TENSIONS AND PARADOXES IN ELECTRONIC PATIENT RECORD RESEARCH

A systematic literature review using the meta-narrative method

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Abstract

Background

The extensive and rapidly expanding research literature on electronic patient records (EPRs) presents challenges to systematic reviewers. This literature is heterogeneous and at times conflicting, not least because it covers multiple research traditions with different underlying philosophical assumptions and methodological approaches.

Aim

To map, interpret and critique the range of concepts, theories, methods and empirical findings on EPRs, with a particular emphasis on the implementation and use of EPR systems.

Method

Using the meta-narrative method of systematic review, and applying search strategies that took us beyond the Medline-indexed literature, we identified over 500 full-text sources. We used 'conflicting' findings to address higher-order questions about how the EPR and its implementation were differently conceptualised and studied by different communities of researchers.

Main findings

Our final synthesis included 24 previous systematic reviews and 94 additional primary studies, most of the latter from outside the biomedical literature. A number of tensions were evident, particularly in relation to: [1] the EPR ('container' or 'itinerary'); [2] the EPR user ('information-processer' or 'member of socio-technical network'); [3] organizational context ('the setting within which the EPR is implemented' or 'the EPR-in-use'); [4] clinical work ('decision-making' or 'situated practice'); [5] the process of change ('the logic of determinism' or 'the logic of opposition'); [6] implementation success ('objectively defined' or 'socially negotiated'); and [7] complexity and scale ('the bigger the better' or 'small is beautiful'). Findings suggest that integration of EPRs will always require human work to re-contextualize knowledge for different uses; that whilst secondary work (audit, research, billing) may be made more efficient by the EPR, primary clinical work may be made less efficient; that paper, far from being technologically obsolete, currently offers greater ecological flexibility than most forms of electronic record; and that smaller systems may sometimes be more efficient and effective than larger ones.

Conclusions

The tensions and paradoxes revealed in this study extend and challenge previous reviews and suggest that the evidence base for some EPR programs is more limited than is often assumed. We offer this paper as a preliminary contribution to a much-needed debate on this evidence and its implications, and suggest avenues for new research.

Background

Electronic patient records (EPRs) are often depicted as the cornerstone of a modernized health service. According to many policy documents and political speeches, they will make healthcare better, safer, cheaper and more integrated. Lost records, duplication of effort, mistaken identity, drug administration errors, idiosyncratic clinical decisions and inefficient billing will be a thing of the past (Department of Health 2008; Institute of Medicine 2009).

But some authors have cast doubt on this vision of a technological utopia (Avison and Young 2007; Hanseth 2007; Kreps and Richardson 2007). 'Failed' EPR programs are common, they claim, and even 'successful' initiatives are typically plagued by delays, escalation of costs, scope creep, and technical glitches including catastrophic system crashes. They suggest that computerized records, by distracting staff into data entry and standardized protocols, jeopardise the human side of medicine and nursing; and that distributed record systems bring unanticipated hazards including (but not limited to) the insidious growth of the surveillance society.

When we began this review in 2007, there were already over 20 systematic reviews on the EPR incorporating hundreds of primary studies, and several more were published while we were undertaking this work (see below for examples). These reviews covered a relatively narrow body of literature restricted largely to experimental studies with quantitative designs. A wider, mostly qualitative, literature on "the people and organizational aspects" of the EPR was known to exist – and to be heterogeneous, complex, theoretically rich and largely uncharted (Kaplan, Brennan, Dowling, Friedman, and Peel 2001). Its points of departure differed, sometimes dramatically, from the assumptions implicit in the studies covered in previous reviews.

Aim and scope

We decided to undertake a new systematic review with a view to mapping, interpreting and critiquing a wider range of empirical evidence on the EPR in organizations. We favoured sensemaking over cataloguing – that is, we saw our primary task as teasing out the meaning and significance of the literature rather than producing an encyclopaedic inventory of every paper published on the topic. This was for three reasons: first, a comprehensive 'review of reviews' on the biomedical literature on the EPR was already being undertaken (Car , Black, Anandan, Cresswell, Pagliari, McKinstry et al, 2008); second, we were not resourced to undertake an exhaustive search of all relevant fields; and third, we considered that making sense of the literature was a worthy goal in its own right.

The term 'electronic patient record' is used in different contexts to mean different things – from an isolated file of computer-held information on a single patient, with or without decision support

functions, to a nationally networked database offering built-in interoperability functions with other technologies and systems and oriented towards secondary uses such as research, audit and billing. As technologies move on, so does the scope and purpose of the EPR. Hence, rather than impose a rigid definition, we chose to track how the definition changed across traditions and through time – and how these framings of what the EPR 'is' inspired different theoretical approaches, research questions, study designs and empirical insights. We took as our starting-point that, however it is defined, the EPR is socially and organizationally embedded – that is, it is used by people in particular contexts for particular social acts.

Our research questions were:

1. What bodies of knowledge and specific research traditions are relevant to the understanding of EPRs in organizations?
2. In each of these traditions:
    a. What are the key concepts (including taken-for-granted assumptions about the nature of the problem), theories, and methodological approaches?
    b. What are seen as the seminal theoretical works and the high-quality empirical studies?
    c. What are the main empirical findings and what has been concluded from these?
3. When comparing across the different traditions:
    a. To what extent are the assumptions, approaches, findings and conclusions of the different traditions commensurable?
    b. What higher-order insights can be gained from the study of the agreements and disagreements between them?
4. Taking account of both the policy context and the breadth and diversity of the existing literature on the EPR, what are the priorities for further research?

Method

We previously developed the meta-narrative method as a way of systematically making sense of complex, heterogeneous and conflicting bodies of literature (Greenhalgh, Robert, Macfarlane, Bate, and Kyriakidou 2004). We recommend that those unfamiliar with this approach access our methodological paper (Greenhalgh, Robert, Macfarlane, Bate, Kyriakidou, and Peacock 2005) and consult the glossary in the appendix to this paper. The essential technique is interpretive synthesis – that is, we read and re-read primary sources and used narrative to summarize their key methods and findings. We applied Kuhn's notion of scientific paradigms to map the meta-narratives (over-arching storylines) of research as they had unfolded in different research traditions, thus revealing how 'normal science' on the EPR has been differently defined and explored by different groups of scholars over time (Kuhn 1962).

A meta-narrative embraces a shared set of concepts, theories, and preferred methods (including an explicit or implied set of quality criteria against which 'good research' is judged). It also includes a time dimension: researchers look back (e.g. in editorials or book chapters) to consolidate what has been achieved to date and into the future to define unanswered questions and new avenues to explore. Star (2002) has defined a scientific discipline as *"a commitment to engage in disagreements"* (page 115). The meta-narrative should be thought of not as the unified voice of a community of scholars but as the unfolding of what they are currently disagreeing on. Researchers within any particular meta-narrative tend to know about and cite one another's work (even if they are citing it to contest it), attend the same conferences, publish in the same journals, and accept broadly similar criteria for judging validity and rigour.

With a view to unpacking these meta-narratives, we used exploratory methods (browsing, asking colleagues) followed by snowballing (searching references of references and using citation-tracking databases) to identify key sources. In a previous meta-narrative review of heterogeneous literature, we demonstrated that both hand searching and applying formal search strategies to electronic databases were significantly less effective and efficient than snowball techniques (Greenhalgh and Peacock 2005). In this review, therefore, we did not hand-search any journals and placed less emphasis on database searches. To aid data management, all sources were indexed on a Reference Manager database according to five criteria: how we identified them, philosophical basis, research tradition, relevance to our review (high, medium, low), and study design.

We identified seminal sources (often books) in each meta-narrative by asking what were cited as key original and scholarly contributions by other researchers in the same tradition. We extracted from these the concepts, theories and preferred methods that formed the criteria for rigor in each meta-narrative, and we used these to guide our appraisal of empirical studies. We gave great weight to studies that had been flagged as 'high quality' by other scholars in a tradition, but because the literature included a wide range of different paradigms, perspectives and study designs, we did not use a formal quality scoring system. In a synthesis phase, we compared and contrasted the different meta-narratives and exposed tensions and paradoxes; and we sought explanations for these in terms of how researchers had conceptualized the world and chosen to explore it.

As we had found previously, the meta-narrative method was an iterative and at times messy affair, with several false starts to the classification scheme and uncertainty about the quality and relevance of papers in traditions unfamiliar to us. In most but not all cases a high degree of agreement between reviewers was eventually reached as the different meta-narratives took shape. We initially planned to produce formal inter-rater agreement scores but in reality the

process was a highly constructivist one in which ongoing dialogue among us was essential for achieving accommodation between our separate interpretations and iteratively revising both our own taxonomy and where each paper was classified within it. The study flow chart is shown in Figure 1.

FIGURE 1 ABOUT HERE

Main findings

Overview and historical roots

We found a complex and heterogeneous literature characterized by diverse philosophical assumptions about the nature of reality (ontology), how that reality might be known (epistemology), and the preferred research approaches and study designs (methodology). Adapting and extending previous taxonomies (Orlikowski and Baroudi 1991; de Vaujany 2005), we identified four main philosophical positions:

- *Positivist*, which assumes an external and knowable reality that can be objectively measured; an impartial researcher; and the possibility of producing generalisable statements about the behaviour of the natural and social world;
- *Interpretivist*, which assumes a socially constructed reality that is never objectively or unproblematically knowable, and a researcher whose identity and values are inevitably implicated in the research process;
- *Critical*, which assumes that the social order is inherently unstable. In particular, it involves the domination of some groups by others – such as women by men, workers by capitalists or patients by health professionals, and that the purpose of research is at least partly to help these dominated groups challenge their position in society;
- *Recursive* (or *integrative*) which assumes that subject and object, micro and macro, social structure and human agency are reciprocally related, and that the purpose of research is to explore the flux between these various dualities over time.

TABLE 1 ABOUT HERE

These four positions, which are described in more detail in Table 1, overlap to some extent. For example, recursive approaches such as structuration theory were initially developed to build links between the polarized worlds of positivism and interpretivism (Giddens 1984). But leaving aside the philosophical small print, this pragmatic taxonomy provides a useful shorthand for describing in broad terms where the researchers in any particular tradition were coming from

and how they (implicitly or explicitly) defined 'rigorous' research. When we describe each meta-narrative below, we make reference to its philosophical assumptions and values.

INSERT FIGURE 2 ABOUT HERE

Our exploratory reading identified a number of historical roots which informed later research on the EPR (Figure 2), including:

- *Human-computer interaction (HCI),* which developed in the 1970s and 80s, sought to optimise humans' use of computers by linking behavioural science (especially cognitive psychology) with technology design (Dix et al. 2003);
- *Evidence-based medicine (EBM)* emerged in the 1990s from within epidemiology. Its aim is to develop mathematical estimates of benefit and harm from population-based research and apply these in the clinical encounter (Timmermans and Kolker 2004). It takes a firm stance that the best research evidence on medical interventions comes from experiments (preferably randomized controlled trials, RCTs);
- *Symbolic interactionism and ethnomethodology.* Symbolic interactionism views humans as pragmatic actors who deal with social situations by constantly interpreting the behaviour of other actors (by assessing its symbolic meaning) and adjusting their behaviour accordingly (Kaplan 2001). Ethnomethodology developed from this and considers how social action emerges as a moment-by-moment sequence of talk and action, each utterance or move taking account of the previous one (Garfinkel 1967b);
- *Workplace redesign.* This management approach was popular in the 1970s; it sought to improve productivity and wellbeing of workers in industrial settings by making the industrial process more efficient and user-friendly (Mumford and Weir 1979);
- *Safety-critical systems research.* This interdisciplinary field links systems research, software engineering, and cognitive psychology to improve safety in high-risk environments (Perrow 1984). It assumes that such technologies cannot be studied in isolation from the humans who use them or the social contexts in which they are used;
- *The social practice view of knowledge.* This conceptualizes knowledge in organizations not as context-free facts that people (or computers) may possess and transfer between themselves, but as a set of practices that are embodied, socially shared and learned as membership of a community (Brown and Duguid 2001; Lave and Wenger 1991). Knowledge exists in two forms: explicit (formal, codifiable, separable from the person who has it) and tacit (informal, uncodifiable, tied to the person and the situation). Only the former can be stored, accessed or analyzed as decontextualized 'data';

- *Complexity theory.* In a complex system, agents are adaptive and self-organizing, and make multiple and dynamic internal adjustments in response to changes in the external (and internal) environment (Plsek and Greenhalgh 2001). The behaviour of such a system is never fully predictable (and the larger and more complex it is, the less predictable it is), hence unintended consequences occur. Local, real-time feedback allows the system to be understood and actions to be planned.
- *Science and technology studies (previously known as philosophy of science).* Key philosophical contributions over the past 25 years include social construction of technology (SCOT), which rejects the idea that users are passive recipients of technology, arguing instead that people actively *shape* technologies by the meanings they give to them (Bijker, Hughes, and Pinch 1987). Another more recent contribution is actor-network theory (ANT), described in meta-narrative 8 below;

TABLE 2 ABOUT HERE

The above ideas, theories and orientations provided many of the underpinning concepts for the meta-narratives of EPR research summarized in Table 2 and described in more detail below. Understanding these different roots helps to explain the different paths taken by the meta-narratives. Because the health information systems literature (meta-narrative 1 below) has been extensively reviewed, we restricted our analysis of this literature to systematic reviews. Our sample of primary studies is thus skewed towards the non-biomedical literature, so the statistics that follow should be interpreted accordingly.

TABLE 3 ABOUT HERE

The 94 primary studies (written up in 129 papers) outside the health informatics literature were philosophically pluralist, comprising 14% positivist, 19% interpretivist, 22% critical, and 55% recursive. As Table 3 shows, they were also methodologically diverse, with a predominance of case studies of different types. In all, 16% of the sources included in our review (excluding background references) came from searching electronic databases; 43% from pursuing references of references; and 16% from citation tracking (mostly using Google Scholar to identify which subsequent papers had cited a seminal early publication). In addition, 16% of sources were already known to our team; 5% came from our social networks (asking colleagues if they knew of relevant papers); and 5% were serendipitous (finding a relevant paper when looking for something else).

Meta-narrative 1: Health information systems (HIS)

Health [or medical] informatics is the application of computers to clinical work, and health information systems (HIS) research is the study of the systems which support such work (Chiasson, Reddy, Kaplan, and Davidson 2006). This predominantly positivist tradition was developed jointly by doctors with an interest in computers and computer scientists with an interest in medicine (Gardner, Overhage,.Steen, Munger, Holmes, Williamson and Detmer 2009). The tradition is rooted in quantitative approaches and came to be strongly influenced by the ideas and values of EBM, with an emphasis on experimental studies; the preferred design is the RCT. Much (though not all) of it has assumed that the benefits of a well-designed EPR with inbuilt 'evidence based' decision support are intrinsic and self-evident – for example, the EPR will reduce legibility errors and hence make prescribing safer. The key challenge was seen as getting the design right, implementing the technology, and ensuring that clinicians used it. Whilst there is a large literature within health informatics on technical design, this is quite separate from the literature on the implementation and use of such systems in organizations. In the latter literature, at least until recently, neither the technology nor its social context was considered in depth. Empirical studies of 'the EPR' (sometimes, a reified concept) or 'computerized decision support' were grouped together by systematic reviewers in meta-analyses.

Our own searches found 24 systematic reviews in this tradition covering over 2000 primary studies, each of which measured the impact of the EPR on some aspect of the quality, safety or efficiency of care. Of particular note is a recent 600-page 'review of reviews' embracing the EPR and other information and communications technology innovations, which covered 37 previous systematic reviews (Car et al 2008). Car et al found that whilst some primary studies and some but not all systematic reviews showed positive benefits from the EPR, the nature and magnitude of benefits were not consistent across studies, nor were there clear findings on how benefits might be maximized or what their opportunity cost might be. The preponderance of small studies with methodological flaws and positive outcomes in the early HIS literature raises the possibility of publication bias, and we were surprised that none of the reviews in this tradition included an estimate of the extent of this.

Kaplan argued in 2001 that the criteria which many systematic reviewers in the HIS tradition used to select their sample of 'high quality' trials led them to focus on studies in which the very features that might explain the effect of different organizational contexts had been designed out (Kaplan 2001). Perhaps partly in response to this, the HIS literature has begun to move beyond studies that are restricted to measuring impact ('EPR on' versus 'EPR off') and to address how context mediates and moderates this impact. A recent systematic review of 183 primary studies, for example, sought to relate the impact of EPR systems to contextual variables (Shekelle and

Goldzweig 2009). The data suggested a significant difference in the likelihood of success between local 'home grown' EPR systems (developed in an ad hoc way by clinicians close to the operational detail of key work practices), and 'off the shelf' systems (developed either as commercial products or as public-sector systems of choice). 'Home grown' EPR systems typically emerged slowly and at the pace of local enthusiasm, energy and need. Some impressive examples of highly efficient systems associated with improved quality and safety of care in world-leading centres of excellence were found (one notable example being the US Department of Veterans' Affairs which introduced a paperless record system and documented significant improvements in health outcomes following this (Kupersmith, Francis, Kerr, Krein, Pogach,.Kolodner and Perlin 2007)). However, the reviewers concluded (page 5) *"these [home-grown] interventions are by nature not widely generalisable"*. 'Off the shelf' EPR systems, on the other hand, were often purchased or acquired as part of a strategy for rapid change (e.g. to solve a perceived pressing problem in the system). These systems typically failed to meet expectations and incurred problems of fit with the detail of work practices. Shekelle and Goldzweig concluded that an EPR system should be considered as a complex intervention with four key components – technical, human, project management and 'organisational and cultural change' – all of which must be systematically studied. This conclusion, implicitly if not explicitly, highlights the need for dialogue between the HIS tradition and some of the other meta-narratives set out below.

Meta-narrative 2: Change management studies within health services research

Researchers in the change management tradition are usually upbeat about the benefits of the EPR but assume that these will only be realized if the change process is properly managed (Heeks, Mundy, and Salazar 1999; Kaplan et al 2001; Lorenzi, Novak, Weiss, Gadd and Unertl 2008). Whilst they sometimes argue that the 'ideal' research design would be a RCT, studies actually undertaken are generally qualitative and built on an interpretivist philosophy. We found 16 empirical studies in this meta-narrative (see Table 2 for details), most of which were single-site or multi-site organizational case studies, each of which had considered the impact of a range of potential enabling or constraining factors on the fortunes of a project to implement a new EPR system. Studies consistently showed that introducing the EPR in an organization or across organizations is a complex task. It requires a well-articulated vision and strategy, strong leadership, adequate resources, good project management, an enabling organizational culture, effective communication, and attention to human resource issues. Even when these preconditions were present, success was not guaranteed – a finding which perhaps reveals the known weaknesses of contingency theories in the study of organizational change (notably that they lack precision and fail to explain much of the observed variance).

Meta-narrative 3: Information systems (positivist approaches)

Information systems (IS) research is a heterogeneous tradition that emerged in business schools to consider the role of technology in business and management. It embraces a longstanding tension between positivist and non-positivist philosophical approaches. In IS research overall, the literature is dominated by the former and is characterized by hypothesis-driven designs predicated on what are sometimes called 'variance models' (DeLone and McLane 1992; Sabherwal, Jeyaraj, and Chowa 2006). But very few such studies have been published on the EPR, perhaps because of the complexity and unpredictability of healthcare work and the highly institutionalized nature of the healthcare sector (DeSanctis and Poole 1994). We found only three empirical studies in positivist IS research relevant to our research question (listed in Table 2), all of which demonstrated that model-based analyses of the determinants of EPR success left much of the observed variance unexplained.

Meta-narrative 4: Information systems (interpretivist approaches)

The interpretivist perspective holds that the use, design and study of information systems is fundamentally a hermeneutic (meaning-making) process rather than a rationalistic, decision-making one (Boland 1979). We found 11 studies in this tradition, including papers that drew on institutional theory (Currie and Guah 2007), symbolic interactionism (Prasad 1993), organizational sensemaking (Brown and Jones 1998; Desjardins, Lapointe, and Pozzebon 2008), and 'soft systems' action research (Checkland and Holwell 1998). These different applications might justify splitting this meta-narrative further into a number of sub-narratives. However, the findings were highly consistent across studies: there are multiple and conflicting framings of the EPR by users (assumptions about it, expectations of it, versions of the problem to which it is seen as a solution), some of which are explained by deeply-held institutional values (e.g. what counts as 'professionalism' amongst doctors or what is seen as 'good nursing care'); these contrasts partly explain the low adoption and slow spread of the EPR in many healthcare settings. 'Successful' implementation requires accommodation between perspectives. Externally-imposed deadlines and technical requirements constrain the process of mutual adaptation by which technologies and work processes become aligned.

Interpretivist approaches are popular in some academic circles, and the retrospective studies cited above offer novel explanations for failed EPR projects. However, there appears to be surprisingly little peer-reviewed research on how interpretivist approaches might be used proactively and explicitly to shape effective implementation and use of EPR systems, especially in large-scale programmes. This may be partly because such studies are highly applied and necessarily pragmatic (hence the criteria for 'rigour' differ from those in more experimental traditions), and the change agents who facilitate the process of soft-systems design or technological co-design sometimes present themselves as consultants rather than academics.

Meta-narrative 5: Information systems (technology-in-practice approaches)

Most studies in this tradition are linked to the work of Wanda Orlikowski and her team who applied Giddens' structuration theory (see glossary) to the introduction of technologies in organizations. Steve Barley's classic demonstration back in 1986 that a new technology introduced into the workplace is an 'occasion for structuring' offered high hopes for the study of a new generation of technologies in the healthcare sector (Barley 1986). His widely-cited work suggests that a structurational approach to the study of the EPR could potentially show how this technology might shape and support new roles and new ways of collaborative working which would then become routinized, with positive impacts on patient care and clinical outcomes as well as effective embedding of the EPR in organizations. Our findings suggest that these hopes have yet to be realized. The eight empirical studies identified provide examples of abandoned EPR systems (Sicotte, Denis, Lehoux, and Champagne 1998), widespread disruption of routines and mismatch of expectations (Davidson and Chiasson 2005; Mogard, Bunch, and Moen 2006), continuing dependence on paper or ad hoc, non-integrated EPR systems (Østerlund 2002); and distortion of organizational response by the prevailing political and financial context of a nationally imposed programme (Rodriguez and Pozzebon 2006). So far, then, the EPR has not been an 'occasion for structuring' in any simple sense.

The largely negative findings from this handful of studies nevertheless provide some important insights. Orlikowski and her colleagues have demonstrated that individuals, working collectively around common tasks in organizations, actively and explicitly shape both technologies and work routines in a way that is mutually adaptive (Orlikowski, Yates, Okamura and Fujimoto 1995). It would appear that in relation to the EPR, this adaptation is not happening – or at least, not happening smoothly or unproblematically. Key influences on the structuration process include the affordances (see glossary) of the technology, the constraints of time and space, the conflicting meanings attached to the EPR by different groups, the patterns of human action and interaction associated with them, and how different 'genres' of medical records are used and combined in both traditional and contemporary patterns of care. 'Failed' EPR projects may be explained by adverse changes in the temporal or spatial structuring of work consequent on introducing new technology, the fact that knowledge is linked in complex ways to identities and social practices, and limitations of the available technology. As the CSCW literature (see below) has also shown, healthcare work is uniquely complex and dependent on the coordinated practice of multiple actors. Research to date has barely scratched the surface of what the introduction of the EPR means, at the level of fine-grained detail, for a healthcare organization and the staff and patients who practice and interact in that setting – and still less so when the EPR is part of a large-scale regional or national program.

Meta-narrative 6: Computer-supported cooperative work (CSCW)

CSCW developed from human computer interaction and considers the collaborative use of computers by people in the workplace (Ackerman 2000; Grudin 1988). It draws eclectically and pragmatically on both positivist approaches such as distributed cognition (the study of how knowledge and computation is shared between various human brains and computers) and interpretivist and recursive ones such as situated action (the study of how action is an ongoing accomplishment achieved by attention to local, situated detail). The preferred research design is the ethnography of the 'situated micro-practices' (i.e. the localized detail of what is done) of collaborative work, focusing on such things as the sequential ordering of utterances or actions and the indexicality of entries on the record (i.e. which other entries an entry implicitly refers to).

We found 11 empirical studies on the EPR in this tradition; in addition, meta-narratives 7, 8 and 9 draw on the principles of CSCW. These rich ethnographies have illustrated, often in meticulous detail, that collaborative clinical work involves the ordering and coordination of tasks, which requires real-time processing of local information. They have shown that clinical knowledge is often tacit, context-bound and ephemeral rather than codifiable, transferable and enduring. In 'failed' EPR projects, technical designers typically missed these subtleties and produced artefacts that fitted poorly with the situated nature of knowledge and the micro-detail of clinical work practices. Paper records, being flexible, portable and tolerant of ambiguity, support the complex work of clinical practice remarkably well. CSCW studies have highlighted a telling paradox – that high-tech healthcare environments such as intensive care units often make extensive use of paper charts, white boards, sticky notes, and oral communication.

Despite its apparently negative conclusion that the EPR is often *less* fit for purpose than paper, the CSCW literature on the EPR is not anti-technology, for three reasons. Firstly, it has shown that humans can be very creative in overcoming the inherent limitations of technologies ('workarounds'). This tradition surfaces and values the 'hidden work' that achieves positive outcomes despite the inflexibility of technology (Suchman 2007). Secondly, the EPR can provide multiple views and framings of the data hence can *potentially* tolerate (and overcome) the ambiguities inherent in interprofessional work and make the work of different professional groups more visible to others (Reddy, Dourish and Pratt 2001). There is considerable scope for more flexible and technologically sophisticated forms of the EPR (e.g. mobile devices) to overcome current limitations. But for this to happen, technology [re]design must occur in intimate proximity to the work process and actively involve users and potential users of the EPR (Hartswood, Procter, Rouncefield, and Slack 2003a; Oudshoorn and Pinch 2005).

Thirdly, CSCW researchers have recognized two potentially conflicting work processes: immediate clinical care (primary uses) and tasks such as audit and research which are one step removed from the clinical encounter (secondary uses) (Heath and Luff 1996; Symon, Long, and Ellis 1996). When used as a formal tool (e.g. with structured templates and a requirement for data to be coded), the EPR often slows down and frustrates the clinical encounter, but it greatly accelerates the secondary uses of clinical data. Rather than promising that the EPR will "save time" or "make clinical care more efficient", a more honest message would be that creating accurate and complete clinical records requires the sacrifice of time and effort by front-line clinical and administrative staff, but that this is (sometimes) justified by the wider benefits in terms of efficient business processes (e.g. billing), governance, and research. Appropriate incentive structures are needed to ensure that those who do the work reap appropriate rewards (Berg 2001; Pratt, Reddy, McDonald, Tarczy-Hornoch and Gennari 2004).

Meta-narrative 7: Critical sociology

This meta-narrative draws on the work of feminist scholars and the philosopher Michel Foucault on power (Schneider 2006; Willcocks 2006). In sum, technologies reflect the interests and values of those who produce them, hence power struggles between bosses and workers, clinicians and managers, men and women, and the state and the citizen are played out partly through the design and use (or, indeed, non-use) of technology (Zuboff 1988). The EPR may be a focal point around which disputes of professional jurisdiction are fought.

We found nine studies from a feminist perspective and three from a Foucauldian perspective. Feminist studies have demonstrated that EPR designers have sometimes failed to understand or fully incorporate the work practices of female staff with relatively low status in the organization, especially front-line nurses. They have also shown that nurses' work (which is largely unpredictable, close to the patient and difficult to standardise or codify) maps closely to what the CSCW community view as *articulation*: the situated actions of creative human agents that can potentially bridge the gap between the formal and the informal, the social and the technical. Thus, whilst some findings appear largely negative and unsurprising (that nurses may 'resist' technology and see it as marginal to their work), the feminist literature also offers a more positive insight – that there is an important, subtle and largely unexplored territory of 'hidden work' by groups such as nurses, administrators and data entry clerks which demands further research and offers potential for systematically exploring and addressing the theory-practice gap in healthcare.

The three studies from a (broadly) Foucauldian perspective link the introduction of the EPR with the rise in managerial surveillance and control of clinical work, and draw on Foucault's concept of the panopticon – that is, an increasing capacity for large-scale surveillance of human activity,

supported by technology but also embodied and policed by the actors concerned. The story is more complicated, however, than an inexorable growth in the oppression of clinicians by management (or patients by doctors), aided by technology – not least because Foucault's definition of power was a more fluid and generative one than this. One ethnographic study, for example, showed that not only did nurses successfully defend their professional practice in the face of a technical system that sought to 'managerialise' it, but also that managers accepted the nurses' account of what was legitimate and valuable and actively colluded with the latter's resistance to a poorly-designed technology (hence paper's title 'The failed panopticon') (Timmons 2003b).

Meta-narrative 8: Actor-network analyses

Actor-network theory (ANT) is built on a recursive philosophy (Latour 1992). It holds that people and technologies are linked in networks, and that the focus of research should be the network's changing relationships and what emerges from these (rather than either the people or the technologies themselves). ANT has been applied in numerous ways, often in combination with other theories. It has been widely criticized, for example for assuming that human and non-human 'actors' can be treated as equivalent (Mutch 2002). Nevertheless, ANT has much to offer EPR research, especially since it is possible to draw on its core concepts while rejecting some of its more extreme assumptions.

An actor-network analysis is a special type of case study in which researchers define and explore a dynamic network of people and technologies as it evolves over time. As Table 2 shows, we found 12 such studies of the EPR, all of which drew on CSCW as well as ANT, plus two empirically-informed theoretical papers from ANT (Iedema 2003; Moser and Law 2006).

Many 'findings' in this meta-narrative are conceptual; they invite us to think differently about the EPR, the EPR user, and the context in which the EPR is implemented. The EPR is not merely a container for information; it accumulates and transforms work (is 'constitutive' of it), and is thus an actor (or 'actant') in the network. The studies consistently demonstrated that the socio-technical network in which the EPR is embedded is typically highly dynamic and inherently unstable. An actor-network can be stabilized to some extent when people, technologies, roles, routines, training, incentives, and so on are aligned. This alignment is achieved (or at least, attempted) through what is known as 'translation', which involves the four stages of problematisation (defining a problem for which the EPR is a solution), interessement (getting others to accept this problem-solution), enrolment (defining the key roles and practices in the network), and mobilisation (engaging others in fulfilling the roles, undertaking the practices and linking with others in the network) (Callon 1986).

Conceptualized from the ANT perspective, EPR projects 'fail' when the elements in the network fail to align – that is, when efforts at translation fail. Codes and standards inscribed in the EPR and its infrastructure may help to stabilise the network and thus shape and constrain medical and nursing work. The various actor-network analyses in this meta-narrative describe the struggles (sometimes successful, sometimes not) of groups of actors who have sought to define and inscribe particular codes and standards into particular EPR technologies, and show how once these have become part of the network, they are hard to reverse and both shape and constrain clinical work. Actor-network analyses of EPR technologies are highly regarded and extensively cited in the field of science and technology studies but have been either ignored or dismissed by most previous systematic reviews on the EPR. The reason for this is probably that ANT papers are often complex, based on very different assumptions and values from most of the biomedical literature (see Table 1), expressed in a language with which most doctors and healthcare managers are unfamiliar, and lacking in clear, unambiguous messages on 'what to do'. However, Berg (among others) has worked hard to make this tradition accessible to health professionals and policymakers (Berg 2003; Berg, Aarts, and van der Lei 2003).

Meta-narrative 9: Systems approaches to risk and integration

As described in meta-narrative 1, much of the health informatics research tradition has been oriented to designing EPR technologies which will improve patient safety by overcoming fallible human practice. Another, largely distinct, research tradition draws on safety-critical systems research and insights from other industries (notably aviation) to address the role of the EPR and the EPR user in complex, 'high-tech' healthcare systems. Such systems are characterised by advanced technology, tight coupling (e.g. B must follow A and in a particular time sequence), and a high level of uncertainty, and – by virtue of all these – they are vulnerable to unpredictable, catastrophic failures (Roberts 1990). Accidents arise, rarely but inevitably, from the accumulation of such things as 'minor' errors of judgement, flaws in technology, and small incidences of disrepair or damage (Perrow 1984). Successful high-reliability organisations are characterised by mindfulness – that is, an ever-present awareness amongst staff of the possibility of error and to the ongoing measures that must be taken to minimise it; over-reliance on technical systems may erode this.

We found 22 primary research studies in this tradition, along with an interdisciplinary literature review that was thorough but not explicitly systematic (Ash, Berg, and Coiera 2004). Overall, this meta-narrative provides considerable evidence that whilst EPRs may contain features that protect against error, they also introduce new risks of their own, including cognitive overload, loss of overview, errors in data entry and retrieval, excessive trust in electronically-held data, and the tendency to conflate data entry with communication within and between care teams

(Ash, Sittig, Dykstra, Campbell, and Guappone 2009; Weiner Weiner, Kfuri, Chan and Fowles 2007).

One body of work proved hard to categorise into a single meta-narrative because its authors explicitly sought to work across different research traditions. This work has been developed by a Norwegian group who drew on CSCW, ANT, and systems theory to study large, networked EPR systems and the challenges of standardisation, integration and scalability within these (see for example (Ellingsen and Monteiro 2003b; Ellingsen and Monteiro 2003c; Ellingsen and Monteiro 2006; Hanseth, Jacucci, Grisot, and Aanestad 2006; Hanseth and Monteiro 1998; Hanseth and Monteiro 1997; Monteiro 2003)). We have placed this interdisciplinary work in meta-narrative 9 in Table 2. An important finding from these authors' work is that networked EPR systems are not unproblematically scalable. The tension between standardisation (which helps stabilise the network) and contingency (which reflects and responds to local needs and priorities) can never be resolved; rather, it must be actively and creatively managed – and this gets harder as the network gets bigger. As predicted by the principles of complexity theory, over-assiduous efforts to 'standardise' or 'integrate', especially on a sizeable scale, are likely to create disorder (and thus generate work) elsewhere in the system (Berg and Timmermans 2000). Because of unpredictability, unintended consequences and the loss of potential for using information in a locally meaningful and situated way, large-scale distributed EPR systems are likely to be less efficient, less cost-effective, less safe and the information they contain less trusted, than smaller, more local systems (Ellingsen and Monteiro 2003b; Hanseth et al 2006; Hanseth and Monteiro 1998; Hanseth and Monteiro 1997; Monteiro 2003). Hanseth has added theoretical weight to these empirical findings (Hanseth 2007).

Synthesis

Because this heterogeneous literature is based on different philosophical assumptions and world views, a meaningful synthesis must not merely summate the findings of different meta-narratives but present the tensions and conflicts between them as higher-order data. We consider below seven key themes, each of which has inherent tensions. Most but not all of the tensions are between studies which take a positivist world view (broadly, meta-narratives 1 and 3) and those which take an interpretivist, critical or recursive world view (broadly, meta-narratives 2 and 4-9), though some traditions (notably CSCW) embrace more than one philosophical position.

The EPR

The first tension is between 'the EPR as tool or container' and 'the EPR as actor'. Positivist traditions tend to take an essentialist, functionalist and determinist view of the EPR (it has inherent properties which will do certain tasks, and if implemented properly, will more or less predictably improve the process and outcome of the clinical encounter). In contrast, non-

positivist traditions view the EPR either as a social construction (something whose meaning and purpose is a matter of interpretation) or as a fluid and flexible artefact which 'acts' (to use the language of ANT) in particular, situated and constantly changing contexts. If these latter two views (built, respectively, on an interpretivist and recursive philosophy) are accepted, it follows that the impact of introducing an EPR cannot be predicted from its essential properties, and hence that studies which seek to 'determine the [generalisable] impact of technology X on outcome Y' have limited value.

Positivist traditions hold that the patient's condition and journey comprise a single reality to be represented in the EPR, and hence seek a single ideal and 'agreeable' form of the record. Multiple 'front ends' of the record are allowable (for example, nurses might be more interested in some data fields and doctors in others), but the underlying *reality* represented by the record is generally considered to be unitary, context-free and unproblematic. Interpretivist and recursive traditions hold that the very notion of an 'agreeable' EPR (or a single reality represented by it) is problematic. As one seminal paper put it, the EPR's bodies are multiple (Berg and Bowker 1997).

Research traditions differ in the emphasis they place on the material properties of the EPR. Positivist systematic reviews typically offer comparisons of the general format 'EPR present' versus 'EPR absent' or 'decision support on' versus 'decision support off'. Similarly, the interpretivist literature has generally placed more emphasis on the meaning of the EPR in the eyes of users and potential users than on what the EPR can and cannot do in particular conditions of use. In contrast, research in recursive traditions (much of CSCW, as well as technology-in-practice and ANT) place the material properties of the EPR (and indeed, the material properties of paper, desks, white boards and so on) central to their analysis. Critical sociology and ANT studies assume that power relationships are (at least to some extent) built into the structure and data models of the EPR. The feminist literature, for example, talks of the "gender scripts" inscribed in technology (Henwood and Hart 2003), and ANT gave us the powerful metaphor of software as "frozen organisational discourse" (Walsham 1997).

The EPR user

There is a tension in the literature between a cognitive view of the human subject (the user is seen as an information-processer or decision-maker) and a relational view (the user is defined primarily by his or her position within a social or socio-technical system). The former perspective explains non-use of the EPR in terms of a 'knowledge gap', 'skills gap' and 'motivation gap' (hence as attributes of the individual actor) for which much of the solution comprises the provision of information, training and incentives. The cognitive view assumes, broadly, that the outputs of a group of people using technologies will be the sum of their individual inputs. The

latter view the EPR user as inextricably linked to (indeed, as embodying and reproducing) wider social structures, institutions or socio-technical relationships (and hence, perhaps, as 'shaping' the EPR rather than 'using' it), and thus sees the collective as more than the sum of its parts. Whilst different language is used in different traditions ('ensemble', 'situated', 'embedded', 'accommodated', 'networked'), there is much common meaning between these terms, and all place greater emphasis on system-level approaches than on interventions aimed at the individual.

One key difference between two traditions which otherwise have much in common – technology-in-practice (meta-narrative 5) and ANT (meta-narrative 8) – is the treatment of the human agent. Technology-in-practice draws on structuration theory and places human identity and agency central to the analysis; it offers a sophisticated theory about what agents 'know' (which, crucially, includes internalized social structures). ANT, in contrast, considers agency to be a *product* of the network rather than something intrinsic to the individual actor, hence such things as knowledgeability and motivation are only weakly and indirectly theorized (Mutch 2002).

Organizational context

One of the most striking differences between the research traditions covered in this review is their treatment of context. The tension might be expressed as 'context as the setting within which the EPR is implemented' and 'context as the EPR-in-use' (reflecting the difference in focus between 'the organization as the place where work happens' and 'the process of organizing, wherever it happens'). The positivist literature effectively views context as a conglomeration of confounding variables, which must either be carefully quantified and modelled, or controlled for in a RCT design. This approach to context must overcome the challenge of repeating decomposition – i.e. the sheer impossibility (especially in the highly complex of field of healthcare) of incorporating anything approximating the fine-grained detail of the numerous contextual variables into the analysis (DeSanctis and Poole 1994). Critical research traditions also tend to view context as an external reality, in this case made up of economic and social structures that constrain action (and which do so in an unequal and potentially oppressive way).

The recursive (and to some extent the interpretivist) research traditions have in common a more inclusive, holistic and fluid view of context. Context is seen as an emergent property of action – that is, constituted by, and therefore inextricable from, an activity involving people and technologies. Researchers in these traditions do not see themselves as studying 'technologies' and 'contexts' separately but technologies-in-use. Indeed, this inseparability of the EPR from its context (the fact that context is constituted by the EPR-in-use) is a defining characteristic of literature that adopts a recursive philosophy.

Clinical work and knowledge

The tension here might be expressed as 'clinical work as decision-making' versus 'clinical work as situated practice', and between 'knowledge as transferable facts' versus 'knowledge as information-in-context'. Positivist traditions tend to view clinical work as largely reducible to a series of decisions, and it follows that decision support technologies will help clinical work so long as they are properly designed and implemented. The alternative view is that clinical work is less about decision-making than it is about addressing the ongoing, local question "what to do next?" (Garfinkel 1967a), and since healthcare work is personalized, exception-filled and context-bound, *"the nature of health care work sets natural limits to the possibilities of IT to revolutionize this work"* (Berg 2003, page 337).

The conclusion reached by this alternative literature is not merely that the considerable research energy and resources that have so far been put into refining and testing decision-support systems and other algorithmic components to the EPR have not substantially improved the quality or efficiency of front-line clinical work *yet*: the conclusion is that they are unlikely ever to produce dramatic gains in these areas. The alternative literature suggests that gains in the quality of care with EPR systems are likely to be *relatively* modest, incremental, local, and based on the study of articulations and workarounds (i.e. of the creative human work that bridges the gap between technical design and clinical reality), though this view still recognizes the major potential efficiency savings which EPR systems offer for secondary uses.

Different traditions in EPR research dispute the extent to which information placed on the EPR can be extracted from its context and transferred to a different context while still retaining its meaning. The biomedical literature sometimes talks of "information superhighways" that will make clinical information instantly available in a way that transcends the context in which that information was originally collected (Detmer 2000). The idea that meaning is transmitted unproblematically along with data underpins many of the large-scale EPR programs currently underway (notably the National Programme for IT in England (Department of Health 2008) and the plans for an extensive expansion of the IT infrastructure in the USA (Institute of Medicine 2009)), but critics of this type of program claim that this is a flawed assumption (Berg 2000). The CSCW, technology-in-practice and ANT literatures all offer evidence that clinical data must be interpreted in context and 'framed' before they become meaningful. Thus, whilst positivist studies of collaborative clinical work view it as largely to do with the exchange of information between distributed decision-makers (human and technological), interpretivist and recursive models place much greater emphasis on *communication,* one aspect of which is contextualising work (prioritising, highlighting, comparing, contrasting, pointing out trends over time, interpreting, negotiating, and other tasks not achieved simply by placing information on an electronic platform

that is accessible by multiple users) (Hartswood, Procter, Rouncefield, Slack, and Voss 2003b; Symon, Long, and Ellis 1996).

The process of change

The tension might be expressed in terms of the 'logic of determinism' versus the 'logic of opposition' (Robey and Boudreau 1999). Taken to its extreme, the logic of determinism is technology-focused, causalist (technology X will produce output Y, and Y can be measured) and fundamentally linear (it recognises complicatedness but not complexity (Plsek and Greenhalgh 2001)); it assumes that the human interactions and organizational context within which technology is used will operate on the same formal and predictable technical principles as the technology itself. In such a model, the change process is one of 'good project management': setting clear strategic goals and ensuring that all parties work systematically towards these.

The logic of opposition, on the other hand, is fluid, contingent, and contains inherent and unresolvable tensions. These tensions are variously expressed in terms of 'competing institutional logics' (Scott 2001), the need for 'accommodation' (Checkland and Holwell 1998), 'sensemaking' (Weick 1995), 'negotiating knowledge between different communities of practice' (Lave and Wenger 1991; Østerlund and Carlile 2005), or 'translation' (Latour 1992) – approaches which have much conceptual common ground (Fox 1999; Weber and Glynn 2006). If this logic is adopted, it follows not merely that the change model will be neither linear nor predictable – but also that there will be *conflict* involved. Whilst good project management is a *sine qua non*, the key task is to manage an essentially political process in a flexible and reflexive way as the drama unfolds.

One aspect of the process of change that is addressed very differently between positivist and interpretivist/recursive traditions is design. As indicated in Table 1, there are, broadly speaking, two opposing philosophical positions on design: the conventional approach (whose roots are in positivism and whose focus is on engineering) and the participatory approach (whose roots are in interpretivism and whose focus is on social meaning). Hartswood et al (2003b) offer a particularly eloquent exposition of the principles of co-design, and call for the development of 'shared practice' between designers and users. Berg talks of "growing" rather than building information systems and working to achieve synergy between three fundamental [re]design tasks: the technical system, the primary work process (e.g. clinical care), and the secondary work process (e.g. audit, management) (Berg 2003).

The impact of change – and the definition of success

The EPR tends to be introduced as part of a project or program, whose success is generally (though not always) measured by some sort of evaluation. The key tension here is between

'success as objectively and prospectively defined' and 'success as socially negotiated and context-specific'. Positivist traditions generally assume that 'success' can be measured unproblematically in terms of metrics (e.g. does the technology work? what are its uptake and usage rates? how satisfied are users?) (Mitchell and Sullivan 2001); and that transferable 'success factors' can be deduced from empirical studies.

The interpretivist, critical and recursive traditions problematize the very notion of success in an EPR project or program (it will, for example, be defined differently by different stakeholders) (Berg 2001; Klecun and Cornford 2005). These traditions also recognize that the most immediate and easily measurable impacts of a new EPR system (such as increased time to enter data or frustrations stemming from the model-reality gap) may fail to capture more subtle or distant potential benefits (such as the easier and more reliable production of aggregated data or greater capacity for research). Hence, just as the 'success' of a project may be talked up for political reasons, so 'failed' projects should not be dismissed unquestioningly (Berg 2001). Critical traditions argue that the success of an EPR project also has an ethical dimension, asking (for example) who has the power to define what counts as success; who sponsors the evaluation and what are its hidden aims; and whose interests are (and are not) represented in the evaluation (Klecun and Cornford 2005).

Complexity and scale

A final tension in the literature is between 'the bigger the better' and 'small is beautiful'. The former view is frequently expounded in the HIS literature, where just as electronic systems are seen as inherently better than paper, so large, integrated systems are seen as having inherently greater value than small, isolated ones (a ubiquitous truism known as 'Metcalfe's law'). Progress in this meta-narrative is defined in terms of shifting from parochial departmental HIS strategies and goals to institutional, national and even international ones, and the concomitant need to explore new, trans-institutional information systems architectures and standards (Haux 2006). Policy decisions in many countries have tended to accept this view and used it to justify increasingly large-scale EPR initiatives (Kreps and Richardson 2007).

The alternative view is that efficiency gains and economies of scale will never be realized because of the trade-off in loss of local, contextual detail (and hence, loss of *knowledge*) and the magnification of political disputes between stakeholders. This view runs across most of the CSCW, technology-in-practice and ANT literature and is captured in the Law of Medical Information: *"the further information has to be able to circulate (i.e. the more diverse contexts it has to be usable in), the more work is required to disentangle the information from the context of its production. The question that then becomes pertinent is; who has to do this work, and who reaps the benefits?"* (Berg and Goorman 1999). Whilst this rule certainly helps to explain the

failure of numerous large-scale EPR initiatives, a more nuanced version of it may now be needed to account for the uncommon examples of successful ones (see meta-narrative 1).

Discussion and recommendations

Both this review and the recently published 'review of reviews' on e-Health research (Car et al 2008) were written by teams from the UK who were also undertaking empirical research on the National Programme for IT (NPfIT), described by some authors as the largest ever civilian IT project (Brennan 2007; Department of Health 2008). The UK NPfIT appeared to be built on six assumptions: that the EPR (a) is primarily a container for information about the patient; (b) can potentially be integrated seamlessly and unproblematically into clinical work; (c) will increase the effectiveness and efficiency of clinical work; (d) will drive changes in how staff interact with the patient and one another; (e) should replace most if not all forms of paper record, which are old-fashioned and limited; and (f) will provide greatest added value the more comprehensive and widely distributed it is.

Much of the literature covered in this review suggests, conversely, that (a) the EPR may be alternatively conceptualized as an 'itinerary', 'organizer' or 'actor'; (b) seamless integration between different EPR systems is unlikely ever to happen because human work will always be needed to bridge the model-reality gap and re-contextualize knowledge for different uses; (c) whilst secondary work (audit, research, billing) may be made more efficient by the EPR, primary clinical work is often made less efficient; (d) the EPR may support, but it will not drive, changes in the social order of the workplace; (e) paper will not necessarily disappear as it offers a unique level of ecological flexibility (though workable paperless systems have been developed in one or two centres); and (f) smaller, more local EPR systems may often (though perhaps not always) be more efficient and effective than larger ones.

Our findings suggest seven areas where further research is likely to add significantly to the knowledge base. Some of these would benefit from secondary research, since there are valuable findings already in the literature.

First and foremost, there is an agenda for *theory-building*. It is striking that many of the alternative approaches to research on the EPR in organizations uncovered in this review have developed in parallel rather than in dialogue with one another. Whilst there is in our view no need for a new 'grand theory', there is certainly scope for developing creative theoretical and methodological approaches by blending existing theories. In particular, some researchers (including our own group) have already begun to combine ANT with a more sophisticated theory of human agency (Greenhalgh and Stones 2009).

Second, there is an extensive primary research agenda on what has been called *"appreciating situated micro-practices"* in different clinical settings (Ellingsen and Monteiro 2006), page 444. The research conducted to date on the micro-detail of collaborative clinical work from an ethnographic perspective appears to comprise fewer than 20 studies in total. There is much we do not yet know, for example, about what 'working knowledge' *is* or how it is produced in different clinical settings and specialties (Ellingsen and Monteiro 2003c). The 'hidden work' of those close to the patient (e.g. nurses and administrative staff) should be a particular focus in this program. There is much scope for detailed study of the communicative dimensions of collaborative clinical work, including how staff contextualise and prioritize knowledge for shared use.

Third, a systematic review is needed on *how information systems in healthcare and comparable settings might be [co-]designed in the workplace* (i.e. on the proactive application of interpretivist and recursive approaches to maximise the socio-technical fit of such systems). This literature was partially covered in this review but we believe there is a need for a more technically-oriented review by an interdisciplinary team with representation from software engineering, design and CSCW as well as sociology and clinical disciplines. Important insights are likely to be drawn from the computing and design literatures beyond the healthcare setting. There is also scope for additional primary studies in this area. This review identified a number of studies on how actors made sense *retrospectively* of EPR projects, but very few published studies in which a sensemaking or soft-systems approach was used *prospectively* in action research or comparable participatory designs. This may be partly because such studies are notoriously difficult to write up as short, focused case studies for academic journals. It may also be because funding for such studies is hard to come by. We recommend that careful thought be given to developing hybrid funding streams from research and service in this area, with a view to developing and disseminating some case examples of what has been called 'engaged scholarship' (Van de Ven 2007).

Fourth, the dramatic differences in success between 'off the shelf' (commercially developed) and 'home grown' EPR systems, and the question of whether and in what circumstances 'small is beautiful' in EPR systems, demand further critical exploration. This review found no evidence that large-scale commercial IT systems in healthcare produce the benefits anticipated by their architects, and a few high-quality studies which suggest that they do not. But we also found recent evidence that if EPR systems are developed organically and in-house, scale *per se* may not be a bar to their success. Prospective, theory-driven primary studies of large-scale EPR systems are urgently needed, and should be undertaken from an interdisciplinary perspective that includes systems engineering, economics, business and management, and clinical

disciplines. This program could include the question of how small-scale, home-grown, modularized systems that support effective collaborative clinical care in local settings could be interfaced with other small-scale systems so as to achieve multiple objectives (local information sharing, local research, and also secondary uses of data at regional and national level).

Fifth, there is a need for a systematic review on the *ethics and practicalities of data sharing*. We identified some important papers on this topic but put them aside because of the resource and time constraints of this review. Such a review should cover topics such as the balance between technical security and accessibility; the nature of the trust relationship between the individual, the clinician and the EPR; the desire (or not) of patients and citizens to view data held on them; the changing dynamics of the clinical relationship as information inequality is redressed; and the involvement of patients, citizens and civil liberties groups in influencing policy in this area.

Sixthly, and perhaps as a cross-cutting theme in all the above areas, the realpolitik of EPR projects within and between organizations and interest groups should be more explicitly explored. ANT offers one (but not the only) theoretical perspective for addressing this. More generally, Orlikowski and Yates have called for more research on the *"messy, dynamic, contested, contingent, negotiated, improvised, heterogeneous, and multi-level character of ICTs in organizations"* (page 132) (Orlikowski and Yates 2006). We suggest that sponsors and publishers eschew sanitized accounts of successful projects and instead invite studies of the EPR in organizations that "tell it like it is" – perhaps using the critical fiction technique to ensure anonymity (Winter 1986).

Finally, given the mismatch between what is known about the EPR in organizations and what many policymakers *assume* is known, there is also scope for research that addresses this mismatch. This review has covered a contemporary policy issue characterized by a vast (but at the same time, ambiguous, conflicting and incomplete) evidence base which both practitioners and policymakers (including those who set research policy) need some guidance to make sense of. The role of the systematic reviewer in this process is itself worth studying, since very little research on knowledge translation to date has addressed such turbulent waters.

This review has also identified some areas where more research does *not* appear to be needed – either because definitive findings have already been produced in those areas or because, for epistemological reasons, there never will be definitive findings (or any real hope of reducing uncertainty beyond its current level). We believe there are three such areas. The first is simplified experimental studies based on functionalist and determinist assumptions of the general format "what is the impact of technology X on outcome Y?" or variations thereof. We are not suggesting that such designs are never justified, but that the circumstances in which they

add value are more limited than is often assumed. Secondly, we believe that surveys of attitudes of patients or staff towards 'the EPR' or 'computerization' which are not adequately contextualized have almost no enduring value. Finally, we caution against under-theorized qualitative studies of 'failed' (or indeed, 'successful') EPR projects. Whilst it is relatively easy to interview a range of stakeholders and ask their views, more studies which show (for example) that leadership and vision are better than no leadership and no vision are unlikely to add to the evidence base. Funding for qualitative case studies on the EPR should be directed at studies which will enrich our theoretical understanding of this uniquely complex field.

The meta-narrative method was developed in a previous study by our team to synthesise heterogeneous research literature on a complex topic (Greenhalgh et al 2004; Greenhalgh et al 2005). This method allowed us to tease out a number of different streams of research and show how seminal books and papers in each tradition inspired programmes of theory-building and empirical research. It also allowed us to compare and contrast these traditions in a structured way as illustrated by Table 2. This review confirmed that even in the 21st century (where the work of researchers in other disciplines is readily accessible), most established scientists, most of the time, still operate largely within a single epistemic community and focus primarily or exclusively on the research questions that are being addressed by a relatively small group of colleagues.

However, we also found that some researchers explicitly made links with other communities and applied concepts and theories from these. In some cases this led to scholarly interdisciplinary research, higher-order insights and the emergence of new paradigms (Ellingsen and Monteiro 2003c; Fox 1999; Østerlund 2004b). In other cases, discipline-hopping produced a study that claimed allegiance to one research tradition but operated on the assumptions of another, or which used a methodological approach that sounded appropriate but which had not been applied rigorously or consistently. Some papers claiming to be seminal (and sometimes cited as such) offered little more than an incoherent list of concepts and jargon phrases. Whilst such confused efforts at scholarship are a fact of academic life these days, the meta-narrative approach allowed us systematically to identify the distorted concepts and flawed reasoning contained in them.

Conclusion

When we embarked on this review, we did not set out to provide an exhaustive account of all research ever undertaken on the EPR or its implementation in organizations. Our goal was more ambitious: we sought to illuminate and challenge the way researchers think. The meta-narrative method has shown that 'conflicting' findings in this large and heterogeneous literature can be

fruitfully expressed in terms of tensions and paradoxes relating to the nature of the EPR, the context in which it is implemented and used, and the way success in an EPR program is defined and pursued. Whilst it is tempting to present the mainstream (traditionally positivist) biomedical literature as incommensurable with, and perhaps philosophically less sophisticated than, studies written from interpretivist, critical and recursive positions, the latest evidence suggests a less polarised picture. Studies from within the health informatics tradition, as well as those outside this tradition, for example, are raising questions about both the scalability and the transferability of EPR systems – especially when such systems are developed commercially rather than grown organically as part of an emergent change effort (Shekelle and Goldzweig 2009).

An interdisciplinary debate on priorities for EPR research and policy with input from academics, service users, clinicians, policymakers, technical designers, research sponsors and the commercial IT sector is urgently needed. We offer this review as a preliminary contribution to that debate, not as the last word on it.

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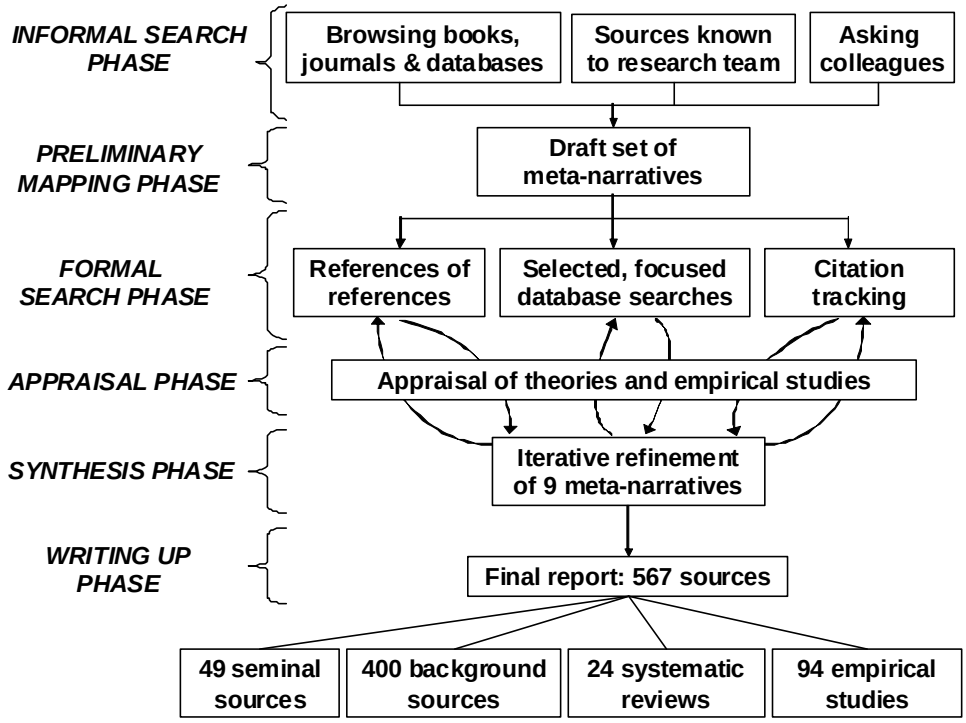
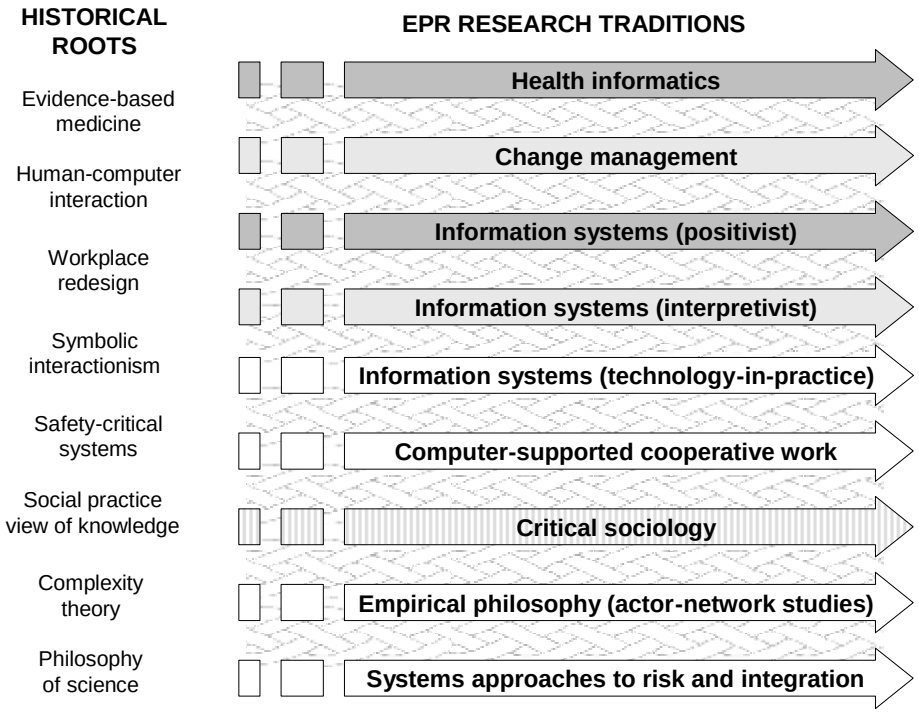
Figure 1: Summary of phases in the meta-narrative review



See Glossary for definitions

Figure 2: Some historical roots and research traditions in EPR research



Note: The historical roots on the left hand side of the diagram do not link in a simple, linear way with the meta-narratives on the right hand side. Different meta-narratives have drawn eclectically and in different ways on all these roots.

Table 1 Philosophical basis of different approaches in EPR research

Partly inspired by previous work (de Vaujany 2005; March and Smith 1995; Orlikowski and Baroudi 1991). Note: design research is not a central focus of this review but is included for completeness

ASSUMPTIONS & VALUES	POSITIVIST	INTERPRETIVIST	CRITICAL	RECURSIVE (INTEGRATIVE)		DESIGN	
				Technology structuration theory	Actor-network theory	Conventional (roots in positivism)	Participatory (roots in interpretivism)
Ontology (assumptions about the nature of reality)	A single reality. Knowable, probabilistic	Multiple realities, socially constructed through symbolic interactionism, framing, and sensemaking	Multiple socially constructed realities reflecting power relations hence influenced by external forces	Multiple realities enacted by social actors, recursively shaped and constrained by macro social structures of signification, legitimation, and domination and by the materiality of technologies	Multiple realities that are recursively shaped and constrained by actants (people and technologies) in the socio-technical network	Multiple, contextually situated alternative world-states. Socio-technically enabled	Co-creation of socially useful artifact through negotiation and sense-making
Epistemology (assumptions about the nature of knowledge)	Knowledge is objective and dispassionate, and has a direct link to reality	Knowledge is subjective, context-dependent, value-laden and emerges from the researcher-participant interaction	Knowledge is subjective, value-laden and critical – i.e. questions how and why the social situation arose as it did	Knowledge is embodied and enacted in particular practices; social structure cannot be directly measured but can be known indirectly via actors' perceptions, understandings and actions	Knowledge is embodied, enacted and generated by social actors who engage in 'translation' as they seek to achieve their goals through particular practices	Knowledge emerges through making and testing-in-reality. Design is objectively-constrained construction within a context. Meaning is revealed through iterative circumspection	Knowledge is subjective, value-laden and emerges through making, which is a social process that requires shared vision and understanding
Role & reflexivity (assumptions about the role of the researcher)	Researcher is a detached observer of truth; no reflexivity needed	Researcher seeks valid, plausible and reflexive understanding of the meanings ascribed by actors	Questioner of the social order	Researcher seeks reflexive understanding of the recursive relationship between the micro (actors' knowledgability and practice) and macro (social structure)	Research is a reflexive performance; researcher seeks understanding of action and emergence in a socio-technical network	Researcher is creative, precise, technically adept; a seeker of elegance and usefulness in an artifact	Researcher is a team member and co-producer of a useful artifact
Methodology (assumptions about what methods will generate 'best evidence')	Observation; quantitative, statistical. There is a hierarchy of research design i.e. one method is inherently	Qualitative, naturalistic; pluralistic (multiple methods preferred to give a rich picture of reality); data analyzed for meanings and perspectives	Participative, qualitative, naturalistic; analyzed for hidden power relations	Qualitative, naturalistic; data analyzed for emergence of actors' understandings and practices and (indirectly) changes in social structures over time	Qualitative, naturalistic, performative; data analyzed for ontologies (things that are brought into being through practice) and the actor-networks from which these emerge	Developmental, with a focus on the technical. Measure artefactual impacts on the composite system	Developmental, with a focus on the social. Measure shared vision, values and collaborative outputs

	'better' than others		embedded in social structures or language				
Axiology (what is of value)	Truth: universal and generalisable; prediction	Understanding and description; situated and particular	Challenge, emancipation	Illumination of technologies-in-practice and how these shape and are shaped by social structures	Illumination of technologies-in-practice and how these shape and are shaped by socio-technical networks	Control; creation; progress; improvement; understanding	Fitness for purpose, ownership, engagement, dialogue

Table 2 Nine meta-narratives that have driven research on the EPR in organizations

Research tradition	Disciplinary and philosophical roots	Definition and scope	General format of research question	EPR conceptualized as	EPR user conceptualized as	Context conceptualized as	Key empirical studies or systematic reviews
1 Health information systems	[Evidence-based] medicine, computer science	The study of the storage, computation and transmission of clinical data. Until recently, focus was on benefits of EPRs and how to achieve them	What is the impact of technology X (e.g. EPR, CDSS, CPOE) on process Y (e.g. clinician performance) and outcome Z (e.g. patient health status)?	Container for information about the patient; tool for aggregating clinical data for secondary uses	Rational decision-maker whose cognitive ability sets limits to what can be achieved without computers	Potential confounder which can be 'controlled for' if the right study design is used	See review of 37 previous reviews (Car, Black, Anandan, Cresswell, Pagliari, McKinstry, and et al 2008), plus one later publication (Shekelle and Goldzweig 2009)
2 Change management (within health services research)	[Evidence-based] medicine, social psychology, management	The study of how to achieve organizational-level change in healthcare.	How can we improve the delivery of healthcare and sustain that improvement?	Innovation which, if implemented widely and consistently will improve process and outcome of care	'Resistant' agent who must be trained and incentivized to adopt new technologies and ways of working	External milieu of interacting variables that serve as barriers or facilitators to change efforts	See footnote <A>
3 Information systems (positivist)	Business studies, psychology, computer science	The study of how organizations adopt and assimilate (or why they fail to adopt and assimilate) information systems	What factors (independent variables) account for the success or failure (dependent variable) of information system X in organization Y?	Unwelcome change, likely to be resisted by individuals and interest groups, and which may fit poorly with organizational structures and systems	Potential adopter who may be actively engaged in the change or resist it; member of group whose power base may be enhanced or threatened	External milieu of interacting variables that mediate or moderate the relationship between input and output variables	(Lapointe and Rivard 2005; Spil, Schuring, and Michel-Verkerke 2005; Wainwright and Waring 2007)
4 Information systems (interpretivist)	Management, sociology, social psychology, anthropology	The study of how organizational members make sense of information systems and thereby assimilate them	What meanings does information system X hold for the members of organization Y? How can accommodation be achieved between different views?	Socio-technical change which holds different meanings for different individuals and groups	Stakeholder whose 'framing' of the EPR is crucial to its effective assimilation. Agent whose creativity and energy can be drawn upon in this effort	Scene and setting for an unfolding story; webs of meaning in which organizational actors are suspended	See footnote <B>
5 Information systems (technology-	Organizational sociology, social psychology,	The study of how social structures recursively shape and are shaped by human	What is the relationship between organizational actors, technology X, and the organization –	Itinerary and organizer whose physical and technical properties structure and support	Knowledgeable, creative agent for whom social structures both create possibilities and	Generated and regenerated through the interplay of action and structure. Researchers	See footnote <C>

	in-practice)	philosophy	agency, and the role of technology in this process, with a focus on the meso-level of organizational life	and how does this change over time?	collaborative clinical work	limit the possible	do not study 'technologies' and 'contexts' separately but technologies-in-use	
6	Computer supported cooperative work	Computer science, software engineering, psychology, sociology	The study of how groups of people work collaboratively, supported by information technology	How can technologies support the work of multiple interacting people?	Contextualized artefact	Agent who seeks to achieve local goals in collaboration with others and creatively overcomes limitations of formal tools	*Either* external milieu *or* an emergent property of action (constituted by, and inextricable from, an activity involving people and technologies)	See footnote <D>
7	Critical sociology	Sociology, philosophy	The study of the relationship between people and the social order and how this changes over time, and the role of technologies in this process	What social structures and inherent power imbalances are embedded in technology X – and what impact does this have on social roles and relationships?	Implicated in micro and macro power dynamics, both within the organization and more widely (because of the link between knowledge and power)	Constrained by dominant social structures or discourses; imagined user, stereotypes about whom may be built into technologies by designers	Social and material conditions into which the (inherently unequal) social order is inscribed; a more or less stable structure of macro social relations	(Bloomfield and McLean 1995; Bloomfield 1995; Darbyshire 2004; Doolin 2004; Goorman and Berg 2000; Harris 1990; Henwood and Hart 2003; Sharman 2007; Timmons 2003b; Timmons 2003a; Wagner 1993)
8	Empirical philosophy (actor-network case studies)	Philosophy, sociology, linguistics	The study of socio-technical networks and what emerges from these. Considers how relationships and power shift within the network	How has the network, with its various relationships, work practices and risks, changed as a result of introducing technology X?	Actor in a network	Actor in a network	The EPR and its context together form the network; the one cannot be studied without the other (since the EPR only becomes 'the EPR' as part of the network)	See footnote <E>
9	Systems approaches to risk management and integration	Systems and management research, drawing on cognitive psychology, CSCW, and ANT	The study, from a systems perspective, of how to promote safety and reduce risk in healthcare	What role in both protecting against and producing error does the EPR play within a complex healthcare system?	Component of complex socio-technical system whose structural features and operational properties, even when designed to protect against error, may come together in unpredictable ways to produce error.	Component of complex socio-technical system whose structural features and operational properties, even when designed to protect against error, may come together in unpredictable ways to produce error.	Complex, changing environment which poses potential risks to patient safety	See footnote <F>

Footnotes:
<A> (Badger, Bosch, and Toteja 2005; Boddy et al. 2009; Doolan, Bates, and James 2003; Granlein and Simonsen 2007; Greenhalgh et al. 2008; Hendy et al. 2007; Hendy et al. 2005; Jones 2003; Littlejohns, Wyatt, and Garvican 2003; Miller and Sim 2004; Nemeth et al. 2008; Ovretveit et al. 2007a; Ovretveit et al. 2007b; Pagliari 2005; Pagliari et al. 2005; Pagliari, Gilmour, and Sullivan 2004; Sanchez, Savin, and Vasileva 2005; Scott et al. 2005; Southon, Sauer, and Dampney 1997)

<B> (Brown and Jones 1998; Checkland and Holwell 1998; Chiasson and Dexter 2001; Currie and Brown 1997; Currie and Guah 2007; Davidson and Heslinga 2007; Davidson and Reardon 2005; Desjardins, Lapointe, and Pozzebon 2008; Eason 2007; Eason 2009; Jensen and Aanestad 2007; Prasad 1993)

<C> (Davidson 2000; Davidson and Chiasson 2005; Mogard, Bunch, and Moen 2006; Østerlund 2002; Østerlund 2003; Østerlund 2004a; Østerlund 2004b; Østerlund 2006; Rodriguez and Pozzebon 2006; Sicotte, Denis, Lehoux, and Champagne 1998; Sicotte, Denis, and Lehoux 1998)

<D> (Bardram and Bossen 2005; Clarke et al. 2003; Clarke et al. 2001; Engestrom, Engestrom, and Saarelma 1988; Greatbatch et al. 1995; Hartswood et al 2003a; Hartswood et al 2003b; Hartswood et al. 2002; Hartswood and Procter 2000; Heath and Luff 1996; Heath, Knoblauch, and Luff 2000; Heath and Luff 2000; Heath, Luff, and Svensson 2003; Kuhn 1962; Luff, Heath, and Greatbatch 1992; Reddy, Dourish, and Pratt 2001; Schneider and Wagner 1993; Symon, Long, and Ellis 1996; Tellioglu and Wagner 2001)

<E> (Aarts and Berg 2004; Aarts, Doorewaard, and Berg 2004; Aderibigbe and McGrath 2007; Berg 1999; Berg 1997; Berg et al. 1998; Berg 1998; Berg and Bowker 1997; Bruni 2005; Constantinides and Barrett 2006; Iedema 2003; Moser and Law 2006; Pirnejad et al. 2007; Pouloudi et al. 2004; Stoop, Bal, and Berg 2006; Winthereik 2003; Winthereik and Langstrup 2009; Winthereik, van der Ploeg, and Berg 2007)

<F> (Aarts, Ash, and Berg 2007; Ash et al. 2006; Ash et al. 2007c; Ash et al. 2007b; Ash et al. 2007d; Ash et al 2009; Ash et al. 2007a; Braa et al. 2006; Braa, Monteiro, and Sahay 2004; Campbell et al. 2007; Campbell et al. 2006; Ellingsen 2003; Ellingsen and Monteiro 2003a; Ellingsen and Monteiro 2003c; Ellingsen and Monteiro 2006; Ellingsen and Munkvold 2007; Ellingsen and Obstfelder 2007; Han et al. 2005; Hanseth, Jacucci, Grisot, and Aanestad 2006; Hanseth and Monteiro 1997; Hanseth and Monteiro 1998; Hasan and Padman 2006; Jæger and Monteiro 2005; Koppel et al. 2006; Obstfelder and Moen 2006; Tamuz and Harrison 2006)

Table 3: Breakdown of systematic reviews and primary studies

	Number of studies/reviews
SYSTEMATIC REVIEWS (MOSTLY FROM META_NARRATIVE 1)	
Review of reviews using Cochrane methods with some qualitative analysis[#]	1
'Cochrane' review restricted to RCTs with a statistical meta-analysis	1
'Cochrane' review restricted to RCTs but no meta-analysis	4
'Cochrane' review of other quantitative designs but no qualitative analysis	6
'Cochrane' review of quantitative designs with some form of qualitative analysis	9
Qualitative review using realist method	1
Other qualitative or narrative review	2
TOTAL SYSTEMATIC REVIEWS	24
PRIMARY STUDIES (THESE EXCLUDE META-NARRATIVE 1*)	
Organizational case study	
Single site (i.e. main goal was understanding within the case)	18
Multi-site (i.e. a key goal was comparison across two or more cases)	20
Ethnography of situated practice*	12
Actor-network analysis†	19
Participatory study	
Action research	4
Co-design[¥]	2
Qualitative study (interview, focus group or both)	5
Quantitative study	
Quantitative survey alone	2
Quantitative survey supplemented by in-depth qualitative interviews	2
Before and after study	1
Randomised controlled trial	1
Other study design	
Empirical philosophy‡	4
Discourse analysis	2
Simulation study	2
TOTAL PRIMARY STUDIES	**94**

[#] This review of reviews included all Cochrane reviews covered here, plus 14 additional systematic reviews on specialist aspects of EPR use

* Detailed ethnography of the fine-grained detail of clinical (or administrative) work, often using techniques such as video or computer screen capture, and drawing on Garfinkel's ethnomethodological approach and situated action theory

† Mapping and analysing a dynamic network in which both people and technologies are 'actors'

¥ A form of action research with a stronger technical element, effectively participatory workplace redesign alongside technical [re]development (sometimes called 'techno-methodology')

‡ Mainly theorising but based on a small amount of empirical data (usually from ethnography of situated practice)

The unit of analysis for empirical studies in this table is the study – hence if one study led to three papers, only one of these is 'counted' here. The only exception is one study in which a complete re-analysis of the data was undertaken using a different theoretical perspective; this study has been double counted in the table.

Glossary

Actor (or actant)	In ANT, either a person or a technology which is part of the socio-technical network
Affordances	The material and technical properties of technologies which create the scope for achieving particular tasks (and which, conversely, make other tasks impossible)
ANT	Actor-network theory – a philosophical position characterized by a focus on a dynamic network of people and technologies which evolves over time
Articulation	The local, situated actions of creative human agents that can potentially bridge the gap between formal and the informal and between social and technical
Background sources	Books or papers that provided key contextual, theoretical or historical detail for this review but which were not empirical studies of the EPR or seminal sources. Includes empirical studies of other technologies offering methodological insights
CDSS	Computerized decision support system
CPOE	Computerized provider [or physician] order entry, known in the UK as e-prescribing
CSCW	Computer-supported cooperative work
HIS	Health[care] information systems
HSR	Health services research
ICTs	Information and communications technologies
IS	Information systems
NHS	[UK] National Health Service
Panopticon	A term introduced by Foucault to depict the increasing capacity for large-scale surveillance of human activity, supported by technology but also embodied and policed by the actors concerned
Paradigm	A particular shared lens through which a group of researchers views the world, comprising four elements: concepts (what are considered the important objects of study – and, hence, what counts as a legitimate problem to be solved by science), theories (how the objects of study are considered to relate to one another and to the world), methods (the accepted ways in which problems might be investigated) and instruments (the accepted tools and techniques to be used) (Kuhn 1962)
Research tradition	A coherent body of theoretical knowledge and a linked set of primary studies in which successive studies are influenced by the findings of previous studies
Meta-narrative	The over-arching storyline that drives research in a particular tradition, which embodies paradigmatic assumptions and values
Seminal source	Theoretical or methodological publications that were cited extensively by subsequent researchers in a tradition, and which shaped the focus and methods of research
RCT	Randomized controlled trial
Meta-narrative method	An interpretivist approach to the systematic review of complex evidence, in which reviewers seek to define the over-arching storylines that drives research

	in any particular tradition
Structuration theory	A sociological theory developed by Anthony Giddens which sought to bring together objectivist and subjectivist approaches to the study of social reality. Social structures have a real existence (i.e. they are 'out there') but they are also embodied ('in here') by human actors. As we enact social structures, we both reproduce and change them.

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