ECW in Complex Adaptive Systems

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This chapter looks at the question of everyday clinical work [ECW] occurring within a complex adaptive system [CAS] such as health care. The focus on ECW provides a useful bridge from Safety I to Safety II and opens a broad panorama of events and experiences that will allow for a better understanding of organisational resilience. With a Safety I orientation, the traditional approach to improving safety and quality has involved a focus on examples of unintentional harm that occurs during the provision of services to patients. While such a retrospective approach to learning has led to some positive results it unfortunately has distracted us from analysing and learning from the majority of events where there has been no harm.

ECW encompasses a wide variety of activities, most involving no harm, as well as the smaller group in which there has been unintentional harm. The effort to learn from the entire spectrum of ECW is a key component of promoting resilient health care and reflects the value of combining Safety I and Safety II orientations to promote maximal learning and understanding of how events evolve in health care settings.

This chapter explores questions starting from the premise that it is useful to examine ECW in the context of health care as a CAS. Does health care reflect the main characteristics of a CAS? What does this tell us about ECW? Can applying CAS principles lead to a better understanding of the ways that health care providers and patients alike adapt in order to produce positive outcomes more often than not? And finally, what does this suggest about the methods that will be most helpful in developing further study and research on ECW?

Common Feature of CAS

Before looking at some of the common features of CAS, in order to determine whether or not health care 'fits the bill', we need to look more closely at the words 'complex' and 'complexity'. These concepts are used frequently without defining the meaning attributed to them. Furthermore, there is very little effort to analyse the implications when these labels are applied to different phenomena. It is entirely unhelpful to say that health care is

'complex' without specifying what is meant by the term. And yet, that is exactly what happens very frequently.

One reason for this dilemma can be found in the many diverse origins, both scientific and philosophic, of complexity science. These range from systems theory to cybernetics and artificial intelligence, culminating in multiple foci that include ecological systems theory, agent-based and computational modelling and complex adaptive systems theory. Castellani (2013) has developed a 'Map of Complexity Science' which illustrates some of the influences that have ultimately coalesced under the very large umbrella of complexity science.

For the purpose of this chapter I will highlight the approach outlined briefly in Resilient Health Care (Hollnagel, Braithwaite and Wears, 2013, chapter 16). Cilliers (1998) has written very clearly about the principles and characteristics of complex systems, both in a general sense and more specifically as they apply to complex socio-technical systems and organisations.

A non-exhaustive list of the characteristics include the following:

- **Relationships are key** to understanding a CAS – links and interactions between components and agents define the nature of a given CAS at any point in time

- **Basic building blocks are agents** – components, units, sub-units, individuals, teams – often referred to as 'semi-autonomous agents'.

- **Interactions between agents are dynamic** and frequently not fully predictable or even knowable (intractability) – constant change and surprises are typical of CAS.

- **CAS are open systems** – with flexible and semi-permeable boundaries that allow the flow of information and energy from the external environment – contributing to uncertainty and unpredictability.

- **Self-organisation** is the underlying 'operating system' of a CAS and occurs as a result of the dynamic interactions of the agents – from these interactions new patterns emerge.

- The **interactions within a CAS are often nonlinear**. They occur locally and are propagated throughout the system producing 'global' effects or new system properties. The new patterns may seem out of proportion to the initiating changes – this is known as the **butterfly effect**.

- The development of new patterns of behavior of a CAS **emerge** from the interactions between agents – thus the concept of **emergent properties of CAS**.

- CAS are **adaptive** as reflected by their ability to absorb energy and information from the external environment and allow self-organisation of their semi-autonomous agents resulting in the emergence of new patterns.

- History co-determines the self-organisation of CAS and all **CAS 'have a memory'** which influences the co-evolution.

As noted earlier (Castellani 2013), complexity science itself has evolved through the interaction of diverse philosophies and approaches to science – one might say that complexity science has emerged from the dynamic interactions of these many influences – a sort of paradigmatic self-organisation. The various originating viewpoints are still evident within complexity science and many will attribute differing weights to the properties and characteristics summarised above (Gleick, 1987). Notwithstanding those differences of emphasis, there is general consensus on the characteristics mentioned above. Figure 1 offers a graphic 'glimpse' of one instantiation of a health care event constellation as a CAS.

Is health care a CAS?

In the past two decades articles and books have begun to examine the ways in which health care structures and initiatives reflect the properties of a CAS. For instance, in Resilient Health Care (Hollnagel et al., 2013, Chapter 6) Braithwaite and colleagues provide three different examples of specific projects that apply and illustrate underlying complexity principles.

A comprehensive overview of the field is provided in Edgeware (Zimmerman et al., 1998) replete with multiple examples as well as suggested approaches to promoting changes and improvements. More examples are provided in Socio-Cultural Perspectives in Patient Safety (Rowley and Waring, 2011), and an interesting article about primary care practices in the U.S.A. (Lanham et al., 2009) provides specific examples of how many of the underlying principles of CAS are manifested in everyday clinical practices.

Table 1 illustrates briefly how typical health care facilities measure up to the list of properties of CAS proposed above. There seems little doubt that health care is a good example of a social organisation that qualifies as a CAS.

Table 1. To what extent does health care embody the common characteristics of complex adaptive systems? A few examples suggest a strong overlap

Characteristic of a CAS	How does health care 'Measure up'?
1. Relationships are key	Patient-centred or relationship- centred care recognises the centrality of trust and the fiduciary link between the individual seeking care and health and the individuals providing it
2. Basic building blocks are 'agents'	Many non-human agents (policies, procedures, values, ethics, tradition, professional cultures…) interact with human agents both individually and at multiple levels/units/teams
3. Interactions between agents are dynamic	Care processes are rarely linear and uni-directional – often multi-level and multi-disciplinary negotiations of goals of care
4. CAS are 'open' – permeable boundaries	Example of the 'pandemic' flu that modified the allocation of resources (human and financial) with far reaching impacts on all levels
5. Self-organisation - the CAS 'operating system'	Trauma, Resuscitation, Neonatal ad hoc teams; multiple examples from Emergency Department function
6. Interactions are often nonlinear	Simulation models for teaching health disciplines students the uncertainty of ECW; minor changes in physiological status of patients lead to major disruptions in health
7. CAS properties and patterns are emergent	Differential diagnosis of individual clinical problems is an iterative process that integrates inputs from many sources and individuals to produce an understanding that may be very different from what was anticipated
8. CAS are adaptive	SARS (Sudden Acute Respiratory Syndrome (2002-03) provided multiple examples of slow versus rapid adaptation in some locations and chaotic non-adaptation in other sites
9. CAS have a memory: history co-determines	The often failed efforts at health care 're-engineering' in the 1990's produced large-scale pushback and negativity towards change initiatives; the 'Magnet Hospitals' movement in the U.S. showing positive impacts of efforts to respect history of a particular CAS

So why is it so challenging for us to understand that health care manifests the properties of a CAS and to then transform that understanding into useful action? A simple reason relates to the tendency to use words without defining them or even paying attention to their meaning. World poverty would undoubtedly be fully resolved if there was a penny donated every time someone said about a particular event or problem 'Oh that – that's a systems issue … .'

There are other reasons why health care appears not so complex after all - which can lead us to ignore elements of complexity. It is clear that some processes within health care are in fact simple and function very much like an assembly line. These processes were described by Perrow (1984) as being tightly coupled and linearly interactive. For instance, the induction of anesthesia in the O.R. normally follows a clear sequence of activities and decisions. The processing of a medication order in a pharmacy also usually adheres to clear rules and policies. It is not so hard to see that we might then migrate tools that work in such a linear environment to broader initiatives and to the system as a whole, without first asking if such a migration is appropriate for a CAS.

The inherent complexity of health care may also be 'camouflaged' by the fact that we can and do produce multiple flow charts and organisational diagrams that create the illusion that we are (or at least can be) in control. The ability to draw a diagram describing the important elements of health care reality does not mean that the system actually functions according to such a designed structure.

ECW in health care: Why Focus on Complexity Issues and CAS?

The field of mediation and conflict resolution has produced a concept that may apply very well to the question of studying ECW in health care. That concept is summarised by the phrase "make the forum fit the fuss" (Goldberg et al., 1999). This means that tools and techniques that are appropriate to a particular type of dispute or conflict should be used if resolution is to be a likely outcome. For instance the approach to a multi-party commercial dispute will be radically different from the approach to a highly charged and emotionally challenging custody dispute between two separating/divorcing parents.

In the same way, it makes sense that we pay attention to the methods and techniques we use to study phenomena. We should use methods that are appropriate to the subject and the contextual setting. It is likely that the approach used to understanding phenomena in a CAS will be different from the way we would study events in simple linear settings. Unfortunately, in health care, we have tended to pay very little attention to this question and have continued to rely heavily on the tools that have worked well in the past when the settings were undoubtedly less complex. These methods (usually quantitative in nature) have been successful in helping us elucidate many problems. These methods should not be

discarded and are particularly appropriate for those units and sub-systems in health care that function in a primarily linear manner.

The challenge is to integrate other methods that are more appropriate to a CAS, as we try to study ECW in our journey from Safety I to Safety II towards a greater understanding of organisational resilience in health care. The next section will examine some interesting approaches that point us towards greater understanding.

How to Study and Learn about ECW in CAS

The field of organisational development (OD) provides some indications of the methods and approaches that may be helpful in the process of studying ECW in a way that is appropriate for activity embedded in a CAS. Olson and Eoyang have written about this question (Olson et al., 2001). Starting from the assertion that "as many as three-fourths of change initiatives such as TQM or re-engineering fail" (Olson et al., 2001, page 3) they proceed to examine traditional OD paradigms that focus on efficiency and control. "If tasks are standardised into 'best practices', routines develop that are grooved and inflexible" (2001, page 5). As the authors make clear, this does not bode well for change efforts in a self-organising CAS. If traditional change efforts are not well suited to the contexts of a CAS, it is not hard to imagine that efforts to study or learn from activities using traditional approaches in such a setting are not likely to be hugely successful.

Olson and Eoyang (2001) identify three conditions that promote or inhibit self-organisation in a CAS. These conditions are (1) containers (C), (2) significant differences (D), and (3) transforming exchanges (E). Together the CDE conditions provide OD practitioners with guidance as they approach change management in CAS. I am proposing that these same three conditions will provide useful guidance for health care system safety practitioners who plan to study, analyse, and learn from ECW in health care.

The concept of container refers to the boundaries of the self-organising system being studied. The larger the container (C) that is selected, the more semi-autonomous agents will be involved in the self-organisation process which will then likely be slower but more comprehensive. Selecting a smaller container for the study of ECW will lead to a more rapid process of self-organisation, albeit one that is more limited in the patterns that will emerge from that process. An interesting example of a huge container can be seen in the public health domain with respect to the very long and slow (and finally very successful)

campaign to establish the link between cigarette smoking and a range of negative health outcomes. Over a period of decades this led to the emergence of new patterns of intolerance of smoking in public places as well as a range of other positive changes.

The question of significant differences (D) refers to the recognition of diversity in a CAS. As cited by Olson and Eoyang, (2001, page 13) these differences may include power differentials, differing levels of knowledge or expertise, gender, race, age, quality, costs, or educational background. Failure to recognise these D conditions as we study ECW can produce a limited, somewhat impoverished understanding of events as well as resulting in patterns that emerge in a more restrictive manner.

Finally the issue of transforming exchanges (E) refers to the resources and channels that exist (whether formally recognised or not) to encourage (or discourage) the flow of information, ideas, values, data, and energy between the various semi-autonomous agents populating the CAS. A study of primary care practices (Jordan et al., 2009) illustrated in an exquisite fashion the role and impact of informal information exchanges in promoting the incorporation of new initiatives in an organisation. Failing to take into account these E conditions will see the emergence of a stunted understanding of ECW. This in turn will limit the value of the learning about organisational resilience that results from such research.

If we accept that the C, D, and E conditions influencing self-organisation in a CAS are pertinent for our study and research of ECW in health care, we are still left with the question about the tools and methods that may be most appropriate. In this regard, a recently published PhD thesis (Jerak-Zuiderent, 2013) proposes that primarily qualitative methods such as ethnographic research will be particularly useful. These include classic ethnography, participant observation, participant action research, as well as ethnographic interviewing to name but a few.

Another paper that directly addresses the issue of evaluation in a CAS (Eoyang and Berkas, 1999) outlines multiple examples of different evaluation techniques and links their use (or sometimes their 'abuse') to the specific characteristics of CAS. The authors note "To be effective, an evaluation program must match the dynamics of the system to which it is applied." (page 1). Surely the same must be said of our efforts to study and learn from ECW. Patton (2011) provides another comprehensive analysis of research and evaluation methods and techniques that 'match' the dynamics of CAS.

An increasing number of papers and publications reporting on qualitative techniques are being published and provide clear indications of the directions we should consider in adopting the study of ECW in health care as a way of moving from Safety I through Safety II to a broader understanding of organisational resilience in health care. An instructive example is seen in the RAG (Resilience Analysis Grid) (Hollnagel, 2011) presently being tested in a number of CAS settings. The RAG relies on the input of frontline operators in the delineation of factors that will influence the self-organisation of the system under study and becomes a useful was of evaluating the organisational resilience of that system. Reflecting the dynamic nature of CAS, the RAG is repeated periodically. This is an example of participatory action research that can serve as a guide to other efforts aimed at learning from ECW.

Several other examples can be cited (Jerak-Zuiderent, 2012, Rowley and Waring, 2011, Lanham et al., 2009, Braithwaite et al., 2013, Kernick ed., 2004, Strachan et al., 2013) reflecting efforts to understand ECW (although the articles and publications may not frame the research using that specific concept) in health care. Taken as a whole, this developing body of literature indicates the many ways we can fruitfully study and learn from ECW in health care, using techniques that "match the dynamics of the system to which it is applied" (Eoyang and Barkas, 1999, page 1).

Conclusion

This chapter has examined the question of ECW through the lens of CAS theory and principles. It seems clear that health care matches the criteria for social organisations to be considered a CAS. It also seems clear that most of the methods presently used to research and analyse events in health care are not well adapted to a CAS – the tools and approaches used are useful for linear systems – and can provide only a limited understanding of events and therefore a limited picture of the organisational resilience of health care.

After a brief presentation of the main characteristics of CAS the chapter presented an approach to understanding and researching CAS that reflects those properties. While the proposals come from the OD literature and tradition and focus on ways to influence the self-organisation of CAS, they apply equally well to research efforts. The chapter then explored some recent examples of qualitative methods applied to the examination of ECW. These examples, and others, point the way for future efforts to strengthen our

understanding of the evolution of events in health care as well as illuminating in a robust fashion the organisational resilience of health care facilities.

There is still much work to be done and it seems clear that research based on an understanding of health care as a CAS is a challenging field. System safety practitioners must take up this challenge – we owe it to patients, providers and the system as a whole.

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