandemic [online]. Accessed via <https://pubmed.ncbi.nlm.nih.gov/34053854/>
- Polgar S, Thomas SA, 2008; Introduction to Research in the Health Sciences, 5th edition. Philadelphia, Elsevier Churchill Livingstone.
- Raj VV, 2006; Occupational Stress and Radiography. *Journal of Radiologic Technology*; 2006 Nov, 78(2), 113-22.
- Reiner BI, Krupinski E, 2012; The insidious problem of fatigue in medical imaging practice. *Journal of Digital Imaging*, 2012 Feb, 25(1), 3-6.
- Richards M, 2020; Diagnostics: Recovery and Renewal. NHS England.
- Schaufeli WB, 2017; Applying the Jobs Demands Resources (JDR) Model: A 'how to' guide to measuring and tackling work engagement and burnout.
- Schaufeli WB, Tarls TW 2014; A Critical Review of the Jobs Demands Resources (JDR) Model: Implications for Improving Work and Health. In: Bauer GF, Hanning O (ed) Bridging

Occupational, Organisational and Public Health: A Transdisciplinary Approach. Dordrecht, Springer.

- Singh N, Knight K, Wright C et al, 2017; Occupational burnout among radiographers, sonographers and radiologists in Australia and New Zealand: Findings from a national survey. *J Med Imaging Radiat Oncol*; 2017 Jun, 61(3), 304-10.
- Society and College of Radiographers, 2021. CoR Diagnostic Radiography Workforce Census 2020 Report. London, Society and College of Radiographers.
- Suzuki K, Ohida K, Keneita Y et al, 2004; Mental Health Status, Shift Work, and Occupational Accidents among Hospital Nurses in Japan. *J Occup Health* 2004, 46, 448-454.
- Tennant R, Hiller L, Fishwick R et al, 2007; The Warwick Edinburgh Mental Wellbeing Scale (WEMWBS). *Health and Quality of Life Outcomes*, 2007 Sep, 63.
- Terrell SR 2012; Mixed-Methods Research Methodologies. *The Qualitative Report*; 17(1), 254-80.
- Tomo A, De Simone S, 2019; Using the Jobs Demands Resources (JDR) approach to assess employee Wellbeing in Healthcare. *Health Services Management research*, 2019, 32(2), 58-68.
- Working Time Regulations, 1998.