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Using Actor-Network Theory to Study Health Information Technology Interventions

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Abstract. This chapter introduces Actor-Network Theory, a sociotechnical approach to studying health information technology implementation. The chapter is intended as a pragmatic introduction to the field, acknowledging that there are many contested features of an Actor-Network Theory informed methodology. Nevertheless, the approach can be usefully drawn on to help to focus data collection and sampling. A case study describing the application of Actor-Network Theory to study the "failed" implementation of national electronic health records in England as part of a national "top-down" implementation program illustrates the main tenets of the approach and provides concrete examples of how Actor-Network Theory may be applied. In doing so, this chapter offers a reflexive account of how Actor-Network Theory has provided a nuanced analysis of how the implementation of national electronic health records affected different stakeholders, organizations and technology.

Keywords. Sociotechnical, Actor-Network Theory, Health Information Technology

Learning objectives

After reading this chapter the reader will be able to:

1. Describe the basics of Actor-Network Theory
2. Pragmatically apply Actor-Network Theory-based approaches to health informatics evaluations
3. Critically evaluate the various assumptions comprised within the Actor-Network Theory-based approach and draw on these for applied use in healthcare settings

1. Introduction to sociotechnical perspectives and Actor-Network Theory

1.1. Sociotechnical approaches to studying technology implementation

The concept of sociotechnical systems[2] emerged from the study of organizational behavior and workplace safety in 1950s studies of English coalmine workers.

The central assumption of sociotechnical approaches is that social and technical dimensions are intimately intertwined and need to be considered together when exploring

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[2] See also Chapter 7, "Distributed Cognition: understanding complex sociotechnical informatics".

organizational dynamics and change. Humans in complex organizational contexts are viewed as being influenced by technological, social and cultural environments which are constantly changing. This is in turn assumed to affect the performance organization. In order to improve performance of the information system and the social context, it is argued that social and technical dimensions need to be aligned - a process referred to as joint optimization [1].

Sociotechnical perspectives have been applied to:

1) information system engineering - in order to inform technological designs that integrate well with the social environments in which they are used; and

2) the evaluation of information system implementation, adoption and optimization - in order to inform organizational efforts to create social environments that maximize benefits of technology [2].

This approach contrasts with earlier perceptions that workers had to adapt to technological requirements in order to realize potential benefits associated with technological change [3].

Sociotechnical approaches are a popular choice when examining the implementation of information technology (IT) in healthcare settings. They are well suited to explore changing organizational and healthcare professional practices accompanying technology introduction in complex environments [4-6]. Here, new technological systems are viewed as an addition to established organizational structures and work practices. These changes can lead to requirements for re-organization in social subsystems, often resulting in a tension between the technological demand for structured data entry and the fluid context-dependent nature of healthcare professional work. Conversely, sociotechnical approaches can also be used to examine how social and organizational practices result in changes in technological design.

Box 1 summarizes Coiera's four rules for sociotechnical design in healthcare settings, which exemplify the implications of a sociotechnical approach [2].

Box 1: Coiera's four rules for sociotechnical design

Rule 1: "Technical systems have social consequences": technology introduction affects the user and the individuals surrounding the user e.g. the patient

Rule 2: "Social systems have technical consequences": e.g. organizational culture, champions, role models may impact on the uptake of technology

Rule 3: "We don't design technology, we design sociotechnical systems": design needs to shift to incorporate social processes, and from consideration of a single user to the recognition that collaboration in healthcare is crucial

Rule 4: "To design sociotechnical systems, we must understand how people and technologies interact": the need to gather more data on human computer interaction in clinical environments e.g. cognitive overload, time pressured situations, workload

1.2. Actor-Network Theory-based approaches to studying technology implementation

Actor-Network Theory (ANT) can be viewed under the sociotechnical systems umbrella, as it focuses on exploring the interrelated nature of social and technological subsystems. It has its origins in sociological and anthropological approaches to

organizational studies and was developed by science and technology scholars Bruno Latour, Michael Callon and John Law. ANT researchers view the world as consisting of networks made up of human and non-human actors. Non-human actors include objects and concepts. The central (and in some cases seen as somewhat controversial) assumption is that non-human and human actors should be treated as equal and that objects have agency (i.e. an ability to exert power over or change in other non-human or human actors) [7]. The ability to have power is assumed to emerge from the way actors are connected and is not assumed to stem from inherent actor characteristics [8]. However, this agency is not inherent to objects on their own – rather it emerges from the way they are related to other objects, concepts and human actors in the network. Both human and non-human actors can be a component of a network but also a network in themselves, depending on the level of granularity the ANT researcher wishes to study. Box 2 provides an overview of the most common terminology used in ANT. The terms provide an overview of the principles of ANT and they are listed for easy reference.

Box 2: Key terminology used in ANT

Actor: the origin of action (can be human or non-human)

Network: relationships between actors

Black-boxing: treating a particular network as a separate unit and specifying inputs and outputs as well as their relationship with the whole network

Intermediary: an individual that serves as a connection between two actors

Translation: process by which actors configure and re-configure each other

Simplification: composition of networks tends to reveal itself when things in a network go wrong and that they tend to be hidden when things go smoothly

Punctualization: process of revealing simplifications

In ANT, social phenomena are assumed to be the outcome of associations between actors [7], and the sociologist studying networks is simply seen as a component of the network. Therefore, ANT in its original "purist" form has been viewed as incompatible with interpretivist sociological approaches [7].

ANT scholars study the makeup and the shifting nature of networks and their components [3,9]. Typically, this involves focusing on some goal-directed collective activity, mapping network components, and in some cases specifying network inputs and outputs [3,8]. Based on this, it is assumed that researchers can make recommendations on how networks can achieve stability and how actors need to be re-configured to achieve a certain organizational aim. The stability of networks is assumed to be determined by the strength of relationships between actors [10].

Just as in overall sociotechnical approaches, networks are assumed to change and re-configure with the introduction of new technology (a new actor) in the organization [11]. Through tracing networks and investigating how they overlap and come into being, it is assumed that researchers can understand how power and organizational processes are generated [10,12].

1.3. The contested nature of Actor-Network Theory and its limitations

ANT is constantly evolving as it gets interpreted and re-interpreted by different scholars, which makes it somewhat hard to define its nature at any point in time [7,10]. It also has several limitations, and these have been extensively debated in the literature. The notion of non-human actors and their ability to possess agency is a particularly hot topic, with some doubting the contribution of this notion.[13-16] Whilst it is beyond the scope of this chapter to discuss all of ANTs shortcomings in detail, the most pertinent ones in relation to health technology implementation are discussed below.

Most importantly, it has been argued that ANT is not much of a theory at all as it lacks predictive power.[17,18] Predictive power is the ability of a theory to prospectively predict a phenomenon under investigation. In relation to health technology, this may for instance include postulations about how certain design features can lead to certain workarounds of users. According to Wacker, for a theory to be "good" it needs to have internal consistency and empirical riskiness - these are areas that ANT does not fare very well in.[18] Internal consistency refers to a theory providing logical and adequate explanations of reality. However, despite providing a vocabulary to describe social phenomena, ANT lacks the ability to explain and integrate the relationships between various human and non-human actors. As a result, ANT accounts can describe how clinical users and technology are related but may leave the reader questioning the actual contribution of applying the lens. Empirical riskiness encompasses the need for a "good" theory to be both risky and testable – but ANT cannot really be tested and lacks specificity.[18] Its terminology (see Box 2) is extremely loosely defined and its networks are potentially limitless, which can result in a lack of focus.[19,20] Consequently, if a theory cannot be subject to prospective tests, it may have limited usefulness.

Other criticisms have included the following: [10,21]

- ANT's perceived inappropriate equal treatment of both human (e.g. clinical users) and non-human actors (e.g. technology, paper);
- the inability of the human observer/researcher to be fully agnostic (as postulated by ANT); and
- the lack of attention to the role of macro structures (e.g. economic, political environments) in influencing micro contexts (e.g. work practices, usability).

Nevertheless, ANT can help to facilitate interpretations of the researcher and provides a helpful vocabulary that can be used to explore a view of a world consisting of networks. This view of the world has several advantages when exploring the implementation of health IT. As such, ANT may be most appropriately viewed as a tool for theory development or a methodological approach in evaluating technology implementations.

2. Using Actor-Network Theory to evaluate health information technology

ANT has been employed by several medical sociologists to explore how artifacts and technologies can shape social processes in healthcare settings. In doing so, it has been applied rather pragmatically as a lens to examine specific aspects of technology

implementation, to explore the effects of technological systems on human actors, and to explain why information systems may be rejected by users.

Although based on paper systems, perhaps the most illuminating examples of employing ANT can be found in a series of three case studies by Marc Berg and colleagues. These, drawing on both single physician-patient encounters and multi-disciplinary care teams, explore how the medical record actively impacts on human action and interaction.[4-6] Berg and colleagues provide detailed accounts of how the record constructs the patient's body/history and associated user practices, how it interconnects activities and actors through time and space, how it shapes relationships between actors and social processes, and how it serves different functions for different agendas. These agendas need to come together for the record to function. Berg at al. describe the complexity and situational ever-changing role of the record by focusing on detailed case scenarios. In doing so, they discuss connections between human actors and the record that capture the processes of how the two relate to each other in both formal and informal work practices.

Compared to paper records, electronic systems tend to pose greater challenges. They can connect human actors beyond physical space and can mediate a greater range of medical activity in a much shorter space of time. ANT has therefore also been used to explain why information system implementations in healthcare fail or why their adoption is often slower than anticipated. For example, Doolin and McLeod describe the implementation of an executive information system in a hospital in New Zealand.[10] The authors argue that failure to build the new network (i.e. the information system) was due to "an inability to enroll the non-human actors" (p.259), which in this case consisted of a perceived lack of data quality in the new digital system. Hence, its use was rejected by doctors.

Similarly, Whitley and Pouloudi use ANT as a framework for analyzing the introduction of NHSnet.[22] NHSnet is a Microsoft Outlook based Web App system that supports communications of medical information in the United Kingdom (UK) National Health Service (NHS). Implementation was completed on time but there were heated discussions with the medical profession over confidentiality and security issues surrounding medical information. In this context, ANT helped the authors to conceptualize how different human stakeholder groups (including doctors, professional groups and technologists) have different interests that are not easily aligned within a single technological solution. As a result of ongoing discussions, NHSnet's design changed over time. This in turn had implications for how human actors were positioned in the network.

2.1. Drawing in Actor-Network Theory to explore the national implementation of electronic health records in English hospitals

In our own work, we have used ANT to examine the implementation of electronic health records (EHRs) in hospitals as part of the English National Programme for Information Technology (NPfIT) (see Figure 1 and Box 3). This case study will be used to illustrate how ANT can helpfully be applied to inform data collection and analysis in studies of health IT implementation.

Box 3: Summary of an evaluation of hospital EHR introduction in the NPfIT [23]

- National implementation of centrally procured software in hospitals
- Qualitative longitudinal investigation in three purposefully selected hospitals which were implementing early functionality (conceptualized as case studies)
- Collected data between 2009 and 2011
- Dataset: 66 interviews with hospital staff, 14 interviews with stakeholders from outside case study sites, 38.5 hours of non-participant observation, 149 pages of press statements, 31 pages of field notes, and a range of national and local documents
- Key findings: users found it difficult to integrate the software with their everyday work practices as the software was perceived to be not fit-for-purpose, implementation had significant consequences for organizational functioning (hampered by local restrictions in software customizability)

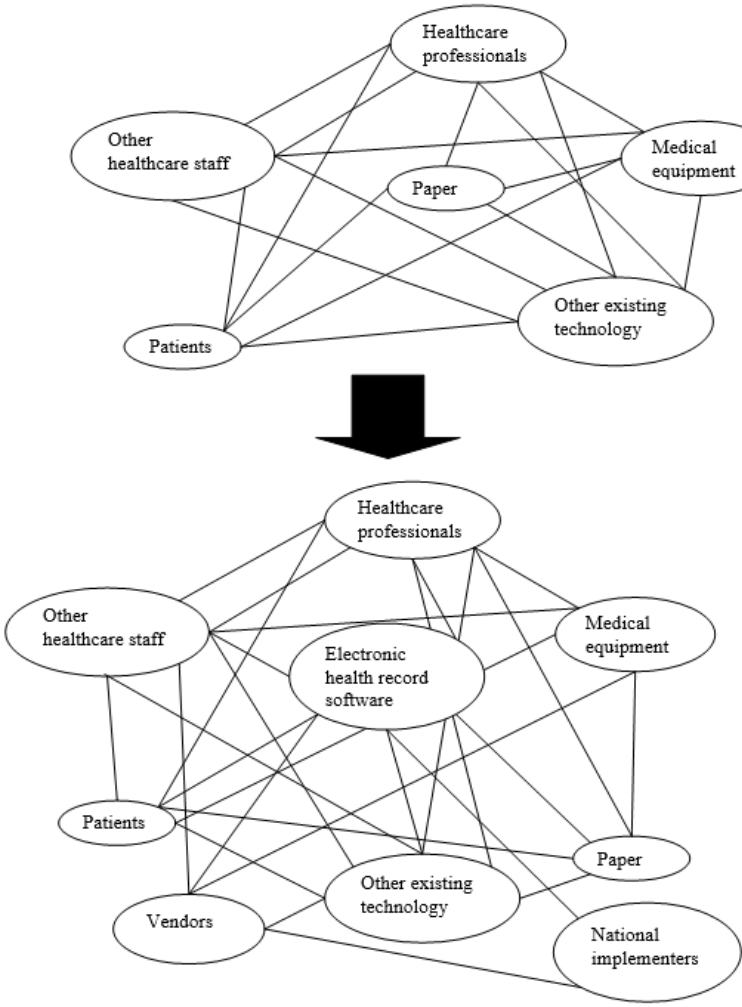

Figure 1. Illustration of an Actor-Network in evaluating the introduction of EHRs in English hospitals as part of the National Programme for Information Technology (based on and partly reproduced from [19].

The context for this analysis was the national procurement of EHRs in English hospitals by the government in 2002. Three commercial information system suppliers were tasked with delivering these, driven by a vision to deliver a record that connected disparate sources of information across care settings on a national scale. In 2011, the £12.7 billion NPfIT initiative was abandoned.

A pragmatic ANT-informed approach was used to explore how EHRs transformed care, healthcare staff relationships, and wider macro-networks (including policy makers and supplier relationships). Despite its limitations outlined above, the notion of the active role of objects in shaping human relationships was a helpful lens to examine human dynamics and technological changes over time. EHRs, other technology, and paper records were viewed as non-human actors, whilst attempts were made to black-box the hospital EHR and analyze its translations over time (see Figure 1).

ANT was used as a conceptual tool for focusing data collection efforts. This was done through sampling those human actors that were connected to the EHR and tracing their relationships (see Figure 1). These network connections were either direct by interacting with or building the technology, or indirect by influencing its strategic direction. Over time, it became clear that the network was not confined to the hospital environment but included for instance policy makers that had procured national technological systems, the media, and information system developers. These could be viewed as intermediaries, as they had an indirect influence on how the technology was used by healthcare professionals.

ANT also helped to conceptualize how care was organized around the record and how the re-organization of the record (by making it electronic) in turn re-organized care and healthcare professional roles (translation). Due to the electronic nature of the EHR, this change was often done at a distance thereby connecting spatially disconnected areas of care. Ultimately, the vision was to do this nationally. Such relational connections and mechanisms are usually poorly described and mapping network components helped to reveal these. Investigating these processes, however, can have practical implications and helped to identify facilitators for adoption and implementation that may otherwise not have been considered. The most helpful aspect here was that ANT facilitated viewing the EHR as an active part of the social world. As in Berg's examples outlined above, we examined how the technology influenced the social relationships of healthcare staff using it, information system developers, patients, policy makers and evaluators (see Figure 1). We also explored how the introduction of technology resulted in the formation of new networks and how these transformed over time (translation). Here, ANT helped to conceptualize how individual and organizational practices were centered around the record, and how its role of directing organizational activity changed when it became electronic.

3. Explaining the "failure" of the nationally procured EHR drawing on ANT

ANT is not a theory in the traditional sense. It describes rather than explains and its explanatory power is limited. Nevertheless, it provided a unique and in-depth insight into the processes and the active role of the EHR in coordinating care and work practices of healthcare staff and hospitals. Thus, it helped to draw a sophisticated picture surrounding the implementation and adoption of nationally procured EHRs that went beyond the simple dichotomy of "success" and "failure". This is because new network formations can be described without making value judgements. Accordingly, analytical focus shifted

from dichotomizing towards stakeholder sense making activities, to negotiation and aligning differing actor perspectives/behaviors.

A range of perspectives reflected different views surrounding "success" and "failure" resulting from different positions within the network at different points in time. For instance, the new software resulted in increased workloads for nurses, who may have viewed the implementation as a "failure" at least in the short- to medium-term. Policy makers, in turn, focused on the progress of developing the infrastructural components underlying the EHR technology. They therefore viewed this aspect of the national implementation as a "success".

The introduction of the new EHR also affected stakeholders in many different ways and revealing these simplifications was a key analytical task. The level of influence depended on their role (healthcare professionals, managers, policy makers, information system suppliers, patients), their local setting (existing relationships, physical environments), and the technology adoption time (short-, medium-, long-term). Common to all contexts and individuals, however, was that the technology adopted was an immature solution that lacked usability and had mostly negative effects. It for instance, increased workloads of users and negatively affected reputations of managers and suppliers. Over time, as the solution matured, some networks began to stabilize with the record gradually fulfilling its purpose of coordinating care effectively and stakeholders acclimatizing to these changes. However, these changes were only visible on a very small scale and in settings that had invested a significant amount of time and resources.

The new information system was procured nationally, so policy makers and system vendors were initially in a relative position of power. Over time, clinical users became more powerful, as they refused to use a technology that was viewed to lack usability. This changed power dynamic led to changes in the national procurement model. It is not to say that other sociotechnical dimensions (including other social, political and organizational factors) are not important in determining "success", but this work has illustrated that the most important pre-requisite for "success" from all perspectives is a usable technology.

When mapping out the larger network and tracing the technology, we ensured that all human actors were either directly or indirectly (i.e. through another actor) related to the EHR. ANT-informed analysis indicated that there were two different networks that were not effectively connected through strong associations (e.g. aligned interests) beyond the technology itself (see Figure 1). These were the users of the technology (i.e. healthcare professionals and organizations) and the national implementers (i.e. policy makers and information system suppliers). Both groups had different views of and intentions for the technology: Policy makers wanted to make or save money/lives on a large scale through improving organizational processes. Users wanted to improve immediate patient care in their own micro-environments. There was thus a tension between the micro and the macro networks in the following ways:

1. Policy makers and suppliers foregrounded the vision of the technology as an integrated national EHR, whilst users had to cope with its manifestations and its lack of usability in everyday life.
2. New technology was designed to structure care to make it more effective (including the imposing of rules, categories and regulations). This was at odds with the nature of clinical reality as these rules inhibited the timely provision of care and also increased individual workloads.

The lack of alignment of these positions was apparent in ongoing tensions and eventually broke up the network, reflected in the media discourse surrounding "the spectacular failure of the NPfIT".

4. Discussion

This chapter has illustrated that drawing on ANT can be helpful in conceptualizing technology implementation in healthcare settings. In particular, the approach can help to inform sampling and to examine how technology actively shapes human relationships and vice versa. It can further inform deliberations on the alignment of various networks at different levels including healthcare professional work, organizational practices, political and supplier relationships. In line with this, ANT-informed approaches continue to be used by health service researchers as tools to facilitate tracing networks of human actors and technologies over time. However, these are mostly small-scale studies exploring health IT implementations in particular settings [24-26].

Due to its limitations, the traditional "purist" ANT approach is likely to be too restrictive and too prone to getting lost in detail to be usefully employed in studying health IT implementation and this is reflected in the current literature, where the use of ANT to inform analysis is generally less common than its role in informing design considerations [24-26]. It is therefore often employed in conjunction with other theoretical lenses under the more general sociotechnical umbrella [20,25].

Sociotechnical lenses are well suited to explore processes surrounding technology implementation across a variety of different stakeholder levels [27,28]. These approaches are proving to be relatively flexible, in particular when considering large-scale implementations of complex programmes where drawing on one single lens may be quite restrictive [29]. However, many existing approaches still examine health IT at one selected level, be it micro contexts, meso (organizational) contexts or macro contexts [30-33]. The relationships between these are often poorly understood and this is where pragmatic ANT-informed approaches, as outlined in the case study above, may be useful for evaluators going forward.

It is difficult to predict if the NPfIT would have had more successes if the design of technologies and implementation strategy had drawn on ANT. This is because the application of the method is very much subjective. However, more generally, rigorous independent formative evaluation methods (informed by ANT in combination with other sociotechnical lenses) are crucial to accelerate learning and optimization of implemented technologies and practices.

Teaching questions for reflection

1. Consider which objects in your environment may be viewed as having agency.
2. Would you draw on ANT in your work? How could you do this?
3. What do you consider to be the most helpful/unhelpful aspects of ANT in health IT implementation?

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