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Crossing the Macro-Micro Divide in Systems Ergonomics

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This paper attempts to further explore the concept of mesoergonomics and the implications this has for the use of the systems approach within ergonomics. The concept has been applied within the field of organisational behaviour to understand a wide variety of complex work contexts and the interaction between individual, group and organisational levels of analysis. More recently, researchers in human factors and ergonomics have similarly argued that there is a need for holistic, integrated accounts of the relationship between macro- and micro- system levels (Karsh, 2003). In order to go some way toward achieving this, we outline two case studies drawn from health care (infection control, electronic medical records) and analyze these using mesoergonomic constructs. The case studies are used to outline a set of steps towards a more general framework for mesoergonomic research.

INTRODUCTION

Researchers within ergonomics and human factors typically draw a distinction between studies which focus on micro-level issues (e.g., the human-system interface) and those concerned with the macro-level (e.g., the functioning of large-scale sociotechnical systems). The subdisciplines of systems ergonomics and macroergonomics attempt to provide a unified picture of how these micro- and macro-elements are combined and intertwined. Whilst there are many accounts of the functioning and workings of “whole systems” (e.g., Hendrick, 1986; Hollnagel et al., 2006), little research within ergonomics has been conducted on causal inter-relationships between micro and macro system levels. As a response to this Karsh (2003), suggested that more “mesoergonomic” studies are needed and defined mesoergonomics as “an open system approach to the development of macroergonomic theory and research whereby the relationship between variables in at least two different levels or echelons are studied”. In this paper we attempt to provide further details on the contribution mesoergonomics might make to our understanding of large-scale systems within ergonomics. More specifically, the paper sets out to describe two case studies which demonstrate the importance of considering causality between levels of analysis within the overall system. A final section outlines the first steps towards a framework for future mesoergonomic research.

Examples of “meso-level” research

Recent research on safety climate provides one example of research oriented around the concept of mesoergonomics. Safety climate can be defined as a reflection of employee’s shared perceptions with respect to safety within their work

environment (Barling, Kelloway & Zacharatos, 2002). Zohar & Luria (2005) carried out a survey using measures of organizational safety climate (e.g., top management attitudes to safety) and group safety climate (e.g., the influence of supervisors on safety perceptions). The findings from the study demonstrated strong linkages between the two levels of analysis. The strength of commitment to safety at the upper most organizational level was a strong predictor of how supervisors prioritised safety issues within their work groups. The study underlined the way in which attitudes can cascade down through the system and underlined the importance of organizational support for safety.

Meso-level research has also proved to be influential within healthcare. Edmondson (1996) for example, carried out a study investigating the causes of medication error within a sample of hospitals in the USA. Hospital staff answered survey questions covering features of their work teams and these were then compared with medication error rates. The results from the study proved at first to be counterintuitive: well structured and managed teams made more errors as compared to their less well structured and managed teams. Follow up observation and interviews with team members revealed that the incidence of medical errors could be explained at an individual level of analysis, as compared to the original intention of focusing on the group (team) level. The qualitative data revealed that teams with authoritarian nurse managers underreported the incidence of errors partly because of the fear of having made a mistake.

Both case studies demonstrate the need to look closer at the issues of levels of analysis when studying complex phenomena such as the nature of accidents, safety and errors.

CASE STUDY 1 – HOSPITAL-BASED INFECTION OUTBREAKS

During the period between April 2004 and September 2006 an estimated 90 people died at the Maidstone and Tunbridge Wells NHS Trust in the UK as a result of becoming infected with the *Clostridium difficile* (*C.diff.*) bacteria (Healthcare Commission, 2007, p.5). *C. diff.* is the major cause of serious bacterial infectious diarrhoea acquired in hospitals in the UK and is particularly resistant to drying, chemical disinfectants and alcohol.

Contributory factors leading up to the outbreaks

The Healthcare Commission (2007) report identified a number of factors that contributed to the outbreaks that occurred with the Trust. These included: the role played by external organisations; management of the trust; clinical management on the hospital wards; the role played by the infection control team; and, equipment and hygiene factors.

The role of external organisations

Within the report both the setting of government-led targets and financial pressures on NHS Trusts were mentioned as background, contributory factors that had an impact on the day-to-day operation of the Maidstone and Tunbridge Wells Trust. In particular, the report mentions the need for Trust board members and managers to meet targets for the use of beds. Higher bed occupancy meant that there was less time for the cleaning and a higher probability of transmission of infection between patients (2007, pp.69-70).

Infection control within the UK NHS is regulated by a number of bodies including the Health Protection Agency (HPA). The creation of the HPA in April 2005 coincided with the first outbreak at the Trust. One part of the HPA, the health protection unit (HPU), was set up in order to support organisations in their management of infections. The report highlights that this caused some confusion within the Trust at the time of the outbreaks, as the expectation was that the HPU could give provide guidance covering the supervision and monitoring of infection control. The HPU did not have close involvement with the Trust and generally worked in a reactive way, responding to concerns as they arose (HC, 2007, p. 8). Similar problems were encountered within the much larger Strategic Health Authority (SHA).

Management of the Trust

The report describes a catalogue of problems and failures associated with the management of the trust at the time of the outbreaks. In terms of clinical risks and incidents, management strategy in general “had been fragmentary and poorly understood” (HC, 2007, p. 77). The style of leadership within the Trust and the overall management culture are criticised in the report. Many staff described the leadership of the chief executive as being “autocratic” or “dictatorial” (HC, 2007 p. 91). The report concluded that the person appointed as director of infection prevention and control had “no real understanding of the role at the outset” (HC, 2007, p. 5). Turnover of managers and directors was high. Between September 2002 and September 2006 five people attended the board in five roles as director or director of finance (HC, 2007,

p. 91). Despite weekly meetings the report concludes that there was little evidence of managers working collaboratively to address problems (HC, 2007, p. 91).

Clinical management on the hospital wards

A review of the case notes of 50 patients who had died having had *C. diff.* found that in 80% of the cases, at least one element of the clinical management, or monitoring of *C. diff* at ward level was unsatisfactory (HC, 2007, p. 4). A number of elements were mentioned, including: infrequent reviews of patients by doctors; lack of systematic monitoring as to whether or not a patient was recovering from *C. diff.*; and, failure to change antibiotic treatment when a patient failed to respond to the initial treatment (HC, 2007, p. 4). Delays in starting treatment occurred on the wards, mostly because there was a delay in sending samples for analysis (HC, 1007, p. 33). The management of fluids and nutrition on the wards was also inconsistent. In 36% of the cases there was evidence of poor fluid management and in 34% nutritional needs had not been assessed or managed (HC, 2007, p. 38).

The infection control team

The role played by the infection control team within the trust was a complex one and one made difficult by problems relating to accountability, the amount of resources available to them and their ability to function as a team. The arrangements for accountability were not clear (HC, 2007, p. 54) and it was not clear who was responsible for the team. Infection control nurses were accountable to the director of nursing, however, the pathology manager held the budget for these nurses, but did not consider that he had any management responsibility for infection control.

Equipment and hygiene

Hygiene practices within the trust and the state of hospital buildings contributed a great deal to the outbreaks. Wards, bathrooms and commodes were not clean and patients had in some cases to share equipment (e.g., Zimmer frames) which were not cleaned before use (HC, 2007, p. 4). The infection control team were keen to isolate patients once they had been identified as *C. diff.* cases, however the scarcity of side rooms made this difficult. As a result many patients before and after the outbreaks were kept on open wards. The design of buildings and their age meant that many wards did not have sufficient space for storage or the provision of hand basins in utility rooms. The buildings in the trust were generally old or in a poor state of repair and when they were first opened did not have adequate cleaning and laundry services (HC, 2007, p. 6).

Analysing the outbreaks: A mesoergonomic perspective

Government, regulatory bodies and trust governance

At the very highest level of the system it is difficult to isolate the role played by government-set targets as a contributory factor leading to the outbreaks. Targets placed many individuals, particularly those at trust board and management, levels under a great deal of pressure. This pressure in itself may have led them to make poor decisions, and in some cases to prioritise bed occupancy rates at the expense of the risk of an infection outbreak. Previous research on the influence that targets have on management decision-making in health care

tends to be equivocal. Bean & Hood (2006) for example, show that the impact of satisfying a specific target (e.g., hospital waiting times) has not been analysed in terms of how this influences other related services (e.g., quality of care). Within the trust it is likely that targets exerted considerable pressure on the system as a whole and this pressure filtered down various levels of the system. It is possible that the drive to comply with these targets increased the likelihood of an adverse event or set of events taking place at some stage within the trust (West, 2000).

Poor communication, confusion of responsibilities and accountabilities between and within the various regulatory bodies delayed the time in which they could react to the outbreaks. A separate report by the Healthcare Commission (2008) examined the underlying causes of serious failures in NHS health care providers and identified large-scale organisational processes such as mergers and poor change management procedures as common factors.

Hospital management

Within the hospital the actions of senior managers were identified as significantly contributing to the failure to prevent and deal with the outbreaks. The link between management, human resource management (HRM) practices and work performance outcomes has been investigated in detail in the last few years. Wood & Wall (2002) for example, reviewed the evidence that suggests there is a link between high-involvement HRM practices and employee productivity. High involvement HRM practices typically include empowering employees to make their own decisions and the presence of self-managed teams. The review showed that these types of practices in organisations do tend to increase levels of employee productivity. Similar effects have been shown between HRM practices and measurements of safety outcomes (e.g., number of adverse events). In general, there is strong evidence to suggest that aspects of management behaviour partially shape and determine the culture of safety within organisations.

Leadership and the behaviour of leaders within the trust were also cited as playing a role in the outbreaks. The review by Griffiths, Renz & Rafferty (2008) cites evidence to show that positive leadership styles such as the presence of a shared vision among managers and staff leads to increased staff and patient satisfaction. Houser (2003) for example, tested a model of nursing leaderships styles, workload and teamwork and found reduced incidence of infections where positive leadership behaviours were present.

Clinical management and equipment and buildings

Understaffing and general lack of resources together played a part in the outbreaks. In general, the research literature provides some evidence that lower levels of staffing increase the likelihood of infections occurring. Hugonnet et al. (2004) (cited in Griffiths et al., 2008) examined the numbers of nursing staff and staff downsizing relative to infection levels. The researchers found an inverse relationship between staff downsizing and the rate of hospital-based infection. Little research has been conducted on the impact of job satisfaction/morale on hospital infection levels, however, work in other domains suggests that lower levels of satisfaction are linked to lower levels of job performance (e.g., Parker, 2007).

The behaviour of clinicians and other health care professionals within the trust shares similarities with those of senior managers and trust board managers. Many individuals at ward level were aware of the levels of poor hygiene and inadequate patient monitoring practices, but saw no way to improve the situation. Weick & Sutcliffe (2003) analysed data from the Bristol Royal Infirmary Report (2002) and concluded that hospital staff became locked into particular lines of action or behaviour where they “search for confirmation that they are doing what they should be doing” (p. 73). These so-called “cultures of entrapment” inhibit an organisation’s ability to break out of patterns of behaviour that over time can lead to adverse outcomes. In the case of the trust they may provide some means with which to explain shared boundary spanning behaviours between levels within the hospital subsystem (figure 1).

CASE STUDY 2 – ELECTRONIC MEDICAL RECORDS

The second case study is concerned with the adoption of electronic medical records (EMRs) within the UK National Health System (NHS). The specific focus of our current work is on the factors hindering and facilitating adoption of EMRs across organizational boundaries (e.g., primary - acute medicine).

The UK National Programme for Information Technology (NPfIT) began in 2002 and represents the largest civilian IT project in the world (Brennan, 2005). One of the main goals of NPfIT is to provide round-the-clock access to EMRs and other electronic medical information to NHS healthcare professionals throughout the UK. A number of types of system have been introduced alongside EMRs in the last few years including systems which facilitate booking of medical appointments and referrals (e.g., “Choose and Book”) and systems which collect, store and distribute electronic X-ray images (e.g., PACS – “Picture Archiving and Communications System”).

Research so far has identified a range of the factors that act as barriers and enablers to the adoption of electronic records in the NHS (e.g., Eason, 2007; Hendy et al., 2007; McGrath et al., 2008; Greenhalgh et al., 2008).

Factors influencing adoption of the EMR

Design and functionality provided by the technology

Many users of the various systems associated with the move to EMRs have been expressed dissatisfaction with their poor design. These concerns have ranged from the “clunky” nature of functionality provided by systems such as “Choose and Book” and other usability problems, to more fundamental problems such as the design of access to patient information on the records. In some cases this has led to disappointing levels of adoption and the increasing use of “workarounds” (e.g., getting patients to book referrals using “Choose and Book” because of the time taken to complete this task in the primary care practice).

Access to patient information and impact on professional identity

Concerns about the security and level of confidentiality of information stored in such databases has also led to patchy adoption. The implementation of role-based access for example, is widely perceived as too complicated and amongst some groups as unworkable.

EMRs are seen by some clinician groups as a threat to their professional identity and authority. General Practitioners for example, sometimes see themselves of the guardians of patient information, part of their role being to “protect” patient data rather than store it in centrally-held databases where its use is difficult to monitor and control .

Presence of champions and end user involvement

In common with other large-scale IT project implementations, the presence of system “champions” and high levels of user involvement have in some cases helped to increase levels of adoption. Greenhalgh et al. (2008) for example, found that primary care trusts commonly had enthusiastic local champions (e.g., a general practitioner or nurse), who form linkages between the development of the technical infrastructure and aspects of improved patient care. The study also demonstrated that clinicians who regularly worked across different healthcare organizations (e.g., primary care practices and “out-of-hours” services) acted as “boundary spanners” and provide important support for systems development.

Past experience with IT project, leadership and management capacity

Past experience with failed or poorly implemented systems can act on the one hand as a barrier to adoption (i.e., increased skepticism toward large-scale IT systems), and on the other serve as a set of lessons learnt which may help to prevent similar events occurring.

Having strong leadership, good managerial relations and a well focused strategic vision are also characteristics of healthcare organizations with high adoption rates of EMRs.

Tensions between centralised control and local development

One of the most important factors that has been shown to influence the scale of adoption is the degree to which the technology has been developed within the local healthcare context (e.g., Primary Care Trust) or has been introduced as part of a national roll-out of IT systems. In the case of national systems, adoption has been hampered by the lack of integration with existing IT systems in operation. Lack of clinician involvement in the design and deployment of the systems has also resulted in the impression that the system has been imposed on users. With Choose and Book for example, there was no integration of IT systems between general practices and acute trusts. As a result staff in acute trusts were not able to reconcile implementation timescales with their primary care colleagues (Hendy et al., 2007).

More recently, there has been a move at national level to accommodate the demands of top-down and local system development activities, through the setting of centralized standards for system delivery which allow for local implementation practices to take place.

Alignment with established organizational routines and procedures

New systems which map onto existing organisational routines (e.g., well established treatment pathways linking clinicians) are likely to result in higher levels of adoption. One hypothesis that our research is currently investigating is that data sharing between organisations will be more likely where there is a tight dependency between the immediate use of the data by other clinicians, as compared to where the data is archived in a database for subsequent later use. These latter “pooled dependencies” between clinician and the EMR, may also be influenced the degree of coupling and past levels of interaction between the various organisations involved.

Wider socio-political influences

Finally, adoption is likely to be influenced by factors which originate from outside of the immediate healthcare system. EMRs have become highly politicised within the UK, partly through concerns which have been raised by the loss of sensitive government and NHS data in the last few years and the influence of civil liberties movements. The move to EMRs has also attracted widespread media interest, some of which has been very critical of the NPfIT programme.

Analysing adoption: A mesoergonomic perspective

The research that has been conducted on the impact of the EMR within the UK still has a long way to go. Much more work investigating patterns of adoption and unpacking the factors mentioned above needs to be carried out. As a result attempts to draw firm conclusions regarding the adoption of the EMR are necessarily tentative. Despite this, it is clear that many of these factors cover a wide range of system-related levels of analysis.

A summary of some of the system-related factors and constructs using a mesoergonomic model of how these may interrelate are presented in figure 2. One of the advantages of this type of model is that it can provide an overview of all of the factors involved in adoption and relate these to possible causal relationships across levels. Greenhalgh et al. (2008) likewise argues that: “multi-level analysis can illuminate how contextual factors shape, enable and constrain new, technology supported models of patient care”.

Figure 2 provides an example from our current work where the hypothesis regarding the sharing of the EMR mentioned above, involves multiple levels across the system (e.g., inter-organisational and individual levels). The degree of organisational and inter-organisational coupling and alignment, alongside issues relating to the storage of EMR data (i.e., “pooled” or “tightly dependent” on the patient’s movements within the healthcare system), are predicted to have consequences for the adoption of the EMR in general. We expect that other hypotheses will be generated as the project progresses and these are likely to shed light on other causal relationships that exist between system levels.

STEPS TOWARDS A FRAMEWORK FOR MESOERGONOMICS

The case studies on infection control and electronic medical records go some way towards demonstrating the importance of establishing relationships between two or more levels within the larger system. In both cases these relationships have consequences for the overall functioning of the system and its associated outcomes (i.e., infection control rates, EMR adoption patterns). One of the key differences between outcomes of the mesoergonomic analyses relates to the nature of the relationships. In the case of infection control the outcomes were a set of hypothesized relationships between constructs which are known from previous literature to causally inter-relate. By contrast, in the EMR case study the analysis resulted in a specific hypothesis which was not tied to previous research findings. In other examples, it may be that the outcomes from a mesoergonomic analysis may be helpful in retrospectively interpreting findings, as in the case of Edmondson's work on medical errors. One part of our current work is to construct a general framework for mesoergonomic research that systematizes these various differences, particularly as they relate to the nature of inferences generated by a mesoergonomic analysis. In addition, we hope that the framework provides more accurate and precise terminology relating to system levels, constructs and relationships. Finally, the framework will consider methodological and measurement issues relating to future mesoergonomic studies.

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Figure 1: Meso-level relationships in the Maidstone and Tunbridge Wells infection outbreak

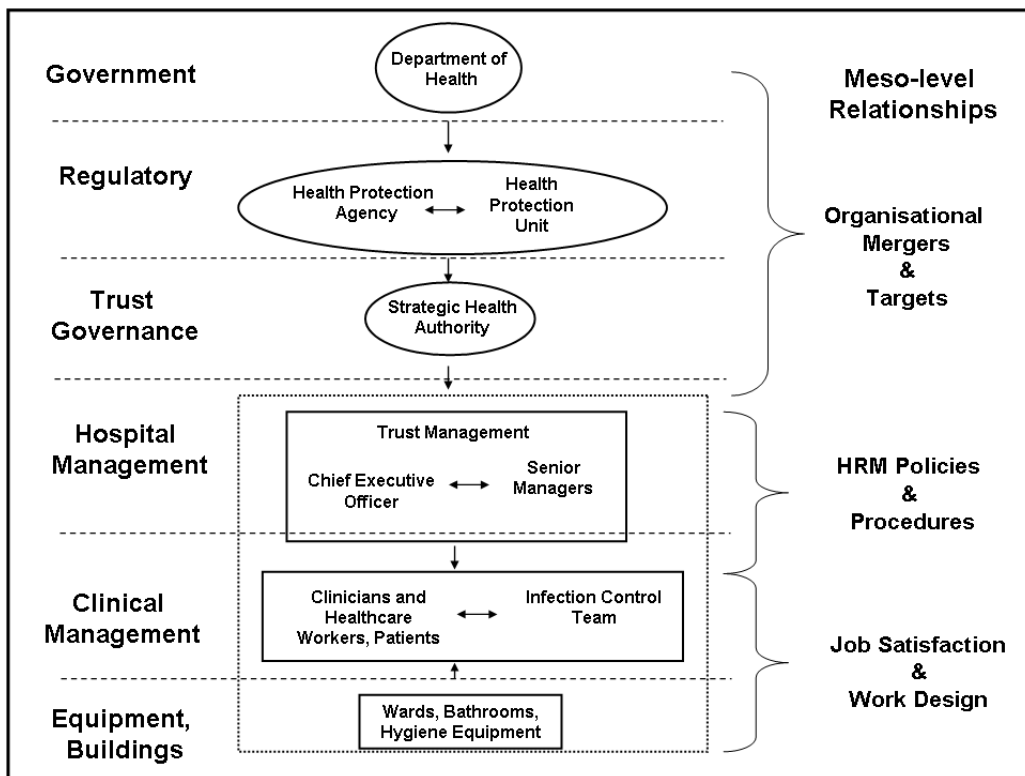


Figure 2: Example of meso-level hypothesis relating to the sharing of electronic medical records

