Refereed paper

Complex adaptive systems: a tool for interpreting responses and behaviours

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ABSTRACT

**Background** Quality improvement is a priority for health services worldwide. There are many barriers to implementing change at the locality level and misinterpreting responses and behaviours can effectively block change. Electronic health records will influence the means by which knowledge and information are generated and sustained among those operating quality improvement programmes.

**Objective** To explain how complex adaptive system (CAS) theory provides a useful tool and new insight into the responses and behaviours that relate to quality improvement programmes in primary care enabled by informatics.

**Methods** Case studies in two English localities who participated in the implementation and development of quality improvement programmes. The research strategy included purposefully sampled case studies, conducted within a social constructionist ontological perspective.

**Results** Responses and behaviours of quality improvement programmes in the two localities include both positive and negative influences associated with a networked model of governance. Pressures of time, resources and workload are common issues, along with the need for education and training about capturing, coding, recording and sharing information held within electronic health records to support various information requirements.

**Conclusions** Primary care informatics enables information symmetry among those operating quality improvement programmes by making some aspects of care explicit, allowing consensus about quality improvement priorities and implementable solutions.

**Keywords:** complex adaptive systems, complexity theory, governance, informatics, primary care, quality improvement

Introduction

This paper presents empirical research on quality improvement through case studies conducted in two English National Health Service (NHS) Primary Care Locality Organisations. This body of work\(^1,2\) contributes to public service management theory by providing a new sociotechnical model for understanding the role of primary care informatics in helping to improve quality within locality organisations in England. Applying a complex adaptive system (CAS) conceptual framework helps to explain responses and behaviours resulting from change instigated by the introduction of policy.

Whilst relationships and knowledge tend to be framed by prior knowledge, experience\(^3\) theory recognises that they have a strong informational component.\(^4,5\) Many studies provide evidence that one tends to find what one expects, which helps to link the psychologies of first impressions to long-term relationships by showing how expectancies are sustained or modified through behavioural sequences.\(^3-7\) Interestingly, from an informatics perspective, responses to a survey reveal some clear differences in the relative importance attributed to each of the principles that underpin medical record standards.\(^8\) It is likely that each respondent group answered the questionnaire in terms of what was most important to them. This would imply that work on reaching consensus on the standards for the structure and content of medical records may be particularly pertinent.\(^8\) Where there is asymmetry in information there will be uncertainty. Conversely, where there is symmetry of information, confidence and implementation are more likely. The
results of this study show that information symmetry is found among those operating quality improvement programmes enabled by developments in informatics that include consensus about the need for standardised clinical coding and clinical audit, which makes some aspects of the quality of care explicit.

Aim
The aims of this study were to identify the key themes and management tools that underpin the effective governance of quality improvement programmes.

Methods
The research strategy includes purposively sampled contrasting case studies – two localities in the north-west of England. Data were generated through multiple methods and carried out within a social constructionist conceptual framework. This approach provides insight into and practical examples of responses and behaviours that relate to the implementation and development of quality improvement programmes from the perspective of those involved between 1999 and 2005. The method and analysis are described in detail elsewhere, including the relative strengths and weaknesses of the data collection methods utilised in the study.

Complex adaptive systems
A CAS is defined as one made up of a large number of parts that have many interactions and interdependencies. Cilliers gives a comprehensive list of key elements and properties that describe a CAS:

A CAS would typically exhibit the whole system element of self-organisation, producing order of a changeable and varied type. Such self-organisation is not merely the result of processes like feedback or regulation described linearly. It involves disorderly, non-linear processes.

Non-linear is defined as:

the result of an action formed by the history and properties of the elements at a given time as well as the size of the input, as these can be variable. Small inputs may have large effects, and vice versa. Individual components within a system operate on local information and general principles.

CAS are understood by observing the rich interaction among multiple components within the system. CAS thinking integrates positive (self-reinforcing) ideas and attitudes through the sharing of information and feedback, supported by technology and automated processes, new ideas and outcomes emerging from the subsequent interaction. This element of emergence provides a rich foundation for thinking about ‘CAS that evolve through the recombination of agents or their schemata’ (p. 225).

CAS as a management tool
CAS as a management tool is summarised in Table 1. The interacting component units within a CAS result in a system-wide governance of quality improvement because influence is exercised both by the system on the units, and by the units on the system, termed mutual causation. Developments in primary care informatics enable network governance models of quality improvement – characterised by self-organising, interpersonal networking. Several CAS authors claim that the rationality of this model is neither procedural, goal driven nor substantive, but ‘reflexive’. This is expressed through continued efforts to generate and share information, proposing horizontal networks of interdependencies to replace hierarchies.

Results
For the sake of brevity, the themed results presented next relate to responses and behaviours attributable to active participation in the implementation and development of quality improvement in two localities.

Theme 1: Multiple stakeholder perceptions, preferences and priorities
Initially, there was no consensus among participants about either the topics or priorities to inform quality improvement programmes. Responses to the survey summarised in Table 2 show this.

Applying the CAS conceptual framework provided an explanation of the rich variety of meaning attributable to multidisciplinary stakeholder responses. A consistent theme emerging from the responses was that an evolutionary approach underpinned the implementation and development of quality improvement. The longitudinal nature of the study enabled the analysis, over time, of the problem-solving objectives of those involved. As a result, core themes emerged around which quality improvement clustered, for example, reflective practices that included clinical
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These findings show that managers need to appreciate the desire to retain control of these functions at a given team or system level that included general practices. Further, they highlight the importance of encouraging cooperation leading to joint decisions about quality improvement priorities.

Theme 2: Development of communication and information systems

The development of communication and information systems supported by technology was emphasised. There was a recognised need to develop the use of electronic health records and to automate information sharing based on clinical audit, in order to improve patient outcomes. For example, more accurate and comparable computer-coded information in order to compare results. Evidence supporting this theme included statements such as 'The PCT has invested in IT to support its GPs, community and corporate services. This forms part of an on-going programme that will lead to the development of electronic GP records and integrated care records' (locality organisation Chair).

Theme 3: Education, training and development

In recognition of the need to build capability and capacity through education and training; an emphasis was placed on developing practical skills across multidisciplinary teams, to be delivered via a range of flexible approaches. Seventy-six percent of survey respondents ranked the need to develop informatics skills as needed, or very much needed.
Theme 4: Resource concerns

All respondent staff groups showed concern about resources, emphasising the need for adequate dedicated time to deliver change.

Theme 5: Emphasis on a positive approach

Low morale and apathy were frequently noted. The above results align with themes identified earlier in this body of work, 1,2 and suggest that the variety of opinions, responses and behaviours shown by participants in the study added to their development; such as recognition of the need to develop practical informatics skills. Table 2 summarises multidisciplinary responses to a survey question that sought to determine quality improvement. The results reveal some clear differences between respondent groups in the relative importance attributed to topics. It is likely that each respondent group answered the questionnaire in terms of what was most important to them. Considering individuals’ perceptions tells us much about their views of the official definitions of quality improvement. Observed responses and behaviours revealed an associated positive or negative effect on other components in the quality improvement programme, or on the wider primary healthcare system.

Discussion

Discussion focuses on how primary care informatics improves symmetry of information, applying the associated CAS management tool to the findings. In response to being perturbed by the introduction of new quality improvement policy, a fusion of ideas was observed aimed at implementing arrangements locally. Perceived consequences of potential lapses in the quality of care meant that the problem of quality improvement was considered collectively in each locality, which guided early discussion. Each individual shed some of their existing ideology in conjunction with others to establish a response to flux and change brought about by quality improvement policies. Individual responses and behaviour are explained as a need to engage in evolutionary learning, to develop communication systems, to share information among a wide range of interested parties. This is enabled by primary care informatics, including developing practical skills and tools (templates, guidelines and automated pro-

<table>
<thead>
<tr>
<th>Survey respondents’ occupation/role</th>
<th>Priority 1</th>
<th>Priority 2</th>
<th>Priority 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>General practitioner</td>
<td>Audit information, coding and recording</td>
<td>Health needs assessment</td>
<td>Information Technology</td>
</tr>
<tr>
<td></td>
<td>Time for any of these</td>
<td>Use of computers in consultation</td>
<td>Audit using your computer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Central venous lines</td>
<td>How can we best do it?</td>
</tr>
<tr>
<td>Nursing PHCT members</td>
<td>Clinical risk management</td>
<td>Audit for staff</td>
<td>IT training</td>
</tr>
<tr>
<td></td>
<td>Provision of resources including equipment to treat conditions, e.g. leg ulcers – Dopplers ETD to help improve understanding of quality improvement process</td>
<td>Central venous lines (equipment to measure rate of arterial/venous circulation)</td>
<td>Looking at specific areas for quality improvement</td>
</tr>
<tr>
<td>Managers</td>
<td>Provision and development of information technology (electronic health records), READ codes, templates Cancer care</td>
<td>Professional nursing issues</td>
<td>Review needs of professionals annually</td>
</tr>
<tr>
<td></td>
<td>Shaving good practice – encourage general practitioners to train together – to accept their limitations</td>
<td>Financial issues</td>
<td>Nil response</td>
</tr>
</tbody>
</table>
cesses) in response to the challenges brought about by social, organisational and policy changes. Applying CAS principles as a tool helps a manager to avoid being overly influenced by the viewpoint of any one individual or team involved in quality improvement programmes. One of the important aspects of applying CAS thinking is that it does not deny or reject any particular world-view. Instead, it allows a manager to add another level of thinking, providing a more holistic local context, and for the convergence (or otherwise) of beliefs over time.

The notion of structure is observed as a patterning of relational dimensions within each quality improvement system. Different professional groups and agencies sought to affect the nature of the standards used within each locality to develop quality outcome indicators. An emphasis was placed on developing the workforce through the acquisition of practical skills, templates and guidelines to facilitate the capture, coding, recording and sharing of information held within electronic health records, which linked to work-based processes. The analysis suggests that the process started with initiatives that connected to a professional agenda, which linked to continuous professional development. Various techniques were attempted, which were observed linking individual, local and national quality improvement objectives. Rules that emerged locally focused on the standardised coding, capture of the diagnosis and management of chronic disease, before there was any formal requirement to do so. It was also focused on multidisciplinary team development. Rules generated structure for each quality improvement programme. One PCO focused on an incentivised local health improvement programme and the other on a Quality Team Development scheme, because the state that is the output of one application becomes the input of another. Dealing with complex problems is essentially a matter of mutual adjustment and cooperation brought about by rule-based responses to positive and negative feedback. The argument for considering such insight is premised on thinking outside the hierarchy and about interpersonal relations and the potential offered by updating internal images based on experience, where there may be no instructive interaction. This analysis suggests that updating quality improvement programmes will be based on experiences; any part can influence any other through connectedness and interdependencies.

Implications of the findings

In practice, the lessons learned provide opportunities to inform future management approaches and the role of primary care informatics improving quality within the NHS in England.

Limitations of the method

As reported elsewhere, limitations of case study methodology include a tendency to provide selective accounts, potential bias and/or the trivialisation of findings, and context specificity, leading to a lack of generalisability. The researcher’s interpretation of reality, as a social construction, may not resonate with that of another. Reasonable attempts were made to minimise bias. The diversity of data collection methods used in the study was an attempt to counterbalance the limitations highlighted in one method by the strengths of others.

Conclusion

Information asymmetry is reduced among those operating quality improvement programmes enabled by developments in primary care informatics.

Applying CAS theory as a management tool helps thinking about the totality of responses observed; and the greater scope for influence to ripple through quality improvement systems. The findings of this study emphasise the usefulness of CAS as a tool to explain responses and behaviours attributable to a multidisciplinary stakeholder perspective. CAS theory encourages an appreciation of the emergence of behaviour that includes distributed responsibilities; and the importance of feedback and the networked exchange of information among interested parties enabled by developments in primary care informatics.

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REFERENCES

2 Ellis B and Herbert SI. Complex adaptive systems (CAS): an overview of key elements, characteristics and application to management theory. Informatics in Primary Care 2011;19(1):33-7.

CONFLICTS OF INTEREST
None

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