Decision-Making in Australia's Healthcare System and Insights From Complex Adaptive Systems Theory

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ABSTRACT

***Background**:* Identifying the optimal allocation of resources to improve health and evaluating the ever-changing nature of healthcare delivery programs have proved challenging. Little is known about how decision-makers actually identify the optimal allocation of resources to improve health.

Objectives: This study seeks to elucidate how decision-makers decide in complex healthcare situations, what tools or methods to employ and why.

Patients and Methods: A theoretical sample of 25 Australian healthcare executives was recruited to participate in individual, semi-structured interviews. The participants were managers at each level of organizational structure with responsibilities for healthcare resource allocation. They were interviewed on their perspectives about the weightiest allocation decisions they had made in the past. All interviews were digitally recorded, transcribed and analysed thematically.

Results: We found that decision-making in Australia's healthcare system is never an individual rational choice. Allocation decision-making involved a multifaceted interplay of elements in situations of action. It was not exclusively rational and no single methodological framework is sufficient. Decision-making relates to contextual run-time factors which change while the system is operating. Problems that combine complexity with uncertainty resisted evidence-based decision-making. Our findings revealed that Australia's healthcare systems exhibits most, if not all, underlying features of complex adaptive systems and confirmed that Cynefin sense-making model can be applied heuristically to analysis of decision-making in healthcare resource allocation.

Conclusions: Healthcare decision-making and policy environment is becoming increasingly complex and inter-dependent. The way forward is only understood through contextual knowledge and relativist understanding of the decision contexts, uncertainty, multiplicity and broader stakeholder involvement.

▶ *Implication for health policy/practice/research/medical education:*
Complex adaptive systems theory has the potential as a guide for teaching and practice. Healthcare managers and authorities need to be prepared for complexity and ambiguity and cannot expect the evidence-based reviews to tell them everything they need to know. They should learn that strict decision-making approaches, though conservative, are no more protective of complex decisions than risk seeking and adaptive processes.

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1. Background

As healthcare delivery becomes more complex, so do healthcare allocation decisions. Several challenges confront healthcare systems in the resourcing and provision

of health services in Australia. Inequalities in health, between the most and the least disadvantaged areas, persist and ill-health is unevenly distributed; females do better than males, rich and well-educated people do better than poor and less well-educated populations, and non-Aboriginal people live longer than Aboriginals.(1-3) Attempts to improve resource allocation decision making have concentrated on economic principles of technical, allocative and productive efficiency, medical evidence to avoid ineffective treatments, public values to respond to social preferences and other ways of incorporating competing demands into existing resource constraint. (2, 4-6) While current studies have addressed the usefulness of these methods or criteria to help decision-makers allocate funds or provide services, it is not clear how decision-makers actually allocate financial resources to achieve better health. Existing measures are often specific to a particular context e.g. at a single level or two levels of decision-making, ignoring various interacting levels of decision-making that occur in a complex health system. Research into health economic evaluation has acknowledged and ascertained the complexity of interventions and the complexity of systems in which interventions are implemented to produce change at multiple interacting levels;(7, 8) however, individual dynamics, social processes and contexts with their pertinent modifying elements and relationships are often unnoticed or marginalized in current resource allocation approaches.(7, 9). Many problems are an effect of the interactive and multi-dimensional nature of the systems, and rarely can be reduced to a one root cause or a single factor.(10, 11). The study of complex decision-making within complex adaptive systems is important and invites us to reconsider both theory and practice. This study sought to elucidate how Australian decision-makers actually allocate limited resources. By providing a framework within which complex adaptive systems theory can be applied, we may better understand why decision-makers decide to utilize a specific method of decision-making for a particular situation.

2. Patients and Methods

We applied a qualitative research method and used a modified version of grounded theory, i.e. situational analysis, to explore and reveal little known information about resource allocation decision-making.(12-14) Ethics approval was obtained from the Human Research Ethics Committee at the University of Sydney prior to commencing data collection. We selected a theoretical sample of 25 Australian healthcare executives for individual interviews. They were managers across multiple levels of Australian healthcare system (i.e. Commonwealth, state and local healthcare administrations) with responsibilities for (financial) resource allocation. They were asked for their views and perceptions of how they processed allocation decisions in complex systems and what factors they applied. Research into decision-

making including detailed empirical observation, actor narratives, qualitative reports of individual decisions as well as institutional plans and policy directives suggested extensive context-specificity concerning articulated views and development strategies for resource allocation. (1-3) This diversity of responses led us to think about some of the implicit ontological and epistemological assumptions which underpin a variety of social science research in many fields. For instance, the idea of gathering and examining a range of individual stories and perspectives, in the light of existing evidence, from different contexts might address recurrent challenges or issues, which would allow researchers to better understand the more common processes or practices which are applied when decision-makers systems try to allocate resources. This led us to develop innovative methods of data analysis that extended grounded theory and situational analysis, through the use of diagrams from complexity and management theories. In particular, we applied the approaches to complex adaptive systems theory including the Cynefin framework (15) to complement the analytic project maps (*Figure 1*). Participants were invited to illustrate their answers with anecdotes or examples through interviews. Each interview was digitally recorded.
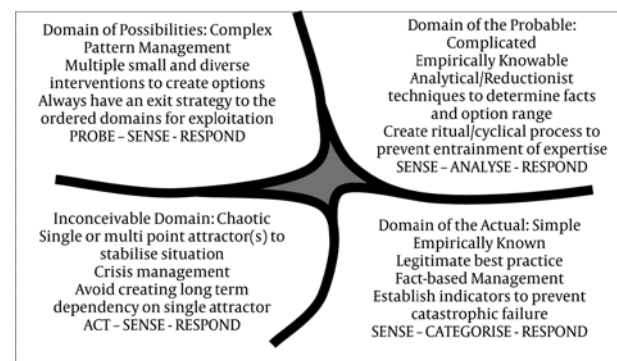

Figure 1. Cynefin Framework, Adapted from: Snowden & Boone, 2007

Full text transcripts of interviews and field notes were imported into NVivo 7 software(16) for thematic coding and analysis. Data generated from interviews were reduced to different codes and categories based on the principles of analytic induction. The data was initially coded line-by-line and closely examined for any similarity or difference. As we became familiar with the data, closely related (initial) codes were densified into more directed, selective and enduring categories with stronger analytic directions (focused coding). (12) Emerging categories were then mapped. This strengthened the researcher's sensitivity to the possibilities for codes, categories and their properties. (12, 14) In addition, we employed memo-writing as a reflective strategy to record abstract thinking about the data while conducting interviews. This helped cultivate and enhance the reflexivity required of social constructivism. (12) The ongoing process of data collection and analysis was followed by selective coding to conceptualize how categories bind to each other

and were integrated into a core phenomenon. Questions about relations among categories were developed and examined in subsequent interviews, and modified as needed. Extra categories that best fitted the data and situation of inquiry were selected and the least relevant categories were excluded, culminating in the creation of several interrelated major categories. Category saturation was reached at interviewee number 20 where nothing new emerged from further interviewing.(12)

3. Results

Findings showed that allocation decisions varied greatly from one facility to another. Participants reported using a complex mix of strategies, processes, activities, tools and methods both individually and collectively; no single strategy or process appeared dominant. For them, allocation decision-making involved a multifaceted interplay of elements, methods, skills and insights in situations of action. It was not exclusively rational and no single methodological framework was sufficient. Several categories of decision-making made up of diverse elements were identified with a single, core category of contextually congruent decision-making as a broad process to which all other categories of decision-making were related. These categories stuck closely to the data and significantly mattered or made a difference to situations of allocation decisions. Decision-making context in this study referred to an environment in which something (human and non-human) existed or occurred, with all its complexity. The categories included:

3.1. Context Sensitivity

Context – any environmental factor which constitutes a situation – was the predominant factor that guided participants to make allocation choices. It helped participants change or maintain their perspective about decision-making in a situation different from their own. I09PK, for example, commented that his resource allocation decisions have not followed the same processes; they have maintained a 'close connection to the context at the time'. Some are politically driven, some are community driven; sometimes there may be issues driven by powerful doctors who have the right contact and use their power to get decisions made in their favor; a lot of the time the senior executives make decisions based on needs; sometimes there is good evidence that we need to change our practice; sometimes we need health economists; and sometimes policy people but the government will set up key projects and issues for health (Interviewee 09).

Different contexts posed different influences on the action of individual participants. For example, participants applied project management style for well-structured activities that had a beginning, a middle and an end, when it would be clear whether they had achieved what they had planned to do. If, e.g. their project was to equip a new

hospital with advanced technologies, they knew what they should buy and install. They used operational management style for the normal routine functions of the healthcare facilities including both simple routine procedures for which there were clearly known protocols, and more complicated procedures which called for high levels of training, skill and expertise. There are some decisions that are not negotiable and pretty easy and straight down the line or we have to consider what our executive has directed us to achieve, they are not negotiable (Interviewee 16).

Unlike the known (ordered) situations that systematically employs a set of actions or steps and sometimes a checklist to guide decision-making, most participants thought that their decision-making practices could never become a rigid set of rules or actions. They viewed decision-making as not just a simple act of choosing among known alternatives but rather as a non-linear, dynamic activity with attribution in hindsight after the fact. In the common view, their decision-making could not be detached from constant coping with risk, uncertainty and contextual complexity, conditions which were not easily made explicit. The decision-making process or management style was an adaptive process that evolved over time, involving initial interactions between decision-makers and circumstances surrounding them. It was a more subtle and responsive kind of management/process which involved constant monitoring of internal and external changes in the healthcare system, and offering changes or innovative services to meet emergent need. Participants used crisis management when something sudden and unexpected happened, like an earthquake or major disaster, or when immediate action was needed, such as when a person with life threatening injuries arrived in Emergency department or there was sudden severe bleeding during an operation. The biggest issue is how to get resources in the first place. We deal with problems as they arise I guess we just get used to doing that in the way we are thinking, is going to work and sometimes being work and sometimes they don't. So we have to then readjust our settings to make sure that the people and the resources are there to get the job done (Interviewee 22). Allocation decisions were often made under conditions of complexity, uncertainty and risk which frequently affected those decisions over time. Such conditions were often part of the operating context and located in an environment where participants made choices without being completely sure what the effects would be. You need to be able to oversee the budget sheet and deal with unforeseen circumstances; the actual process of checking, rechecking and rechecking with different groups of people is very important, even at the end you probably find a little problem. We will always make mistakes in some point especially with the budget (Interviewee 07). Failure to properly define the context and its underlying relationships may place unrealistic expectations on deci-

sion-makers of what healthcare settings might achieve. Below we describe the context categories and subcategories and explain how each one contributed to the process of decision-making.

3.2. Institutional and Organizational Context

During interview sessions almost all participants addressed a range of institutional and organizational (administrative and legislative) factors that influenced their allocation decisions. These included system's elements, organizational structure, policy objectives and flow of information and control.

Consideration of organisational structure and system's elements allowed participants to better review the process of financial decision-making within their facilities; to better set up, maintain and implement decision practices; and to better cope with contextual complexities. I believe the Australian healthcare system is extremely complex, there are three regulatory levels and involvement: Commonwealth, state and local levels. Many funding streams are coming from each of those arms of government and the private insurance arrangements, they are extremely varied (Interviewee 22). Under scarce resources you need to have learned a bit about the organisational structure, how things work (Interviewee 13). Participants validated their allocation decisions by looking to see whether they fitted within the organisational mission, vision, values, policy objectives and guidelines. The government policy objectives including national policies sought to utilize the best possible evidence, mainly research evidence to initiate and refine health policy intervention. Participants had to ensure that they maintained the standards, followed the correct procedures within those frameworks and acted accordingly.

We need to be consistent with what departmental policy prescribes for us. Any sort of major decision needs to be consistent with whatever the relevant policy might be in terms of service provision to target areas like the aboriginal community or victims of domestic violence (Interviewee 10). The way in which control was distributed or information was applied could contribute to decision-making practices. In highly controlled authority structures, information might flow up and commands flow down and decision-making was centralized based on the information possibly gathered at the periphery. However, some participants noted that decision-making was largely consultative or participative. We certainly get a lot of communication coming up and we certainly listen to that consult but the decisions ultimately have to be taken by senior people (Interviewee 11). I think to a large extent, what we as an organization have tried to do is, have decision-making removed from one person and put it in the hands of several people. It does in a sense help remove the participant favouritism. Decision-making is handed to committees and several people than to one person (In-

terviewee 24).

In addition, for most participants the decision-making processes differed in the extent to which they, individually or collectively, involved in decision-making. They reported that their contribution depended on the nature and importance of the interventions under evaluation. Several senior managers, staff, doctors, etc are involved in decision-making process. Sometimes, only senior executives make decisions, sometimes it is driven by other matters; sometimes there are political reasons for doing that and the other factors not just one. I have been looking at funding and giving advice about what we should do the final decisions will be approval given by the board, but the board in general acts to convey advice given to them by CEO [i.e. Chief Executive Officer] and senior staff (Interviewee 09). Participants also pointed to the diversity e.g. disease patterns and cultural interfaces that existed within and between healthcare entities. Participants recognized elements of the same type as different. It was likely that diversity, e.g. differing cultural factors across communities, could drive differing health outcomes and decisions.

3.3. Quality and Safety

Participants tried to base their decisions on the highest quality and safety. In many cases allocation decisions were driven by occupational health and safety considerations for both patients and staff. All equipment has to make the strength standard, and it has to be safely used within this environment, both safety of staff and safety of residents (Interviewee 24).

3.4. Ethics

In the face of financial constraints, decision-makers reported that they must prioritize the set of decisions which they could ethically make. They worried whether their practices sufficiently addressed the ethical implications connected to decision outcomes. I think the decision-making process has got to balance with patient safety needs, patient care needs alongside the fiscal requirements and rights of the patients that come through the facility (Interviewee 07).

3.5. Community-Based Features

Sometimes, changing demography and disease patterns posed a growing burden of mortality and morbidity rates and healthcare expenditure. Having a population with diverse age groups, in particular ageing, produced situations in which participants could no longer follow the old organizing principles and expect similar outcomes. Interviewee 11, for example, pointed to the 'types of patients that are coming in for their primary diagnoses'. He pointed to the 'ageing population' and 'people in the seventy five plus category' as a 'strik-

ing issue that the health industry faced'. We are finding that people are living longer, when they are coming to hospital they are coming with co-morbidities, which are many illnesses. So one of the major issues for us is that our hospitals in the future won't be able to meet the growing demand for services particularly for the older people; our aged care population is increasing very quickly, so that's why we put a lot more money into aged care (Interviewee 11).

3.6. Economics

Rules underlying randomized controlled trials and economic evaluations could also help participants improve the decision-making process when there were conflicts regarding the assessment of the cost and/or consequences of those interventions. However, for participants, seeking economic data was most often in the form of budgetary impact analysis and cost measures rather than formal economic evaluations. I signed up with a little bit of expenditure but I don't have much delegation; budgets are developed historically which just covers our salaries and almost no money to spend, there is no need in fact to have an economic analysis there is no point to do it (Interviewee 10). Evidence from formal economic evaluations played a key role in guidance issued by the Commonwealth Pharmaceutical Benefits Division mainly appraisal of new innovative medicines.

3.7. Politics

Some other times, politics – not simply policy directives and guidelines or the requirements to follow national policies – played a critical role in processing resource allocation decisions. There have been situations in which changes in political cycles and coalitions shifted the organizations' goals in favor of particular policy initiatives. In such a highly political arena, allocation decisions were often manipulative, in that political preferences replaced organizational goals and facilitated or hindered the success of allocation decisions. Participants noted that decisions often 'are politically bounded' and 'you would be very naïve to think that you are not affected by the political environment at the time' (I04CH & I16LM). I20SB also added that 'within the health service, for as long as I can remember' changes happened 'just because we have a different political party'; reflecting the ideological stances of different political parties and subsequent campaigning as well as pressure groups and advocacy for action. In policy terms, although our participants claimed that the organizing, administrative and legislative principles and rules were significant reasons for them to improve the resource allocation decision-making processes, they exercised degrees of autonomy and flexibility of how to apply them in order to learn and adapt to their ever-changing fitness landscape.

3.8. Knowledge Source

In tentative, operational situations participants referred to a set of particular sources of knowledge that helped them construct or instruct their actions. Often they applied their mental short-cuts, learned methods, educated guesses, common sense and intuition together with empirical and rational tools as they encountered risky and uncertain conditions or when they needed to do something quickly. Budget build-up is a multitude of different things; you will pull together to actually start developing a base budget and certainly you can't do any of it without a great deal of experience, and also the ability to draw from other people the information is required (Interviewee 07). In some situations, they shifted to a recognition-primed decision process or to cognitive and available heuristics. They utilized the ways that they were most familiar with and made choices that had worked before. They applied a range of strategies to make risk adverse decisions quickly in situations which were likely to reduce adaptability. Interviewee 019, for example, noted that her decision rules and behavior depended on how similar the process was to past behavior and outcomes: 'what others have used and found easy to use and beneficial'. The strategy of Interviewee 22, mentioned above, also referred to making decisions based on similar or repeatable events in the past and implicit action. It was also associated with the heuristics of trial and error because he relied on his guess. He selected the most likely solution that he 'thought is going to work', applied it to the decision and, if it was not successful, generated or executed another potential option and so on until the decision-making process ended when a satisfactory pattern or alternative was found. His comments that decisions don't work sometimes, reflects the complexity of decision-making. Yet, some participants pointed to learning through making 'mistakes' and drive their decisions to closure. Many participants reported that knowledge of decision-making was not so much driven by rationality, inference or the use of reason as it was by common sense; a notion that they usually tended to link with human experience and intuition (experience and accumulated judgment), unconscious understanding or gut feeling. Participants applied common sense reasoning to decision-making situations to determine which aspects of the situation were significant to the practice at hand. The intuitive approach, however, was particularly pertinent when decision-making involved uncertainty and perceptual cues.

You sit with people to see how they make decisions and you learn how to make decisions; you wouldn't have a good decision if you have not a good mental from leaders. I didn't do specific training. A lot of this is common sense; some of this stuff is not learned, you can't teach someone who does not understand these very well or does not want to learn. There is also some intuition (In-

terviewee 09). Yet, all participants acknowledged that in complex situations the cause and effect relationships were not immediately apparent, and the way forward was only determined based on shared vision and experience. This allowed the right decision to be triggered in the right context. For them decision-making in this sense was more emergent than explicitly structured or rational. It was interpersonal skills and accumulated knowledge which mainly enabled them to behave in ways that enhanced the likelihood of achieving desired allocation outcomes. Interactions are embedded and integrated in social realities, where socially constructed, complex and contextual patterns are constantly shaped and reshaped. They utilized information collected from evidence or through interaction with others as clues when making resource allocation decisions however financial constraints necessitated some rationing. This helped them to survive, learn, and adapt over and over. In our management team, we have a decision support unit that includes somebody very familiar with casemix funding, coding of patients' data, and also financial data that prepares a briefing on not just the financial benefits of providing services, but also the types of patients that are coming in their primary diagnosis. Based on the data which is validated by another team at area health service we have good positive data to make decisions (Interviewee 11). Collaborative effort was unlikely to be adopted if there was not a high level of mutual trust and confidence between collective decision-makers. Within the context of trusting relationships, they could help each other to cope with challenges associated with allocating scarce resources. Through interactions participants also created a dynamic system which achieved feedback and redundant communication that supported emerging patterns. Feedback mechanisms helped them self-regulate their activities and get a better grasp of the reality. All participants pointed to creating and developing interactions, partnership and positive interpersonal relationships in order to work together. In particular, working together emerged when evidence-based information like policy objectives failed to fully address contextual complexities. The premise behind working together was that knowledge might emerge in social interactions that were not available to individuals working alone. Decisions which were made collectively were significantly different to what any or all the individuals made independently.

Together we make better continually a broader understanding of client needs because everybody in the team is involved to make the decision rather than one individual (Interviewee 01).

4. Discussion

A relatively growing body of literature provides insights into complexity theory to explore the application of it to evolution, and its possible implications for hard and nat-

ural sciences (e.g. mathematics, biology, physics and economics) and social science for some time[17, 18] e.g.,[19] but very little in the field of health. This study revealed that senior executives in Australia's healthcare system talked about most, if not all, features of a complex adaptive system without explicit knowledge of complexity theory. Although complex adaptive systems theory is increasingly used in an explicit way in the British National Health Service and in some United States health systems e.g.,[15] our data suggest that these executives were using decision-making methods to deal with complexity without the benefit of explicit knowledge and methods associated with complex adaptive systems theory. The study of complex adaptive systems exhibits a number of properties that make them appropriate for the study of social systems.[20, 21] Each property is interdependent and linked to other properties, so that each property can be a cause or effect of the other properties.[20, 22, 23] These features, mainly specific to social systems, are highly context-sensitive and do not react in the same way to the same stimulus at different conditions, times and places.[20] We drew on these characteristics to provide a conceptual framework for analyzing data in this study.

4.1. Adaptable Elements

Complex adaptive systems bring an intricate web of diverse, rule-based and interconnected components – referred to as agents or elements – under their control. These elements can change themselves and self-organize. For example, micro-organisms develop resistance to antibiotics and people learn.[20-22, 24-28]. In this study Australia's healthcare system was adaptable in two senses. Agents or sub-systems within the system adapted to systemic and environmental changes and the system as a whole adapted to change in its environment. Decision-makers learned to re-organize themselves by creating patterns that enable them to facilitate efficient adaption to their changing environments aiming to generate sustainable solutions for system survival. At times, they needed to modify their past experience to adapt to the new situation; and that very adaptation changed the situation. In a complex adaptive systems the agents are partially interconnected but yet autonomous in a net of relationships whose actions are contingent on local knowledge and characteristics of the other agents within or outside the system's fuzzy boundaries, so that one agent's actions affect the context for other elements.[22, 24, 29, 30] They have degrees of freedom to generate possibilities to act in their individual context.[22, 24] Such autonomy, along with dependent nature of many elements, makes it difficult to predict the behaviour of complex adaptive systems within various contexts. For example, individuals in a social system act autonomously; however, they may be influenced by their family and/or the organization they belong to. While they are in dy-

namic interactions with their family and organization, they are also able to influence the environment beyond the family or organization's boundary. Meantime individuals may adapt to their context, i.e. family and organization, through a feedback loop. The agents' upcoming actions may also be influenced by their own earlier actions and systems' history.(22) The adaptation possible in a complex environment aims to generate sustainable solutions for system survival and if it fails the response may not be pleasant.(24, 31) In this study we found that even though the Commonwealth, states and territories jointly were responsible for regulating health workers especially medical professions were largely self-regulating. While state and territory governments had a great deal of control and power over hospital decision-making, the medical profession exerted extensive power and control in the public hospital system because of a high degree of autonomy.

4.2. Simple (Stimulus-Response) Rules

Complex outcomes or intelligent behavior can emerge from a set of several simple rules that are locally applied. (21) It is the tendency of complex adaptive systems to spontaneously generate orders and patterns that pursue the rules governing the interactions of elements, feedback loops and local behavior.(23, 25, 32, 33) Rules have the potential to create structure or facilitate an emergent behaviour away from their individual capacity and in turn form massive complex patterns. In social systems such rules need to be internalized if they are to produce expected outcomes.22 For example, for a flock of birds a simple rule might be flying an average distance from the neighbors. In this study, a rule might be 'assessing the equipment whether it is safe to buy' or 'ensuring complete safety for patients based on the strength standard'.

4.3. Non-Linearity

A complex adaptive system is non-linear if there is no definite, predictable causal relationship between elements or systems.(24) Small, random changes in initial conditions, input or any layer of the network can have large effects on outputs or the system as a whole, and large changes may have small effects.(22, 26, 34) Such a change can either force the system into chaotic behaviour or lock it into stable performance.(35, 36) For example, a large political campaign may produce little change in health policy initiatives, yet a local council or health board can significantly shift an organization's goals in favour of particular programs.

4.4. Not Predictable in Detail

No single agent in the system knows the behaviour of the system as a whole due to nested nature of elements. (27, 37); one cannot adequately understand and predict

the behavior of a complex adaptive system by breaking it down into its components parts and considering each in isolation.(26), (38-41) 'Forecasting is inherently inexact, yet bounded. For example, the extent and severity of a new influenza epidemic cannot be predicted with any accuracy, but it is bounded in the sense that we can make generally true statements about things like the probability of a new outbreak or likely patterns of spread'.(21) The behavior of complex adaptive systems is better perceived if the systems are observed within the multiple and multilevel contexts within which they are embedded considering their previous states and interactions.(24) Because the behavior of a complex adaptive system cannot be anticipated or deduced from the behavior of lower-level entities the behavior is said to be emergent.

4.5. Emergent Behavior

Continual creativity and novelty is a natural state of the system.(21) Interactions within a complex adaptive system lead to order and innovation to emerge spontaneously, exclusive of being externally enforced or imposed from a leader.(26, 27, 34, 36) The emergent properties have their own patterns and synergistic characteristics; the whole that emerges over time is greater than the sum of its component parts.(9, 40, 42) For example, in complex situations in our study, instead of looking for empirical evidence and rational argument before acting, it was often more promising to try new ways of doing things, to encourage innovation and creativity in local situations, then monitor these trials, seeding small interventions to see which took root and grew, which innovations changed the existing patterns in ways they wanted; which worked and which were taken up.

4.6. Inherent Order and Distributed Control

Self-organization is a key idea in complexity theory.(22, 24, 34) The system can be orderly, and self-organizes itself in the sense that no central and hierarchical control, directing intelligence or intentional force is required. Order just emerges as a consequence of individuals acting unilaterally and conforming to local organizing principles or rules.(15, 43, 44) For example, there is no central controller for the Internet or for the food supply of a city; economic markets operate without central control. Despite having an overall emergent orderliness, complex adaptive systems operate in ways that appear arbitrary at close inspection.

4.7. Context and Nested Systems

Complex systems exist within systems, and contain subsystems, one nested inside another. For example, Australia's healthcare system exists within a net of parallel and bigger systems e.g. community at large, and contains many subsystems (such as hospitals and com-

munity health centers) made up of diverse interacting autonomous agents, both human and non-human (such as nurses, patients and multi-resistant bacteria) as well as situations of varying complexity at multiple administrative levels. While we can study the constituent parts a complex adaptive system independently, the multiple and multilevel contexts within which it is embedded matter in fundamental ways.(21) Diversity in contexts and perspectives creates more creative options, more interactions and richer patterns within systems.(22, 24) Such diversity enhances the emergence(28).

4.8. Co-Evolution

A complex adaptive system moves forward through constant tension and dynamic balance.(21) Self-organization provides elements within the system – and the system as a whole – with the capacity to constantly interact with the environment to survive; the system thus not only learns and simultaneously adapts to and influences its environment but also creates, evolves or changes its rules and behavior to meet the changing demands of context stimuli. (26, 29, 37) Competition and cooperation are both intrinsic to the way health professionals work; improved nursing or medical techniques are usually developed through multi-disciplinary collaboration. 'Tension, paradox, uncertainty, and anxiety are healthy in a complex adaptive system. In machine thinking, they are to be avoided'.(21) This study demonstrated that decision-making in Australia's healthcare system is not exclusively a rational activity and does not occur within a single static framework but it is primarily contextual and changes over time. Decision-making in this system stemmed from a multifaceted interplay of factors and behaviours in the situation of action. It involved multiple processes, with rational, cognitive and intuitive practices as well as shared or competing visions mutually informing allocation decisions. Despite being exhorted or (in many cases) taught to use rational and linear approaches to economic analysis and evidence-based decision making, they reported the use of all kinds of knowledge (explicit, implicit and tacit) that are generated by individual or collective decision-makers who engage at different sites and are embedded in different networks. The system may not adapt to situation unless it learns to make sense of it. The review of findings reflected that relying on tacit knowledge and collective sense-making or interaction with others was predominantly a sign of coping with contextual complexities. Participants frequently attempted to generate ideas through creating a sense of community, an atmosphere which resulted in a complex network of commitments, credibility and mutual trust. Trust and confidentiality in this sense is a natural occurring phenomenon because all collaborative decision-making activity is constructed on a voluntary basis(45). That is, trust cannot be conscripted. Systematic evidence-based reviews were used in some

contexts, but not widely throughout the health system, and the main focus of decision-makers' attention was on adaptive decision-making. There were huge pragmatic barriers in applying these formal procedures to the situations which combine complexity with uncertainty, and occupy most of decision-makers' attention and time. The dominant modes of practice and administration, looking for evidence-based best practice, tended to inhibit creativity and were risk averse. This was highly appropriate in simple and less complex situations (e.g., in PBS case), but was counter-productive in complexity and chaos.

In complex situations decision-makers tended spontaneously to generate order and patterns through applying simple rules (e.g. interaction with others who had knowledge and expertise). Their decisions could not be isolated from the context and were dependent on many other previous activities and decisions in the historical path. They frequently seeded small interventions and 'experiments' (using heuristics of trial and error and analogy), and intuition to observe patterns and then to encourage promising directions. Over time these small adaptive changes into adjacent possibilities can grow, usually gradually but sometimes by threshold leaps, into new patterns and forms. Within complex adaptive systems theory this research confirms that the Cynefin model of knowledge management(15) can be applied heuristically to analysis of decision-making in healthcare resource allocation. That is, healthcare decision-making can be divided into two ordered domains (simple and complicated) and two unordered domains (complex and chaos). In the ordered domains the traditional rational models of decision-making can be applied, whereas contextual or adaptive decision-making processes are appropriate in the unordered complex domain. The Cynefin model helped determine the prevailing operative context that decision-makers applied to make appropriate choices. According to Cynefin, decision-makers work in different situations which require different actions. These findings need to be confirmed and further clarified within healthcare systems. The Australia's healthcare system is in a period of rapid change from healthcare technologies, significant demographic shifts (including population ageing), global warming, economic crisis, increasing globalization and rapid changes in information technology. What is needed in this context is flexible decision-making, constant adaptation to change, innovation as well as stability and continuity to produce reliable results and dependable high quality healthcare for the population. 'Decision-makers must learn to accept that rigid decision frameworks, even if very conservative, are not any more protective than risk-based, adaptive ones'.(46)

Our study also draws attention to an alternative method of data analysis, i.e. complex adaptive systems theory, which may better reflect the complexities inher-

ent in real social world decision-making than quantitative approaches. It departs from historical emphasis on rationality and reductionism in favour of flexibility and adaptability. This led us to wonder how future interest in understanding the failure (and success) of allocation decision processes and policy instruments may change if we conceptualize healthcare systems, and the multiple and multilevel contexts within which they are embedded, as complex adaptive systems. Healthcare organizations have many actors, belonging to many professions with different knowledge assets, and different approaches to knowledge construction and dissemination. It is not possible to elicit all the knowledge that a skilled and experienced professional can bring to a clinical problem. The data are limited to self-reports that introduce biases. The description, account or story of decision-making by participants does not tell us how they actually made decisions. Knowledge is contextual and revealed in action.(15)

5. Conclusion

In conclusion, this empirical research showed that healthcare decision-makers relate to contextual run-time factors which change while the system is operating, and utilize a multifaceted array of elements, methods, skills and insights in situations of action. As healthcare decision making becomes increasingly complex in difficult economic times traditional evidence-based methods of decision-making are not widely utilized, but there are no obviously better alternatives. Systematic evidence-based or officially prescribed models of decision-making may offer a set of theoretically valid, rational principles for conceptualizing resource allocation. However, healthcare resource allocation decision-making in Australia is not or cannot be purely based on rational processing or technical issues. Complex adaptive systems theory has the potential to support robust decision-making and enrich and broaden our understanding which might shed more, or different, light on complex policy issues.

Authors' Contribution

A.B. conceived the study aims and design, contributed to the systematic review and data extraction, performed the analysis and interpreted the results. G.T. and Y.B. drafted the manuscript, contributed to the data extraction and to the revision of the manuscript.

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