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A preliminary ergonomic analysis of the MRI work system environment: Implications and recommendations for safety and design

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ABSTRACT

Introduction: The MRI work system environment in acute hospitals poses a significant risk of harm to patients, healthcare practitioners and others, but knowledge of hazards and potential design improvements are limited as safety research is lacking. The aim of this exploratory study was to understand how the discipline of Human Factors and Ergonomics (HFE) can support the understanding and improvement of safety and performance of MRI working environments.
Methods: A multi-method study of two MRI units in Scottish acute hospital settings based on Human Factors and Ergonomics (HFE) principles was undertaken in May 2016. Data collection sources included published literature, local and national safety incident data, site observations and staff interviews which were triangulated and subject to a content analysis.
Results: A diverse range of system-wide hazards were highlighted which impact on the complexity of MRI work, patient and staff safety and system performance (e.g. adequacy of training and procedures, interactions with equipment, organisation of work). Preliminary recommendations were made to improve system design related to national approaches to safety (e.g. equipment procurement; staff training and procedural standards); interaction design and standardisation (e.g. physical design and barriers, staff uniforms, checking processes); and introduction of MRI passports for patients.
Conclusions: This exploratory study suggests the need for national co-ordination and standardisation of MRI safety management strategies, based on safety science and HFE evidence and approaches to improve system design and reduce risk to patients, staff and others. A series of provisional recommendations are offered for consideration.

Introduction

The use of Magnetic Resonance Imagining (MRI) equipment is widely established as a clinically important requirement for modern hospital medical imaging departments to inform patient diagnoses, management and treatment.[1] However, as a continually evolving technology the full risks associated with the MRI working environment of high relevance to patients and staff are not fully understood, indicating limited consideration of potential impacts from a work system design perspective.

The risks associated with the MRI working environment should be managed to reduce these to *As Low As Reasonably Practicable* – ALARP.[2,3] To judge what is reasonable requires an understanding of the scale of the problem, the nature of system hazards and the risks (the likelihood and severity of consequences related to identified hazards) to organisational performance and human wellbeing. However, this is problematic given the lack of related research to inform design solutions for improving MRI work system resilience and the welfare of people interacting with this technology.[4]

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The safety of the MRI working environment requires continual management and actions by healthcare practitioners to avoid harm to patients, staff and visitors. In the United Kingdom (UK), national recommendations and standards are disseminated by the Medicines and Healthcare Products Regulatory Agency (MHRA) to aid this process, which also requires the knowledge of multiple other procedures, guidelines and standards.[5,6] In summary this outlines the safety issues associated with exposure to strong magnetic fields, defined under four categories: biological effects; burns and hearing damage; projectile effects; compatibility of implantable medical devices; and compatibility of peripheral equipment. Further guidance is also available for informing the build requirements for local MRI facilities and for healthcare practitioners and scientists (e.g. Radiographers and Physicists) responsible for informing the usability and safety of diagnostic imaging facilities.[7–9]

The main risks of MRI interactions are associated with the exposure to the radiofrequency transmitter field and static strong magnetic field. These include biological harm, ferrous magnetic materials as projectile hazards, compatibility of implantable medical devices and peripheral equipment.[5] The risks of radiofrequency exposure are better understood and limits for safe patient exposure are established but this is not the focus of this research.[10] The exposure to the magnetic static field is less well understood. Precautions relating to this risk focus on avoiding ferrous magnetic materials within the field of the magnet, however legislation does not exist by which to judge the level of compliance and safety provided by individual imaging units.

The goal of this exploratory study was to apply a Human Factors and Ergonomics (HFE) perspective. Human Factors (also known as Ergonomics) considers the interaction between people and the systems they work or exist within. The term 'system' may refer to a working environment, building, technical artefact, organisation, team or society.[11,12] This approach will inform the current work to understand the context of the MRI work environment, highlight existing hazards and suggests how HFE principles can inform existing approaches to safety management of the expected and unexpected.[13–15] We aimed, therefore, to:

- Identify system-wide hazards related to the MRI clinical work environment that impact on the health and safety of people and system performance.
- Offer preliminary examples of system-wide design recommendations for improving MRI safety performance and protecting peoples' wellbeing.

Methods

Study design

A multi-method, ethnographic approach to data collection, analyses and triangulation was undertaken. Study design and data analysis were informed by the Safety Engineering Initiative for Patient Safety (SEIPS) model,[12] which represents a flexible approach to understanding and improving healthcare work system design based on HFE principles.

Data collection

Search of healthcare literature and safety guidance

To identify previously published MRI-related system hazards and risks, a comprehensive literature search was completed.

MRI site visit observations and staff interviews

A chartered ergonomist and human factors specialist (LP) conducted MRI site visits to two Scottish acute hospital settings (A and B) during May 2016. Methods were guided by the SEIPS model and included ethnographic observations over two days (9-h in total), and opportunistic interviews with convenience samples of relevant staff ($n = 11$): Superintendent Radiographers ($n = 2$), Radiographers ($n = 4$), Student Radiographer ($n = 1$), Radiology Department Assistant ($n = 1$), Consultant Radiologists ($n = 2$) and Consultant Anaesthetist ($n = 1$).

Data triangulation, analysis and presentation

All data were triangulated[16] by LP and a content analysis was undertaken using a deductive approach.[17] To enhance validity, the analysis was independently cross-checked by PB (Chartered Ergonomist/Patient Safety Scientist) and BN (Superintendent Radiographer). All authors met to discuss the findings and agree tentative recommendations based on combined knowledge of the MRI working environment and HFE design principles. Disagreements were resolved by gaining consensus on which data elements and interpretations fitted with each component of the SEIPS model. The study findings are presented categorically in line with the SEIPS model components.

Results

The following interacting system issues were highlighted:

Safety incident data

International evidence is summarised (Table 1), which highlights a range of system-wide MRI related incidents and hazards that are known to impact on patient and staff safety and have implications for overall system performance.

External environment

The social expectation, clinical preferences and national demand for MRI scanning contributes to workload and time pressure. National safety standards or regulations to ensure safety goals are protected in the context of increasing demand do not appear to exist, which places a reliance upon local decision-making to interpret how safety is protected in the light of workload. While the MHRA recognises the range in job roles and responsibilities and provides suggestions for staff training requirements, there is currently no standardisation of training hence a reliance upon each local area to develop their own training with no formal accreditation to suggest an agreed standard has been reached.

Organisation

High demand for MRI scans has led to contracting out of services to mobile MRI units. An unexpected consequence is that some patients are unable to cope with this environment and scan quality was sometimes sub-optimal. Both factors may contribute to patients requiring further scanning, so dual time slots are used to achieve a good result. The organisation's targets influence where safety strategies may be compromised to achieve greater levels of efficiency to satisfy the clinical demand.

Local recommendations suggest patients should change clothes prior to scanning to ensure safety. However, having suitable clothing, available time and changing facilities influences the number of scans achievable in a day and, therefore, changing clothes may not always occur. This creates the opportunity for metal to be contained within clothing and increases the reliance on staff performing checks.

Table 1
Examples of MRI system safety incidents, hazards and issues reported in healthcare literature.

Potential Burn
- Non-disclosure by patient of ingested ferrous magnetic material[18]
- Spontaneous discharge of firearm[19]
- Unreliability of patient information and scanning of pacemakers. Lack of use of ferromagnetic detectors limited use of external audits of safety procedures and some evidence to suggest requesting MRI relevant information from referring physicians helpful but often incomplete[20]
- Object used to assist patient positioning or imaging has unobservable and unknown metal content[21]
- Burns through non compatible materials in MR environment[22]
- Burns from electrode cables[23]
- Undetected metal foreign body in eye – limitations of checklist/pre scan questionnaire as may not fully recognise thoroughness of removal of metal is highly relevant[24]
- Undetected silver fibres in under shirt – 'tech' clothing likely to be increasing and stresses the need to get patients changed[25]

Potential Projectile unrecognised
- Poor communication, projectiles[26]
- Increase in events associated with projectile oxygen cylinders[27]

Device Malfunction
- Overall, no significant changes were seen in pacemaker device function, and no adverse clinical events were observed. A minority of patients with older devices had unpredictable changes in device behaviour, which stresses the need for close monitoring during and careful device interrogation after scanning[28]
- The limited available data indicate a manageable but not negligible MRI-associated hazard in patients with implantable cardiac devices. Further controlled studies and large, independent registries, particularly in Europe, are needed to provide important safety information[29]

Contraceptive implants
- Presently, there is no scientific evidence that contraindicates performing MRI on women with any kind of gynaecological device[30]

Deep brain stimulation implants
- Parallel transmit arrays can be used to generate implant-friendly modes[31]

Metallic headframe
- Our results confirm that the manufacturer's recommendation to use insulating nuts reduces the induced currents in the headframe nearly to zero, effectively preventing heating and minimizing the likelihood of thermal injury[32]

Orthodontics
- The temperature changes of the specimens were considered to be within acceptable ranges. With regard to magnetic field interactions, brackets can be considered MR Safe; however, it would be safe to replace the wires before MRI[33]

Orthopaedic implants
- Fassier-Duval (FD) rod are safe and pose no risk of migration, heating effects, or artefact when undergoing an MRI of the spine using a 1.5 T magnet. With the introduction of magnet strengths higher than 1.5 T, further testing should be performed[34]

Cochlear implants
- Even with protective head bandages, 1.5-T MRI in patients with CIs led to a variety of adverse events, including discomfort or pain and displacement of the internal magnet. Therefore, sedation and careful head positioning may be appropriate for some patients with CIs who undergo MRI, and these patients should be carefully monitored to decrease the likelihood of such adverse effects[35]

Internal environment

The physical design of MRI units and associated recommendations reflect the need to promote safety through ergonomic design by creating physical barriers and clear delineation in work areas where magnetic forces will be experienced. Physical limitations in the layout or space allocated to MRI units can immediately create a significant hazard. For example, in both study sites if the door to the MRI environment was open at the same time as the door into the Controlled Access Area, patients who may not have been checked may inadvertently be exposed to the static field. There was no clear delineation or physical barrier between the zones. Warning signs and staff attentiveness to chaperone patients are the main controls used to manage exposure to the magnetic fields.

Patients may be transferred from anywhere in the hospital or arrive from home as an outpatient. Visitors to the unit e.g. relatives or staff from other work areas also need to be screened prior to entering the Controlled Access Area. The corridor outside the MRI unit may be the only safe environment to complete screening if the magnetic field extends to the entrance doorway to the MRI unit. Anaesthetising patients and managing medical situations may be dealt with in close proximity to the scanning unit and the entrance to these units.

The document from National Health Service Estates[36] outlines criteria recommended for the physical design of scanning facilities. At site A limitations in workspace meant changing rooms facilities for staff or patients were lacking – a single toilet was used for this purpose, with clothes hung within an equipment storage cupboard. Furthermore, rest areas for staff wellbeing appear compromised if located within the vicinity of patient waiting areas.

Several practitioners may share the Controlled Access Area within the MRI unit to complete different task functions: communicate with patients and staff, assist patients with changing, operate imaging equipment, interpret scan images, complete documentation, and provide training. A busy control room creates a noisy environment which caused distractions for practitioners required to complete cognitive work e.g. interpreting scans. At site A this was compounded by a shared control room, due to lack of space, for both the MRI and CT scanner. The perceived hazards were emphasised by the fact that management had an expectation that a joint control room led to an acceptable reduced level of staffing to operate both scanners. However, each modality requires a different safety culture for safe operation.

Checking procedures, warning notices and continual reminders by MRI Authorised practitioners are heavily relied upon to maintain staff, patient and visitor safety. High levels of visual clutter are evident and lack of salience in key signs aiming to provide a safety safeguard was therefore limited. The absence of a sign to specifically differentiate between the MRI and CT scanner was also noted.

Tools and technology

The interaction between technology and other equipment creates the greatest hazard to safety and the quality of scans produced. Equipment entering the MRI unit should be assessed and labelled in one of three ways: MRI Safe (no hazard); MRI Conditional (safe in defined conditions); MRI Unsafe (unacceptable hazard). The current labels used were insufficient to tolerate daily infection control cleaning requirements. However, even equipment considered MRI Safe may contain some ferromagnetic metal e.g. a MRI Conditional patient transfer trolley mechanism. This does not make them unsafe, but if ferromagnetic detectors are in place this can produce an alarm which creates a false positive.

The fast pace of patients and staff moving between different demarcated zones combined with MRI-unsafe mobile items presents a significant hazard of ferrous magnetic material entering the Projectile Zone. The defibrillator unit is clearly labelled as MRI-unsafe and so procedures and training are required to ensure cardiac arrests or other medical emergencies are dealt with outside of the MRI Environment. A considerable level of knowledge and attentiveness is required by staff, within and beyond the MRI unit, to evaluate patients and the compatibility of any implantable medical devices to recognise potential risks. Learning through incidents also provides valuable knowledge e.g. autoclaving certain medical equipment then implanted within a patient may develop ferromagnetic properties, although previously deemed MRI-safe.

Tasks

A general overview of the process associated with the transfer and checking of patient information was considered. For example, it was highlighted that incomplete or inadequate checks or non-compliance by patients allows opportunities for safety to be compromised. Evidence also suggests that patient referral information may be unreliable and was not always trusted by radiographers. The predictability, frequency and time pressures associated with clinical activities may influence the memory recall necessary to complete activities relied upon to ensure safety e.g. checks, emptying pockets, removal of hair slides. Similarly, emergency tasks or other infrequently completed tasks (e.g. changing light bulbs) can present a risk for staff not routinely involved in interacting within the MRI unit.

People

Training and education of MRI staff groups is strongly recommended in MRI guidance. However, there is currently no national guidance or requirements associated with demonstrating the levels of training and competence required. Furthermore, no recommendations on the number, grade level or skill mix recommended for MRI scanning in the context of different specialities are available. This does not support local units to ensure safety is optimised during organisational efficiency initiatives. Variability in the type and quality of training creates a workload for each unit to develop local training and the potential for variability in the knowledge held by staff required to rotate throughout a regional area. Non-technical skills of staff are vital to supporting the safety, performance and efficiency of a MRI unit, but are not formally taught.

Summary of recommendations for improving system performance and human wellbeing

A diverse range of tentative recommendations for improving safety performance and human wellbeing are offered for consideration by MRI-related stakeholders (Table 2). The recommendations are directly informed by the risks identified and are based on a holistic system perspective, reflected by the categories captured within the SEIPS model.

External environment

National MRI safety initiatives

- National centre for procurement of MRI conditional equipment should be developed and adopt HFE principles in product evaluation to ensure all user and safety requirements are considered during the procurement process relevant to all environments where the equipment is required.
- National standardisation and accreditation by relevant professional bodies for MRI training programmes to accommodate the different levels of expertise required.
- Establish scenario-based training to enable simulation-based training to support safety and performance in the context of MRI work activities.

Internal environment

Building design

- Develop design requirements for MRI units which acknowledge the necessity for the involvement of MRI staff, safety scientists and architects to enable safety to be designed into MRI units**.** HFE analysis should inform the evidence used to support design and development of MRI facilities/work processes.
- Develop a national risk evaluation tool to identify how existing local design influences safety.

Work environments

- Provide physical prompts to the removal of metal prior to entry into the controlled zone that consider mimicking existing systems recognisable to society e.g. security at an airport emptying contents into black trays with images of typical objects outlined in tray.
- Installation of ferromagnetic detectors at the MRI Environment (scan room) door entrances and for staff and patient screening purposes.
- Clear delineation between MRI zones, either through coloured floor changes or physical barriers indicating need for greater safety precautions e.g. stereotypical safety indicators recognised by all users.

Tools and technology

- Design studies to develop national warning signs based on universal design principles and relevant standards. Ensure standardisation and evaluation of warning signs, include a requirement to label doors relative to the type of scanner e.g. MRI, CT.
- All equipment within the controlled zone if mobile should be MRI-safe or MR Conditional. Equipment inventories within a MRI unit should indicate MRI safety/conditions. The term equipment refers to any tool used in the context of a MRI unit including everyday objects e.g. pens, scissors etc. MRI Conditional writing materials should be readily accessible within treatment and scanning areas.
- Equipment providers and MHRA to consider how medical devices introduced into healthcare may be exposed to MRI scanning and support the funding of evidence on the implications to share with national organisations.
- The introduction of a specific MRI uniform, pocket-free, for all regular MRI staff.

People

- Introduction of MRI passport to enable GP practices to provide a summary of MRI contraindications for the patient to retain, whilst a duplication is held electronically.

Table 2
Improving system safety suggested recommendations for consideration.

System domains and suggested recommendations
National MRI safety material e.g.
• Nationally maintained website to support interpretation, usability and accessibility to the large number of guidelines, evidence and recommendations required to manage a MRI unit.
• Establish professional consensus on safety screening questions and educational content to allow standardisation of a national approach to safety checks, education and competencies.
Building design e.g.
• Develop design requirements for MRI units which acknowledge the necessity for the involvement of MRI staff, safety scientists and architects to enable safety to be designed into MRI units.
• HFE analysis should inform the evidence used to support design and development of MRI facilities/work processes. Develop a national risk evaluation tool to identify how existing local design influences safety. This would focus risk management on how and where to reduce or mitigate identified risks and when cost-benefit analysis is required for a judgement of as low as reasonably practicable (ALARP) to be achieved.
Work environment e.g.
• Provide physical prompts to the removal of metal prior to entry into the controlled zone that consider mimicking existing systems recognisable to society e.g. security at an airport emptying contents into black trays with images of typical objects outlined in tray
• Installation of ferromagnetic detectors at the MR Environment (scan room) door entrances and for staff and patient screening purposes.
• Clear delineation between MR zones, either through coloured floor changes or physical barriers indicating need for greater safety precautions e.g. stereotypical safety indicators recognised by all users.
Warning signs and reminders e.g.
• Design studies to develop national warning signs based on universal design principles and relevant standards. Ensure standardisation and evaluation of warning signs, include a requirement to label doors relative to the type of scanner e.g. MRI, CT.
Organisational safety e.g.
• Research the variability within the activities/tasks associated with referral, screening, information exchange and checking patients prior to MRI scanning. Understand the pros and cons of each screening tool e.g. Ferromagnetic detectors, checklists to develop and evaluate a multi modal checking pro forma.
• The requirements for developing a positive safety culture in the context of MRI units should be researched with a MRI safety culture tool developed for national consultation.
Incident reporting
• Develop a reporting system based on user centred design principles which can capture retrospective e.g. incident, prospective risk data alongside positive reporting of events; where safety was ensured in the context of MRI units.
Equipment and tools e.g.
• All equipment within the controlled zone if mobile should be MRI-safe or MRI Conditional and Equipment inventories within a MRI unit should indicate MR safety/conditions. The term equipment refers to any tool used in the context of a MRI unit including everyday objects e.g. pens, scissors etc. MR Conditional writing materials should be readily accessible within treatment and scanning areas once personal equipment has been handed in.
• Equipment providers and MHRA to consider how medical devices introduced into healthcare may be exposed to MRI scanning and support the funding of evidence on the implications to share with national organisations.
Procurement e.g.
• National centre for procurement of MRI conditional equipment should be developed and adopt HFE principles in product evaluation to ensure all user and safety requirements are considered during the procurement process relevant to all environments where the equipment is required.
Training e.g.
• National standardisation and accreditation by relevant professional bodies for MRI training programmes to accommodate the different levels of expertise required.
• Establish scenario-based training to enable simulation-based training to support safety and performance in the context of MRI work activities.
Staff uniforms e.g.
• The introduction of a specific MRI uniform, pocket-free, for all regular MRI staff.
Patient factors e.g.
• Introduction of MRI passport to enable GP practices to provide a summary of MRI contraindications for the patient to retain, whilst a duplication is held electronically.

Organisation

- Research the variability and reliability of the activities/tasks associated with referral, screening, information exchange and checking patients prior to MRI scanning.
- Develop guidance for evaluating and developing a positive safety culture in the context of MRI unit.
- Develop a reporting system based on human factors principles which capture retrospective e.g. incident, prospective risk data alongside positive reporting of events.

Discussion

The study achieved its aims of shedding light on system hazards that potentially impact on performance and safety in the MRI working environment. Overall, the study provided some evidence for the potential of HFE theory and practice to reveal system performance and human wellbeing issues in this complex, high-risk clinical environment, while offering tentative recommendations for improving related practices and design.

Key strengths included the multi-method HFE systems approach adopted in understanding the nature of the study problems and offering recommendations to be considered for improving system safety based on these established principles. The research team are also highly experienced in HFE and included frontline clinical expertise to ensure a participatory approach to gaining a realistic understanding and interpretation of issues identified. Limitations include the small-scale nature of study within two hospital sites, meaning the findings are likely biased and not generalisable, although the findings should still have wide interest. Additionally, the safety issues, implications and recommendations will require further in-depth exploration and consideration by a range of other stakeholders such as strategic decision-makers, regulators, architects, designers of technology, clinical leaders, educators and practitioners.

Evidence of actions adopted to address and manage known hazards within MRI environments include: production of local guidelines/procedures; education and training; additional staffing; checklists; ergonomic design principles; use of local equipment that is MRI-safe; local safety evaluation; clarity in delineation in work zones; appropriate patient clothing and uniform design.[37–41] Healthcare in all contexts is being tasked to consider how HFE can address safety issues and improve well-being and system performance.[14,15,42] At least two published studies provide some evidence of this approach to manage the safety issues associated with MRI contexts,[39] and in considering environmental design and work flow

to address hazards and support essential training and procedure development.[40]

Certain roles are stipulated as necessary by the MHRA,[5] but evidence presented by the Institute of Physics and Engineering in Medicine[8] highlights that 18% of 49 MRI units sampled in the UK did not have sufficient scientific expertise. Therefore, this suggests the level of resources or knowledge of the recommendations may create differences in the interpretation or adoption of safety guidance. Furthermore, it questions the investment placed on ensuring safety and raises the question is legislation required to guarantee access to MRI Safety Experts and adherence to critical safety guidelines? An overwhelming volume of information, guidelines and recommendations is available to manage. The compliance with large numbers of procedures is recognised more generally as an issue within healthcare.[43]

Implications for policy, practice and research

The potential of HFE to improve system performance in healthcare is promoted by the World Health Organisation and other leading authorities. While some policy progress is apparent in NHS England in exploring the potential benefits of HFE integration in healthcare, this has yet to occur at the system level in Scotland. The evidence strongly suggests that many quality and safety problems in healthcare are directly related to the lack of attention given to HFE thinking and approaches to enhance human performance and system safety. Based on the limited published evidence and our small study findings, the MRI working environment appears to be a perfect example of where multiple and diverse design interaction issues potentially impact negatively on staff and patient safety and the effective functioning of the care service due to a failure to adequately engage with HFE specialists and safety scientists.

To highlight a single issue, healthcare suffers from an endemic problem of a lack of engagement in formal incident reporting and learning by care staff, and a bias towards the reporting of certain types of incidents e.g. overlooking the significance of capturing 'near miss' events.[44] The scale of risk associated with MRI scanning is currently unknown due to a lack of standardisation of, and staff engagement in, reporting incidents so further research is clearly necessary.[4] Our findings suggest some concerns being highlighted about local incident reporting systems related to inconsistency in reporting and coding of data combined with how risks were identified and managed. However, work is now currently ongoing involving MRI practitioners in Scotland to improve the consistency in incident data reporting and coding which is a positive co-design to developing a more useable reporting system.

The findings also highlight the need for significant development, research and evaluation in partnership with multiple stakeholders to explore MRI safety and design issues, and to review the evidence and the potential to test HFE-informed solutions within a resource-limited healthcare service. Ultimately the accumulated evidence points towards the co-development of a standardised and integrated safety management system for MRI working environments that is implemented and 'normalised' in the NHS and other care systems worldwide. Recent high-profile MRI-related accidents that tragically resulted in death and serious injury point to the limitations of current safety procedures and designs, and the need for a co-ordinated response from the international MRI community.

Finally, the concept of safety is frequently considered to be the absence of things that go wrong and much of this thinking has underpinned the study perspective. A recent shift in thinking suggests that considering a small pool of data, for example, incident data – and then creating barriers to that alone is insufficient in safety management.[45] Evidence in safety science considers that adjustments and variability in human performance within a complex system are normal and necessary for the system to succeed in terms of balancing safety with work efficiency demands.[46] It is proposed, therefore, that there should be two approaches to managing MRI system safety: Safety-I refers to a retrospective view of incidents (the current approach), while Safety-II prospectively seeks to understand how the system succeeds under normal work conditions and where variability may reduce or enhance the resilience of the system.[45] In this way, MRI teams can begin to consider how to monitor, learn, anticipate and respond to threats and build resilience into the system rather than solely relying upon, for example, the individual person and the quality of checks.

Conclusions

This preliminary review of MRI system safety evidence and work environments suggests that a range of hazards are currently managed and rely heavily upon the attention and skill of the staff managing these environments. A reliance on staff time additional to their normal working hours to develop and ensure safety strategies are established is apparent. A lack of national co-ordination of safety data and activities creates a greater than necessary demand upon local units to develop their own training and competencies. In the context of an increasing demand for MRI scans and time pressures created by national and organisational targets, safety can become compromised as teams develop strategies to balance the need for safety with efficiency. Further work is required to consider variation in safety issues across all MRI units and develop a strategic approach and integrate HFE to develop a general safety management approach for the UK (and potentially internationally).

Ethical review

Under UK 'Governance Arrangements for Research Ethics Committees', NHS ethical research committee review is not required for service evaluation or research which, for example, seeks to elicit the views, experiences, knowledge and contributions of healthcare professionals on a given subject area.

Conflict of interest statement

None.

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