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Heath services system improvements: case study of stroke unit using design research methods

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RESEARCH

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Abstract

Background

This paper describes recent research involving a user focused design analysis of in-hospital residential treatment for stroke patients in a dedicated stroke unit.
The focus of the research was to identify potential design strategies to improve stroke unit patient care from a health services user perspective. The theoretical perspective used is *systemic* in which the performance of the stroke unit in its hospital context is analysed as a *designed socio-technical system* that includes all of the designed objects, processes, infrastructure, subsystems, organisational behaviours, rules and legitimation, and resources that enable its functioning.

Method

The data collection and data analysis used systems and design research tools and analyses. Data collection is from a single 'deep slice' case study following a single patient through a stroke unit in a medium scale hospital of (approximately 280 acute beds overall) with 26 stroke unit beds. The case study involved over 200 hours of observations over nine weeks and liaison with hospital and family over the four months of the patient's stay in hospital. Design analysis followed two pathways: 1) identifying problems of service to the health service user that offered design opportunities for improvement or resolution; 2) systems design analyses to identify root causes of user problems and process failures.

Results

The case study identified multiple problems and multiple design opportunities for resolving problems and addressing process weaknesses and failures. In addition, the systems design analyses identified three structural systemic problems that appear to be causal factors for most of the design problems identified in the stroke unit case study.

Conclusion

The paper concludes with three design proposals for improving stroke unit outcomes via improving the design of stroke unit organisational systems. These proposed design strategies may be of benefit more widely in hospital system design for improving health services' outcomes, financial efficiency and user interaction.

Key Words

Stroke unit systems design, user-focused interaction analysis, case study, viable system model, variety analysis.

Background

This research project focused on design issues relating to integrated in-hospital stroke units. The theoretical perspective used in this research is systemic. The stroke unit in its hospital context is viewed as a designed socio-technical system that includes all of the designed objects, processes, infrastructure, subsystems, organisational behaviours, rules and legitimation, and resources that enable its functioning. The theoretical perspective used has three lenses through which the data was collected and the organisational design that shapes stroke unit performance was analysed. First was a focus on simple non-systemic design failures (1, 2). Second was analysis of the stroke unit as a designed socio-technical system by comparing it to a *viable system model* (VSM) (3-6). The viable system model was developed initially by Beer(3) and maps out the structure of system entities, functions and relationships necessary for a system to be viable; i.e. achieve its outcomes without collapse and be managed

successfully. This VSM approach to systems design analysis and evaluation has been widely tested for quarter of a century in organisational, management, information systems and military fields. The third lens of the theoretical perspective is that of seeing the system in terms of its *variety distribution* and in particular a perspective that focuses on comparing the variety available to the managers to control the system with the variety which the system generates as described by Ashby's Law of Requisite Variety (7, 8).

It is important to note that this theoretical perspective is fundamentally focused on organisational design considerations, rather than clinical or medical treatment. Its aim is to identify structural factors that result in operational and management failures, and opportunities for design improvements that would result in improved quality of functioning of the stroke unit, health system delivery of medical and related services, and improved health outcomes from the hospital system; resulting in improved quality of life overall for stroke patients in the society serviced by the hospital.
These design research approaches were used to investigate potential for design improvements in the stroke unit studied and potentially in stroke units sui generis. This study may be of particular relevance in view of the currently conflicting discussions and evidence as to the benefits of integrated care pathways in in-hospital stroke units (9-12). Research reported by the Royal College of Physicians(13) in Scotland identified that stroke units sit on a boundary in which it is unclear whether, organizationally, integrated care or 'usual' hospital care offers the best advantages, and thus stroke units act as a potential boundary indicator in terms of hospital organisational structures. In theory, integrated care pathways would be expected to provide significant benefits in the case of stroke treatment, which involves an interdisciplinary approach, yet evidence indicates there are no significant benefits in outcomes. This suggests other unaccounted limiting factors are the determinant of outcomes. The relatively high level of process and care problem instances observed during this study suggest that these, and by implication their underlying causes, may significantly act as limiting factors influencing the stroke unit effectiveness independently of medical facilities and care protocols.
The research identified system design issues that offered opportunity for improvement in hospital services to the patient between the time of emergency admission and the time of discharge nearly four months later. Many design issues were identified as being associated with or caused by specific structural organisational system problems that can be improved via design.

Of particular interest, as the research progressed, were the obvious failures of sub-system integration and coordination of hospital services and the integration and coordination with non-hospital support services essential to patient care. These problems occurred within the stroke unit organisation, in the hospital external to the stroke unit and between the stroke unit and hospital services and external services.
This issue is especially significant. Integration and coordination within the stroke unit's multi-services providers, with hospital services, and with external support services is a core function and primary reason for the existence of integrated in-hospital stroke units. Hence, these systemic problems are of central interest in design research terms for improving in-hospital stroke unit quality of medical services provision and health and quality of life outcomes for patients.

The outcomes of the research were twofold; in-line with the twofold nature of the analyses. The first design research perspective resulted in identification of 14 'clusters' of design problem issues of the type typically caused by specific in design processes or resources. These occur, for example, where a design team undertakes design of layouts, signage and traffic flows without access to logistic and way-finding design expertise, or where funding or time shortages preclude sufficient attention to these issues, or where communication is weak between different design teams.
The second design research perspective resulted in the identification of three deep systemic problems that appear to be the causes of the core failures of the integrated in-hospital stroke unit fulfilling its intended purpose. As a similar type of failure of outcomes is reported more widely, it may be expected that other stroke units have the same systemic problem causes, particularly as the identified system problems are typical in hospitals.

Method

The research was undertaken in a developed western country. Identifying features of descriptions have been changed to avoid identifying the patient, the hospital or the healthcare provider. It used a conventional design research data collection tools and analyses. Data collection was undertaken by "deep slice" case study approach. The researchers followed a single patient in their path through the hospital system from entry to the hospital and its integrated in-hospital residential stroke unit exit to exit to nursing home care. Data collection was by informal observation of user interactions between health services staff and processes and the patient and family. The researchers observed these interaction for more than 200 hours (between 3-5 hours of observer involvement six days a week for nine weeks) plus liaison on and off ward with hospital staff and family members over the whole of the four months of the patient's stay in hospital and their transition to a residential nursing home.

The research was informed by two design research perspectives. The first perspective focused on everyday design failures or problems of the kind that can be addressed by local redesign. These are issues such as failures of medical information about the patient. An

example is the design failure of using a whiteboard to avoid medication mistakes by marking patients with duplicate surnames, and having no system or process to check whether names were missed. This first approach to design analysis was undertaken by following an historical timeline through the patient's involvement with the stroke unit. Design-related problems were noted as and when they were identified. Obviously, this is a lower bound on the design problems in the situation as there are potentially design issues and problems that were not observed that would appear in the case of other patients or other observers.

The second design research perspective focused on systemic design issues, i.e. root causes of design problems. This second perspective asks the question 'how do systems need to be changed so that designed-in problems are avoided?' In line with these perspectives, data analyses were focused on identification of systemic problem issues and the application of systems analysis tools, Beer's Viable System Model (VSM) and Ashby's Law of Requisite Variety (LoRV) with extensions by Love and Cooper (see, for example, Beer, 1989, 1995; Glanville, 1994; Heylighen & Joslyn, 2001; T Love & T Cooper, 2007; Stockinger, n.d.). The purpose of the Viable System Analysis is to identify whether a socio-technical system such as the stroke unit has the structure by which it can function viably as system and be managed successfully to achieve its intended purposes and outcomes with high performance.

Comparison of the systemic structure of the stroke unit with the VSM indicated whether the structure of the stroke unit as a socio-technical system is of a form that avoids intrinsic structural factors resulting in failures of performance. This VSM approach is especially useful in systems that are dominated by complex organisational considerations because prior use of the tool over the last quarter century has identified characteristic pathological system behaviours that relate to particular systemic structural forms (3). These pathological systemic behaviours can be checked and triangulated against what is observed of the system's behaviour. Variety analysis using Ashby's LoRV both provides triangulation of the findings from VSM analysis and provides insights into the functioning and malfunctioning of a socio-technical system in its own right. 'Variety' of any aspect or element of a system is the number of states that element or aspect can have. For example, a light switch has a variety of two states: on and off. Similarly, a nurse can act in a particular situation in a variety of ways. The greater the number of ways the nurse can act, the greater the variety of that aspect of the system. The numbers of elements and aspects that can have variety in a socio-technical system such as a stroke unit are very large. What is of interest, rather than the total number of the variety, are the relative dynamics of the distribution of variety. This is because comparison of relative system and control variety at local points in the system indicates whether the system CAN be managed at that point to shape its behaviours. Ashby's Law of Requite Variety (LoRV) states simply that the control variety must exceed the system variety (7). This basic axiom can be extended into a variety of systemic contexts. Variety analysis based on Ashby's LoRV offers deep insights into whether and how a system is being managed and by what means this is done – not always those intended! In the case of a highly complex dynamically changing socio-technical system such as a stroke unit, the distribution of system and control varieties may be irregular, complex and continuously dynamically changing across the system. These effects can be analysed by extensions to Ashby's LoRV that look at the implications at different systemic scales and of different systemic structures (14). This second approach to design analysis reviewed the integrated in-hospital stroke unit as a hospital and health service sub-system using VSM analysis to identify characteristic system pathologies and systemic causes, and Ashby's LoRV to identify structural reasons for power and control, to triangulate the analyses and provide additional insights. The benefits of undertaking a case study following a single patient through the system, rather than (say) using aggregate data across many patients, are that the case study reveals specific systems failures and links them to their antecedents. It offers the opportunity to ask in the moment, 'how could this system be designed better'? It reveals and identifies in a concrete way specific design opportunities that follow from particular real world events that are part and parcel of being a hospital user, medical professional or healthcare manager.

The above two forms of systemic design analysis were chosen because they are foundational to quality improvement in managed organisational and service providing systems. Ashby's LoRV is widely considered as a core building block of all systems analysis and the VSM identifies core requirements for any managed system (7, 15). Organisations and institutions that align with the VSM (i.e. are viable systems) and make sense in the alignment of their variety distribution with their intended purpose are self evidently likely to respond well to quality improvement interventions. This is because their organisational elements, staff roles, management paths and organisational relationships map to their intended purposes. In contrast, organisations that show as compromised under the above two analyses are unlikely to respond successfully to quality improvement initiatives because they contain organisational structures, staff roles and relationships that not aligned with their organisational purpose. In this situation, initial apparent benefits from quality improvement initiatives are quickly reversed as a result of intrinsic systemic problems, and investment in quality improvement is wasted.

Results

The design data collection and identification of design issues followed the health services interaction with an elderly man who was admitted to hospital following collapse and unconsciousness later identified as a major stroke. He was discharged to residential nursing care 3 months later. The time line of the main organisational aspects of his use of the health service is shown in Table 1.

Table 1: Timeline of user interaction with health service

Time	Location/health service
First morning	Ambulance to Accident and Emergency Department
2 nights	Medical Assessment Unit (MAU)
3 nights	Male surgical ward
3 weeks	Stroke unit acute ward
2 months	Stroke unit rehabilitation ward and administration for transition to residential nursing care.
1 months	Arranging external technological support (wheelchair, support chair) - overlaps last month of stroke unit.

Medical Assessment Unit (MAU)

The MAU is for patients awaiting test results that determine treatment and identify the appropriate specialist ward. The patient spent 2 nights (3 days) in the MAU because the stroke unit had no spare beds.

Design issue – best practice in stroke treatment is immediate rather than holding.

Design issue – stroke unit capacity can be planned based on historic and trend stroke data for the hospital's catchment and demography. Part of this issue also relates to a design issue identified later on administrative problems resulting in difficulties in patients' transition out of the stroke unit.

It is unclear whether standard recordings and clinical observation charts were undertaken at the MAU, but these could not be found some weeks later when they were requested.

Design issue – clinical observation charts are important for identifying short-term clinical deterioration (see, for example, 16) and for identifying severity of impairment and recovery trajectory.

Male Medical Ward

After 2 nights the patient was moved from the MAU to a male medical ward geared to surgery. They stayed in the male medical ward for 3 nights. As in the patient's extended stay at the MAU, their stay in the male medical ward was because there were no spare beds in the stroke unit.

Design issue – stroke treatment is specific and multi-disciplinary. Conventional care gives worse outcomes than stroke unit care. In this case, it appeared the male surgical ward was specialised in ways that were not well aligned with treatment of stroke patients

The patient was immobile and aphasic. His relatives inquired about nursing precautions to prevent bed-sores. No pressure relieving mattresses were available and they were told that nursing care would ensure the patient did not develop bed sores.

Design issue – the numbers of pressure relieving mattresses needed for stroke patients can be calculated on historic and trend stroke and demographic data.

Design issue – it was obvious that nursing care was overloaded and managing bedsores was of lower priority than other patient care issues and unlikely to be undertaken (confirmed as the patient had bedsores from this first week to transition out of the hospital to residential nursing care 3 months later).

Design issue - the reason for using pressure relieving mattresses is to reduce overall costs compared to the expensive costs of the same tasks undertaken by nursing staff. The lack of equipment would be expected to increase costs and result in worse outcomes.

Design issue – design or pressure sore avoidance with appropriate risk assessment should start within 6 hour of the start of admission to an episode of care (17)

The male medical ward was almost exclusively geared to the needs of patients recovering from surgery. It was incidentally used as another temporary space for patients with a variety of needs placed there because beds were not available in the correct specialist wards.

Design issue – short and long term planning of wards, medical facilities and staff profile did not align with needs of health system users. Historic and trend medical data and demographics of catchment potentially provide a basis for improved planning.

Staff in the male medical ward did not have good understanding of, or made no allowance for, the needs of non-surgical patients, e.g. all patients were dressed in hospital gowns rather than pyjamas as a matter of course.

Design issue – this is a local suboptimisation problem where local practices and cultures of sub-units reduce the quality of the health system overall. There is a design opportunity to design out the local suboptimisation through management, training, culture change and process.

Staff in the male medical ward assumed that aphasic patients were unable to understand. The staff did not talk to the patient, reassure him, explain procedures or seek his consent.

Design issue – this is a significant training issue with human rights and ethical implications. The patient clearly understood speech. Although he was unable to speak, he was easily able to indicate his agreement and disagreement if asked. Improved staff training would have enabled staff to seek the same feedback and patient decisions that they would from a non-aphasic patient.

Patients' names were written on a whiteboard. To avoid medication confusion and errors, patients who shared the same family name were identified by an asterisk placed by their names. The researchers noticed two pairs of patients shared the same family name, but only three patients had asterisks by their names. One of the four patients had been missed.

Design issue – if using the whiteboard in this way is a core part of avoiding medication errors, there is potential for design of an improved system.

Design issue – in any complex organisational system that is informatically complex and has multiple information systems, the informal use of whiteboards is a powerful tool to address system and process problems and deficiencies. The use of whiteboards in this manner, therefore, is typically a strong sign of failing systems and processes.

Before the patient left the male medical ward, he developed a sore on the heel of his immobile leg. A pressure relieving mattress was eventually located after his relatives drew attention to his need.

Design issue – the health service provides expertise to its users and presumes its users and related stakeholders are not expert. Users and stakeholders should not be able to influence the management of the hospital service provision. That this was both possible and needed suggests multiple systemic failures with concomitant opportunities for design improvements.

The patient's bed sore was not fully healed when he was discharged from hospital over three months later.

Design issue - Pressure sores significantly reduce the quality of life of patients and increase the costs of patient care and length of hospital stay, and their prevalence can be significantly reduced by best practice (17, 18).. This offers potential for design improvement across multiple sub-systems because the problem started in the MAU and Male Medical ward and persisted through the stroke unit and later resulted in additional costs to the external residential nursing care institution.

Stroke Unit

Five nights after admission, the patient was transferred to the acute section of the stroke unit and remained there for just over two weeks. The patient was assessed and found to have a weak swallow reflex, which meant he could only be fed by trained nursing staff. He slept a lot, a side effect of a stroke, and feeding could only occur when he was not drowsy. The patient's meals would arrive and a trained staff member would sometimes look in to see whether he was awake. If he was not awake, or if no trained staff member was available to feed him, his meal was removed, even though a few minutes later he might wake up and be able to be fed.

Design issue – local suboptimisation of the food delivery system led to failure of patient feeding. Food delivery staff delivered food and removed residue at fixed times independent of patients' ability to eat or need for food. In this case, it led to a cumulative systemic failure of medical care including physiotherapy. There is a design opportunity for addressing the local suboptimisation problem.

At this stage, the patient had not eaten for over a week. He had received two gastro-nasal feeds and visibly lost weight. Under this feeding regime, four weeks after the stroke, the patient had lost 15kg and looked emaciated (appearance at admission was of BMI ~ 25).

Design issue – There is an opportunity to design a more flexible arrangement for patients whose feeding is compromised by the routines and processes of food service delivery.

Three weeks after admission, the patient was started on physiotherapy planned to be on a daily basis. He was rarely getting sufficient food and appeared tired and weak. The physiotherapists decided that he was not making rapid progress and decreased the frequency of physiotherapy. This had important consequences because it reduced what is regarded as an important component of stroke treatment.

Design issue – There appears to be an opportunity to design better communication between different stroke services providers.

Each patient was given a fixed physiotherapy time slot. Physiotherapy was not undertaken any day that the patient needed diaper changing. Care staff routines were such that they were unable to coordinate diaper changing with physiotherapy time slots. This resulted in physiotherapy not being undertaken with the patient.

Design issue – local suboptimisation of individual stroke services resulted in failure of service provision when services depended on each other. This situation provides an opportunity to design better coordination and

communication arrangements between stroke medical support services and remove the local suboptimisation.

Design issue – the raison d'être of stroke units is exactly to resolve these problems of coordination between stroke medical support services. This raises the larger design opportunity of analysing why, systemically, these coordination problems apparently remain commonplace.

The acute stroke unit wards had a shared hand basin to enable staff and visitors to wash their hands as an infection control measure. Infection control in this hospital was a particular concern with extensive public awareness posters and education schemes to promote hand-washing by staff and visitors. The sink waste became blocked and staff and visitors were unable to wash their hands. Care staff reported the problem. It was not been repaired a week later when the patient was transferred to the rehabilitation ward. The reason given was the repair was classified as non-urgent.

Design issue – this is a design problem related to lack of consistency and coordination between hospital sub-units. In this case, it was not clear whether this is a local suboptimisation problem, a prioritisation problem, or a system failure. All three offer design improvement opportunities.

A nurse, recently demoted because of lack of competence in distributing medicines, was performing duties as a trained staff member. The reasons that she had been demoted were overlooked in terms of local suboptimisation to reducing costs and address staffing shortfalls.

Design issue – there is opportunity for the design of systems to improve quality in terms of managing relationship between individual competence and staff roles.

Stroke unit rehabilitation ward and administration for transition to external residential nursing care

For seriously affected older stroke patients, transition to residential nursing care is typically the only satisfactory care option. Financial considerations are an important issue because residential nursing care is expensive. The availability of government funding for residential nursing care depends on judgements made at a case conference involving all specialists at the stroke unit. Families need to know the outcome from this conference as soon as possible because it takes time to organise a place in a residential nursing care home, places are scarce, and nursing care homes are naturally unwilling to hold beds empty.

The case conference for the patient was scheduled two months after admission and was cancelled. It occurred two weeks late. The various specialists (speech therapist, physiotherapist, care manager, nurse, the doctor did not attend) presented their findings and it was suggested the patient would need nursing care and be eligible for financial support. Relatives were advised the patient's eligibility for financial support for a nursing home place would be confirmed to them on a specific date within two weeks. They were advised to urgently look for a vacancy in a nursing home. After considerable effort, the patient's relatives found a nursing home place and the nursing home agreed to hold the place until the date of the decision about financial support. The hospital administrative processes failed again, however, and the financial decision and confirmation was delayed because the relevant paperwork had not been signed by key staff.

Design issue – there is opportunity to redesign overall the coordination between hospital services and external nursing services. This coordination is a common requirement for stroke patients. Both forms of organisation are funded and managed under the auspices of the national health care system. Coordination should be routine and yet it is clearly problematic.

The nursing home agreed to hold the place for a further week. The arrangement to make the financial ruling failed on a further two occasions, with different hospital staff providing different explanations and excuses (contradictory). This resulted in very high levels of stress on the patient's relatives and the patient.
The nursing home was not able to retain an empty bed and the relatives were forced into searching for a new residential nursing home place.
The patient's relatives were placed under considerable pressure by hospital management to agree to the patient's discharge from hospital without the completion of the administrative process addressing the payment for the residential nursing home fees. There were multiple problems with the inter-professional communication and integrity by hospital and stroke unit staff On one occasion the relatives were assured by the hospital care manager that financial support had been agreed for the patient. A few minutes later, nursing staff informed the relatives the patient's financial case had not been considered by the panel. A few hours later the relatives were informed by the hospital that the care manager had made a mistake.
The patients relatives were concerned that if they moved the patient from the hospital into a nursing home, the hospital would (influenced by health services accountants) reverse their judgement that the patient required financial support for nursing care. After the third delay, and third failure to sign the confirmation of need for nursing care, and under pressure from both the hospital and nursing home, the relatives agreed to the patient's discharge into the nursing home. A few days after the patient moved to the nursing home, the relatives were informed the patient's approval of financial support had been reversed.

This placed the patient in an impossible position in terms of getting necessary nursing care. At this point, he needed high dependency care, could not communicate, and had a thrombosis in one leg. The extent of his abilities were to move one arm and apparently to understand conversation (he could nod and shake his head). It was unclear how he would manage without nursing support. On appeal, after considerable effort and time by the relatives, the financial ruling was overturned and nursing care was funded.

Design issue – there appear to be significant design opportunities to improve the decision-making processes and internal coordination of administration between specialists relating to the stroke unit, particularly in relation to the transition to external residential nursing care. This stroke unit had a dedicated and competent manager with this role and these failures indicate a deeper systemic root cause.

Design issue – there are opportunities to design better training for staff interacting with health system users. Obviously contradictory explanations of a failure of administrative process indicate a lack of professionalism of staff (weaknesses in information, lack of honesty and concern about the image of the organisation and its staff over the care of users).

Design issue – There are opportunities to design to reduce failures of these administrative processes and these would positively contribute to patient care outcomes by reducing patient stress.

Public financial support pays for most of the costs of residential nursing care. Otherwise, patient and the relatives have to pay around $2000/ week for the care. This contrasts with the public cost of $2000/ **day** for hospital care in that jurisdiction. The researchers noted some stroke victims remained in hospital for extended periods over and beyond that needed for hospital treatment because of lack of funding for the patient to move into residential nursing care. This is in spite of the 600% additional public costs to retain them in hospital.

Design issue – there are design opportunities for significant financial gains from improving the design of the administrative system for transition of patients from stroke unit to residential nursing care or other care pathway. The current administrative failures and delays result in high levels of unnecessary costs for the health service.

Design issue – there are design opportunities for improving hospital and stroke unit functional efficiencies by improved design of administrative system for transition of patients from stroke unit to residential nursing care or other care pathway. The unnecessary delays of stroke patient discharge are considerable – in some cases many weeks - and this results in lack of stroke unit beds and consequent reflow of acute stroke patients into other wards on their admission and consequent delays of days in commencement of treatment for stroke patients as well as reduced efficiencies for the wards in which stroke patients are parked awaiting stroke unit beds.

Arranging sitting support

The patient needed specialist sitting support (an important part of recovery). These chairs are normally provided by the health services. The patient's relatives asked how they would obtain a suitable specialised wheelchair and armchair. This triggered a wheelchair assessment process during which it transpired that wheelchair would be provided by the hospital but would take between two and six months to be made available.

Design issue – there is a design opportunity for an improved system of stock management of wheelchairs.

The wheelchair arrived eight weeks after the patient's discharge. The wheelchair service had no record of the residential nursing home to deliver the wheelchair. They obtained the address only as a result of the patient's relatives contacting them.

Design issue – there is opportunity for the design of improved coordination of information between stroke unit and other hospital services.

The patient also needed a specialist support armchair (paid for by his relatives). This required special assessment and measurement to be undertaken whilst the patient was in the rehabilitation ward. This is a common requirement of stroke patients. The assessment process only happened as a result of relatives' requests, and occurred too late for the patient to be able to use the chair on arrival at the nursing home. There was no process to inform relatives of the timescale or to ensure patient assessment was completed to allow time for fitting, manufacture and delivery.

Design issue – there is opportunity for the design of a complete process for management of assessment and procurement of stroke support technologies needed after transition from hospital care to residential nursing care.

The patient was discharged without either a wheelchair or custom armchair as a result of failures of communication, faulty system processes and unplanned and unmanaged delays in the stroke unit systems.

Design issue – in system design terms, the ubiquitousness of failures of process, the similarities of these failures of hospital processes to those identified earlier, and the weaknesses of user focus in health services provision and services together suggest deeper structural systemic causes of problems. Typically such systemic causes play out in a wide variety of process

failures and compromised outcomes that initially appear amenable to simple design treatment but when corrected transform into other problem outcomes.

That the process worked at all was due to persistent proactive efforts by the patient's relatives.

Design issue – there is opportunity for design for improvements relating to addressing the ethical issues when systems and processes can be influenced by individuals external to the proper management of the process. That this influence is possible is indicative that the system or process has opportunities for improvement more widely.

Design issue - Sundry

During the time of observation, it was clear that most staff were working beyond what could reasonably be expected. Many were working beyond their hours in an attempt to rectify problems that were caused by the failing of hospital systems.

Design issue – there appears to be design opportunity for review and redesign of the relationships between designed processes and systems, tasks, resource management, workload management and staffing.

Discussion

The design issues identified above can be clustered under the following themes:

- Communication processes
- Differences in professional assumptions and practices of different disciplines
- Poor system integration (this may actually be a system of systems problem rather than a single system problem. However, diagnosis and designed solutions are similar in both cases)
- Local suboptimisation. This occurs when a functional group, which may be an individual, optimises its tasks for the benefit of itself at the expense of the overall system.
- Confused management processes. This design problem appeared common and often occurred when either a single individual has multiple managers who each have a claim on their time, or where multiple functional units or staff (e.g. nursing, food supply, physiotherapy, neurology, community care coordinator) are all necessary to a satisfactory completion of a task and yet this depends on individual decisions by their managers, whose focus is in optimising the functioning of their own cost centred area.
- Non-medical client services.
- Significant tensions between crisis medical care, acute medical care and rehabilitation medical care
- Weak integration of community care and transition to community care with medical services and hospital care services.
- Poor transitional arrangements. This design issue was observed to occur across all dimensions and systems. It occurred at the boundary between the community and hospital systems; at the transition between acute care and the medical ward; at the transition between the medical ward and the short term-acute stroke care; and at the transition from acute stroke care to rehabilitation ward. It also occurred in multiple dimensions of the transitions between in-ward nursing care and in- ward physiotherapy services and at the transition between in-hospital care and community care, in this case, the transition to a residential nursing home.
- Weak integration between hospital strategic planning and lower level processes both at the level of individual patient care services and, above that, in the provision of professional specialist services, and the management of both sorts of services.
- Care co-ordination and professional staff. During the case study we observed professional behaviours that compromised the bigger picture of the hospital service in user terms as a 'temporary health support to enable individuals to be able to return to normal lives in their community'. These problem behaviours primarily appeared to be related to underlying systems problems and in some cases appeared officially sanctioned by managers to address hospital system failures.
- Staff, especially trained nursing staff, were often unable to complete their work in the time available. Some stayed on at the end of their shift to try to complete tasks, even though they did not get paid for this extra work. Some staff complained about the pressure they felt under and how this eroded their sense of job satisfaction. For some staff alcohol abuse seemed to be an issue; often symptomatic of unsustainable staff stress (19).
- Ongoing multidimensional tension between hospital management processes and the management of specialist professional liability and risk
- Ongoing overwork of staff in the main to rectify problems intrinsically caused by problematic designs of hospital systems. Classically, this latter is a management issue rather than a failing of workers (20).

Many of the above design issues relate to weakness in the integrity of complicated hospital decision-making processes, particularly when they relate to integrated multi-service provision. They typically occur when decisions have multiple dimensions and are delegated to specialists each with a limited focus. Addressing this is a core systems design issue and applies whether a hospital applies models of conventional care, multidisciplinary care or integrated care pathways.

Currently, most hospital and health service systems primarily comprise two contradictory and conflicting system characteristics:

- Specialists with highly focused specialist knowledge and bounded knowledge and responsibilities (this is to avoid specialists acting outside their expertise

in ways that might lead the health service to be subject to litigation and legal charge of incompetence). These specialists are reified as managers of medical care within their specialist field and this reification of decision-making culturally has extended beyond that remit.

- A health provision situation that requires complex integrated multidimensional services responses across multiple specialist functions and integrated with general user care functions within the hospital and care and service provision outside the hospital.

Attempts to resolve this systemic contradiction have typically been limited to two paths: 1) multidisciplinary case meetings; and 2) the appointment of specialist integration managers whose responsibility is to manage the integrated care of patients across multiple services. Our observation is that both approaches fail to the extent that the overall hospital systems fail. It was inferred from observation that a primary reason both these approaches failed to provide successful integration and coordination of multiple specialist health services for patients is because of the embedded culture of reification of individuals specialists as managers. This is particularly evident in the system tensions between acute, crisis medical care and longer term care. It occurs in different forms. In acute crisis care, integrated responses appear to be subsumed to 'addressing the crisis of the moment'. In longer term medical care, the failure seems to occur because of a focus on maximising efficacies and reducing the Coasian transaction costs of day to day care processes. The weight of time, effort and attention is on the habituated delivery of routine services of feeding, medication delivery, toileting, and managing visitors. As a result, in both cases, integration and coordination management of multiple health services and administrative processes is regarded as an add-on to be deferred or ignored. All of these are characteristics of systems with structural systemic conflicts and a lack of user focus in processes and decision making.

Systems Analysis

[In design terms, many of the above design problem themes can be interpreted via Beer's Viable Systems Model (VSM) (21, 22) and Ashby's Law of Requisite Variety as extended by the authors. Beer's VSM is highly regarded in this role and is used by governments, large corporations and military in a parallel role to that described here.

In system terms, a system design analyst could locate most of the above design problem themes as system pathologies on the VSM shown in Figure 1.

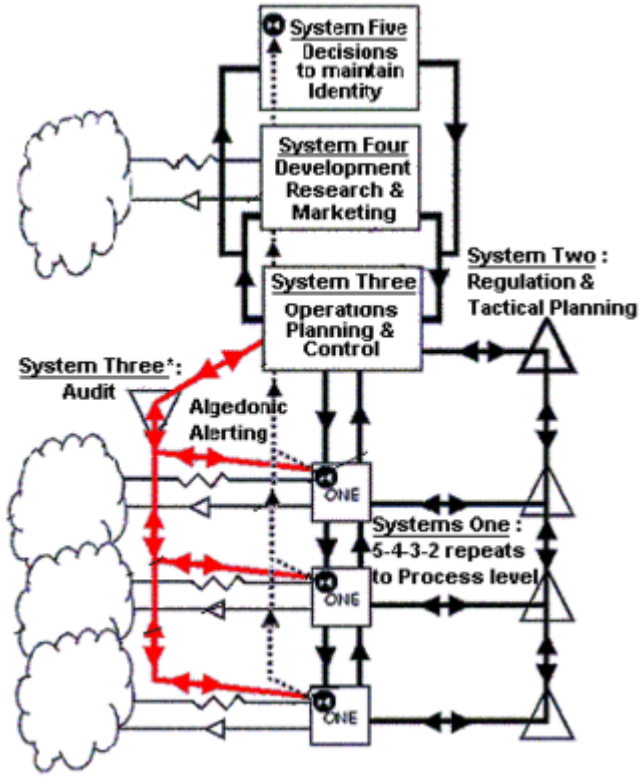

Figure 1 Viable System Model (23)

Beer's Viable System Model (VSM) shows the essential elements and relationships needed by any system to be viable and function successfully. The VSM is recursive in that any of the system 1 elements, the operational parts of a system, also themselves can be regarded as a complete VSM.

A viable system comprises five main subsystems. Systems 1 are the sub-systems that fulfill the main purposes of an organization. These interact directly with users from the external environment (represented by the 'clouds'). In a hospital these would include specialist medical services; patient care services such as feeding; general support services such as cleaning; and routine administration. Each of the system 1 has a manager. System 2 comprises the processes by which Systems 1 interact and are monitored and coordinated by System 3. In Figure 1, the system 2 comprises the links on the right of the image between the Systems 1 and linking the Systems 1 to the System 3. System 3 is the intermediate management sub-system between the operational level activities undertaken and managed by Systems 1 staff and managers and the managers in Systems 4 and 5. Systems 3 and its manager provide the coordination to integrate the activities of all the Systems 1 into a successful functional whole and to monitor whether the Systems 1 are acting in the intended coordinated manner. In the stroke unit system, System 3 is undertaken by integrated care manager. System 3 also includes an algedonic loop 3* to manage rapid change of crisis and failure. Note: this is crisis and failure of the system – not the patient. The focus of System 4 is gathering information from the external environment in order to advise mangers in Systems 3 and 5 about future

conditions. In the hospital system, this is information such as changes in demographics and trends of medical need, the needs of the constituencies the hospital supports, new medical technologies and improved ways of designing hospital systems. System 4 provides evaluation and forecasting information to management systems 3 and 5. System 5 managers provide overall policy and strategic guidance for the whole organisation. At whole of hospital scale, this is typically the role taken by the hospital board and senior administrators. For a more detailed description see, for example, Beer (3, 24) and Hutchinson (25).

Where an organisation is designed such that any of the VSM functions are missing or weak, then a range of typical organisational pathological developments occur. System pathologies also occur when additional links and relationships are in place that compromise the main functioning of the system, when different parts of the system take on the roles of other parts of the system or when management duplication occurs.

Several of these characteristic system pathologies are found in the list of design problem issues and themes that emerged in the case study. Three particularly obvious system pathologies visible in the identified design issues and themes are:

1. Multiple individuals and groups acting as Systems 3, which are uncoordinated and have weak line management and information flow relations with Systems 2, 4 and 5. The consequences of the pathological failure of Systems 3 (and the concomitant weaknesses of Systems 2, 4 and 5) are failures due to management confusion, lack of coordination, faulty integration of services, and the flawed transitional arrangements that typify most of the design issues identified earlier.
2. Reification of some Systems 1 managers and operational staff (in particular doctors and specialist medical personnel) such that tacitly and sometimes explicitly individuals are locally given the status and line management of Systems 3, 4 and 5. This results in complete failure of integrated management of the stroke unit system.
3. Attempts from hospital management to superficially remedy the problems of failure of Systems 3 by overemphasis of System 2. That is, this intervention unhelpfully requires some Systems 1 managers and staff to be subjected to high levels of self reporting to management. This approach fails on a number of counts, the most obvious being that System 3 is weak and unable to fulfill its role. An additional effect is that it results in System 3 responsibilities being pushed down to individual Systems 1. Again this destroys the primary functioning of the System 3 role of providing integrated management of Systems 1.

The above analyses can be cross checked via a different analytical pathway; that of variety analysis through Ashby's Law of Requisite Variety (LoRV). Ashby's LoRV can be phrased in many ways. It focuses on the amount of variety in a system and the amount of variety needed to manage the system. Variety is the sum of the number of states of everything in a system that can be changed. Some systems are simple and have very low variety. For example, the variety of a light is low. It has two states: on and off. In contrast, hospitals have very high levels of variety.

Ashby's Law of Requisite Variety simply states that the variety available to the managers of a system must be greater than or equal to the variety generated by the system. This is self evident in simple case such as the light example. If a light has two states: on and off, then to manage it, the manager must have access to a control (the switch) with at least the same variety (the two possibilities to switch the system on and off).

Ashby's Law underpins most theories of managing organisations. Over the last few years, the authors have extended Ashby's LoRV to complex organisations by considering the effects of variety distribution across sub-systems and dynamic change of variety over time both of the system varieties and the management control varieties (14, 26-30). This approach provides a method for analysing and designing organisational and management approaches to successfully resolving complex organisational issues and underpins the following discussion.

Applying Ashby's Law of Requisite Variety echoes the picture outlined in the VSM analysis of the stroke. In a hospital system that is operating in an organisationally healthy manner, the primary generator of variety would be expected to be the patient. The health system and hospital would provide the minimum control variety to efficiently manage the additional variety of the patient's state (due to ill health and related issues, e.g. missing work, managing children, financial issues, personal responsibilities, cultural and religious considerations etc) and enable the extra variety to be reduced to the point that the patient can return to their ordinary life.

This can be seen as the core function of the hospital to act to support each individual health service user to return to normal life. In variety terms, the hospital acts as a system of controlling variety in which the variety due to the patient's illness is attenuated in an appropriate manner such that the patient can leave hospital and as much as possible return to and resume their life.

The case study above reported a situation in which the largest generators of system variety is not the health services users, the patients, but the hospital systems and services themselves (this variety then needs additional health service control variety to manage it with no improvements in output or output quality). Much of this hospital-generated extraneous system variety is in

operational variety, but a large amount is management generated while responding to systems failures and defects. This is a situation with feedback loops that exacerbate the problems. In this situation, a problem results in administration which results in further problems and additional remedial responses and further problems and additional administration and so on. Examples of this in the above case are the failure of integration of patient feeding processes, the failure of case meetings and the failure of the community care and care funding decision making processes. These defect and failures of system design resulted in additional work to respond to the patient's relatives, providing additional hospital services to the patient because of the earlier failures compromised the patient's recovery; and redoing of administrative and decision making processes with additional layers of paperwork. In systems terms, many of these issues are caused by mismatch in the distribution of the generators of system variety and control variety driven by local subsystems' attempts to manipulate the system to gain additional power, status and resources (14, 30, 31).

A different analysis of the same situation can be undertaken via Deming's (20) classic work on quality management in which he described the central importance of designing systems so as to primarily reduce defect generation. In the case of the hospital systems of the stroke unit observed in this case study; defect generation was high and mainly comprised failed provision of integrated services or failures in transition of the patient and patient control between sub-systems. In essence, these failures are primarily generated by the hospital systems themselves. A Deming-based quality analysis suggests similar conclusions as the analyses using Beer's Viable System Model and Ashby's variety analyses.

Multidisciplinary care or integrated care pathways

The findings of this research suggest that the potential benefits attached to the use of the integrated care pathway model over multidisciplinary care are only likely to be available with resolution of the systems problems identified above. The analyses provide an explanation of the findings of Sulch and colleagues (9) who found no differences in outcomes between integrated care and conventional multidisciplinary care models of stroke treatment in spite of the obvious benefits in theory of the integrated care pathway approach.

The design research reported in this paper suggests outcomes of both integrated care and conventional multidisciplinary care in stroke units are both deeply compromised by systemic organisational problems due to structural issues relating to the viability of health services systems in system terms. The design issues discovered in the 'deep slice' case study and design analysis indicate that without significant structural system changes to health services systems and processes – including hegemonic relationships - *all* hospital processes are likely to be significantly compromised where they involve supplying multiple services to a patient. This indication is derived from the indication from the VSM analysis that many hospital systems exhibit the pathologies of a compromised viable system. The compromised nature of hospital systems due to the pathologies identified above would be expected to cut away the potential advantages of the integrated care pathways model and reduce outcomes of both it and the conventional multidisciplinary approach to a similar level as found by Sulch (9). The difference is that the VSM, Ashby and Deming analyses also imply that both integrated and multidisciplinary care approaches are both performing poorly. The implied opportunity is to improve stroke unit outcomes by resolving the systemic issues first.

Conclusion

The above stroke unit case study used design research data collection and analysis methods to identify and analyse design problem issues in an in-hospital stroke unit in terms of both single design issues and systems design characteristics. It did this using three approaches. The three analyses triangulate and all indicate significant opportunity for benefits from improved design of both stroke unit and hospital systems.

Some design issues appear foundational and likely to benefit and address wide swath of problem areas. Three significant systemic design issues are:

- addressing systems integration
- dealing with transitions
- Addressing the contradictions between specialist professional services and management of integrated service delivery.

They suggest three design strategies for creating improved design solutions for stroke units. The characteristics of the design problem issues and their apparent structural systemic causal underpinning suggest these strategies would also be expected to apply more widely across other hospital systems and other hospitals:

1. Review existing hospital systems in terms of the Viable Systems Model to identify structural problems in systemic design, and design new systems to address these structural problems
2. Focus design resources on supporting management to address provide significantly improved support for fully integrated care provision. This means developing designs that will in parallel support specialist professionals in avoiding liability whilst acting against the current culture of inappropriate reification of specialist professionals.
3. A focus on integrated care at organisational transition points. This requires all dimensions of patient care, community issues care and medical care to be managed in an integrated manner when the patient is transferred into and out of the hospital and within the hospital from one subsystem area to another.

The above analyses suggest that targeting these three areas of design will place the focus on leverage points for addressing the primary areas of stroke unit and hospital systems failure. In addition, it might be expected that addressing these issues will also incidentally address most secondary systems and design issues and open up the potential for effective evidence-based testing of the relative benefits for stroke patients of convention care, multidisciplinary care and integrated care pathways.

To summarise, this paper has described research focused on identifying opportunities for generic design improvements to stroke unit outcomes using data collection and analysis tools from a design research toolbox and a user-based perspective on the health service. The analyses are based on data collected from a 'deep slice' approach in which the progress of a single health service user, a stroke patient, was observed from admission into hospital to transition 3 months later to a residential nursing home. The analyses identified multiple design issues and multiple opportunities for designing improvements. In addition, the analyses identified structural systemic factors likely to be drivers and causes of problem issues both in the stroke unit systems and more widely in hospital and health service systems and cultures.

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