Enhancing healthcare services in an orthopaedic department utilising a system dynamics and participatory action research perspective to optimise patient flow

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Abstract

Background

The high burden of trauma in Durban results in longer elective surgery waiting periods, which exacerbates the in-patient hospital days and increases the average length of stay. Quantitative analyses of the data clearly demonstrate a growing list of elective patients awaiting surgery while the rate of acute trauma admissions continues to escalate. It has been demonstrated that interactions of patients between the various stages of care should be carefully studied in order for policymakers to identify limiting factors and leverage points.

Many public health interventions run aground and fail to actualise their initial objectives since the system is deconstructed and reduced to simplified autonomous components. A restorative undertaking to remedy this syndrome is to reconstitute the normative conventions of framing, mapping out and scrutinising deficiencies within healthcare systems. This paper explores a model of total patient flow through the orthopaedic service to test alternative major new structural options for relieving pressure on health services.

Methods

Qualitative data was collected using purposeful sampling to conduct 20 semi-structured interviews as well as including discourse analysis and ethnographic research. Participatory action research (PAR) was the main epistemological method driving the study under the auspices of a system dynamics framework.

Results

Areas of potential improvements have been identified which can ameliorate the flow of patients between the different departments together with the challenges and uncertainties that are present in achieving this.

Conclusion

Efficient patient flow management is a cornerstone in optimising healthcare services; the failure of such a system burdens the entire health system.

Level of evidence: Level 5

Keywords: patient flow, system dynamics, participatory action research

Introduction

This paper seeks to address how the potential use of system dynamics theory can enhance a quantitative patient flow perspective of healthcare to develop dialogue around the activity of resource allocation between the many stages of the patient flow process.

Healthcare is a large, complex adaptive system that does not naturally lend itself to simplistic evaluation and operational design. Contributing reasons include the dynamic components which interact with each other creating large-scaled complexity and several diversified multilayered output variables.[1]

A contributing factor to the mounting litigation described above is often the disconcerting outcomes seen in public healthcare governing regulations due to a truncation of systemic approaches to dissect through these systems with the necessary rigour. Many public health interventions run aground and fail to actualise their initial objectives since the system is deconstructed and reduced to simplified autonomous components, rather than being viewed as a homogenous, unified whole entity.[2,3] A restorative undertaking to remedy this syndrome is to reconstitute the normative conventions of mapping out and scrutinising deficiencies within healthcare systems.[4]

Explicit within this definition is the foundational basis for feedback undergirding the inter-relationships. These constructs of feedback loops form the structural core of systems thinking.[5] In order to comprehensively restore value to social systems, there has to be an appreciation of the structure of the system governing overall behaviour. Further enhancing the understanding of the system

are the various inter-relationships between the variables and the effect they have on each other.[6,7] This has direct implications on representing a paradigm shift: from scrutiny on individual details of a potential problematic situation to one of appreciating a more universal understanding of the diverse range of feedback influences capturing the underlying complexities.[8]

A wide variety of systems thinking tools are at the disposal of the practitioner to utilise in the sense-making process of the above. These include causal loop diagrams (CLDs), behaviour over time graphs (BOTs) and systems archetypes.[8,9]

Causal loop diagrams enable a functional method of representing pictorial overtures of the systemic issues being explored. This rests on an implicit understanding of the interconnected nature of variables within the system and the manner by which they continuously interact with each other.[10] They are as a heuristic to aid researchers, in explicitly expressing perceptions regarding the variables, which are then analysed to generate meaningful insights.[11,12] CLDs link variables by illustrating critical causal relationships with relevant polarities to demonstrate patterns of cause and effect from a systems vantage point.[9,13]

Patient flow perspective needs to be addressed with a view to implementing systematic, holistic organisational improvements that can increase productivity and service excellence.[14] It is hoped that it can be shown that adjustments to 'flow' variables in a system create more of a productive impact as opposed to only focusing on 'stock' variables.[2,15] An enhancement of the system would be to apply 'whole system thinking' which can develop dialogue around resource allocations and the complexities of the patient-flow processes.[11] The high burden of trauma in Durban results in longer elective surgery waiting periods, which exacerbates the in-patient hospital days and increases the average length of stay.[16] Quantitative analyses of the data clearly demonstrate a growing list of elective patients awaiting surgery while the rate of acute trauma admissions continues to escalate. It has been demonstrated that interactions of patients between the different stages of care should be carefully studied in order for policymakers to identify limiting factors and identify leverage points.[11,17] The various stages will be discussed below.

Methods

The researcher opted to adopt a participatory action research (PAR) approach to the methodological application. This mixed method modality of research consisted of qualitatively undertaking 20 semi-structured interviews from a mixed sample of respondents. This sample consisted of a cross-section of patients, nursing staff, medical doctors and managerial staff. Sources of data collection also included hospital records as well as statistics collated from the use of the Vula mobile app which records the number and nature of orthopaedic surgery consults from referral hospitals.[18]

Twenty semi-structured interviews were held on a one-to-one basis with the respective participants, comprising two managers, two clinicians, five nursing staff and 11 patients; this created room for a spectrum of perspectives to be collated.

The use of interviews was employed against a backdrop of PAR which enabled participants to highlight their different perspectives openly by trust and confidence in the researcher. In this regard, the researcher was known to all the participants in the study by way of inter-colleague relationships developed over many years. Patients were also familiar with the researcher by way of the researcher being their attending healthcare provider. Hence, the participants did not experience the added pressure of opening up to a complete stranger who was conducting research. This can be attributed to long-standing relationships ensuring transparency and trust which is a key feature of PAR.

The interview schedule was designed by the researcher and did not utilise a template. The application of system dynamics (SD) to the realm of orthopaedic surgery was not found to be in extant. Questions were thus designed around the relevant healthcare variables in line with meeting the research objectives and questions of the study. This included establishing a basic formal rapport, extending to one of the specific questions related to the presenting injury and deeper probing into the specific contexts of orthopaedic care received in the ward.

Ethnographic data was also collected in the form of data collected over a period of two years. This included all orthopaedic surgical admissions, number of theatre cases performed and recorded outpatient assessments. Statistics were obtained from registries incorporating outpatient departments, inpatient wards, casualty and theatre at one of Durban's busiest central hospitals.

The contribution of PAR as a research modality was considered beneficial to the researcher. There are several cardinal reasons for use of this modality. First, it facilitated access to areas of influence whereby the researcher was empowered to be an active agent of transformation instead of being relegated to being a passive observer.[19] The researcher participated ontologically in the empowering process of not only being included among the affected community, but also one who crystallised agency to institute transformation.[20,21] Secondly, PAR further accomplished a symbiosis of the subject and the object by means of validating the points of view of the participants who were directly affected by the challenges being discussed as the first portal of disseminating insider knowledge to generate change.[22]

Thirdly, PAR was seen as a pragmatic means to dissect through the web of complexity by systemically generating insights at each level. This was accomplished by delving into the cyclical learning nature of PAR as a methodological tool. This necessitated a gradual process of developing, implementing and reflecting on action taken at each stage of the learning cycle, as part of the research process. Ultimately PAR presented an extended viewpoint to appreciate the study of diverse variables which underscored complexity, by motivating for change and then reflecting on the process as a conduit to further ongoing research and pedagogical outcomes.[23,24] The entire process was also seen to be congruent with the epistemological derivatives of SD frameworks.

The PAR reflection points mentioned in this paper serve as action points at the confluence of the principles of both PAR and SD paradigms. Hence the researcher has woven this into the fabric of the discussion by being inspired by SD core principles for reasons outlined below.[3,25]

These PAR reflection points assist in achieving insight into how individuals unwittingly contribute to the very dilemmas they are attempting to ameliorate. This is a process of engaging them on an ontological plane to reflect upon their own intentions, thought patterns and subsequent behavioural responses.[25] They also reveal how actions in the system sometimes feed into unintended outcomes, as the researcher has discovered after implementing some changes. The responsibility of harnessing transformation is placed on all relevant stakeholders to jointly collaborate to achieve target outcomes by a process of continuous reflection and questioning, keeping in mind current realities and the outcome sought.[22,26]

Results

There is much synergy and synchronicity between PAR and SD. One of the key influential links between the two paradigms is that of emphasising ownership in improving one's own working environment rather than providing generalisations around issues concerning healthcare.[26] This resonates with systems-as-cause thinking whereby an active role in taking responsibility is stressed instead of seeking to allocate blame to other sources.[4]

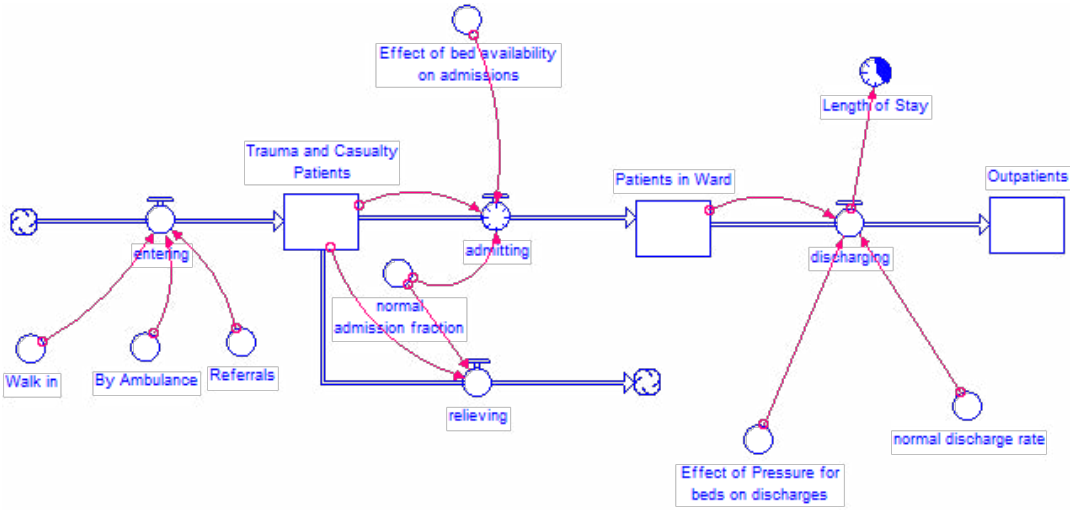

Figure 1. Stock flow diagram indicating flow of patients through the orthopaedic department

The researcher has particularly considered the empowering stance merging PAR with SD. This collaboration has served to be a locus for innovation, since both perspectives provide an evolutionary niche creating room for learning, in an ever-changing context such as a large healthcare setting.

Figure 1 pivots on the concepts of patient flow models and the associated frameworks describing the 'routes' through the system rather than a deconstruction of the factors influencing the rates of flow of people along the routes.[27] The major routes are depicted by double lines by which patients 'flow' through the different components of the health system. They flow from infinite 'sources' of untreated patients to infinite 'sinks' of treated patients (both shown as clouds) and their progress is considered to be regulated at each point on each route by 'rate of flow' variables on the pipes (shown as circles).[27] The flow variables are often dependent on further variables, such as resource allocation and budget deficits as well as current proportions of patients moving from stage to stage. Flow variables permit patients to flow into and out of different stages of care, depicted by boxes, where they wait for further triage through the system.[28,29]

This conceptual framework was developed to introduce the mapping symbols utilised in SD modelling as well as to generate dialogue surrounding the emerging pathways related to which factors expedite or delay patient flows.[30] It is hoped that these concepts will be communicated back to the executive management committee of the hospital to oversee potential adaptation assimilating these pathways. Other authors have also given credence to these presentations of patient data to influence managerial change.[3,11]

Flow of the system – emergency department

Patients enter the hospital from different portals. These include access as walk-in patients, brought by paramedics or by direct referral from outlying hospitals which do not have fully fledged orthopaedic departments. According to the severity of the injury, patients are then triaged – septic cases are seen in the casualty department while other modes of trauma are seen at the emergency department (ED).

If the nature of the clinical condition necessitates admission, patients are sent up to the orthopaedic ward which has a bed capacity of 51 patients. If the condition can be successfully managed in the ED or in casualty, they are discharged home with continuity of care being established by way of an outpatient appointment at the outpatient department (OPDB). Patients attend OPDB as many times as required – sometimes requiring additional admission to the wards until they are completely discharged.

Data collected revealed where major bottlenecks in the system lie; the researcher was able to place in perspective the various stages of patient care right from entry as depicted in *Figure 1* to the wards which will be discussed below, theatre and then obstruction at the outpatient level.

PAR reflection points

Inappropriate referrals: Adding to the long lists of patients waiting at trauma often results from non-relevant referrals from the trauma/polyclinic. This practice needs to be carefully screened and checked by encouraging referring doctors to be more rigorous and consistent. Early morning tutorials were offered to them to ensure patients are correctly triaged prior to being referred to orthopaedic surgery. A letter from the Department of Orthopaedic Surgery was drafted to the referring doctors to strictly make sure all referrals are not made in isolation by junior doctors; rather they should be overseen and supervised by experienced medical officers. This action has filtered out unnecessary, irrelevant referrals thereby decreasing the number of patients seen in the ED.

Upgrading of clinical skills: Skills development of attending casualty/trauma doctors in the outlying areas need to be established such that simple fractures or dislocations may be reduced instead of being referred to the hospital. Minor procedures requiring incision and drainage under local anaesthesia for instance, can be performed under best practice regulations thereby reducing the number of overall referrals. These matters have yet to be addressed by managerial committees on both ends to design an intervention to address this shortcoming. Since this matter is outside the scope of the researcher, it will require the outlying hospitals to institute a semblance of their own orthopaedic department.

Flow of the system – outpatients department B

The model given in *Figure 2* is not exhaustive; however, it demonstrates how various parts of the system are interlinked and influence each other. It demonstrates the manner in which the reinforcing feedback loops, R1 and R2, operate as vicious circles; however, it is possible to transform them into virtuous cycles. In this paper the researcher argues that in order to implement this change, it necessitates drawing attention to two action points in particular: the need-of-care assessment point and the actual appointment made by the nurses in the OPDB.

These two arenas of care are pivotal from the vantage point of the promotion of lighter services and the dispensation of

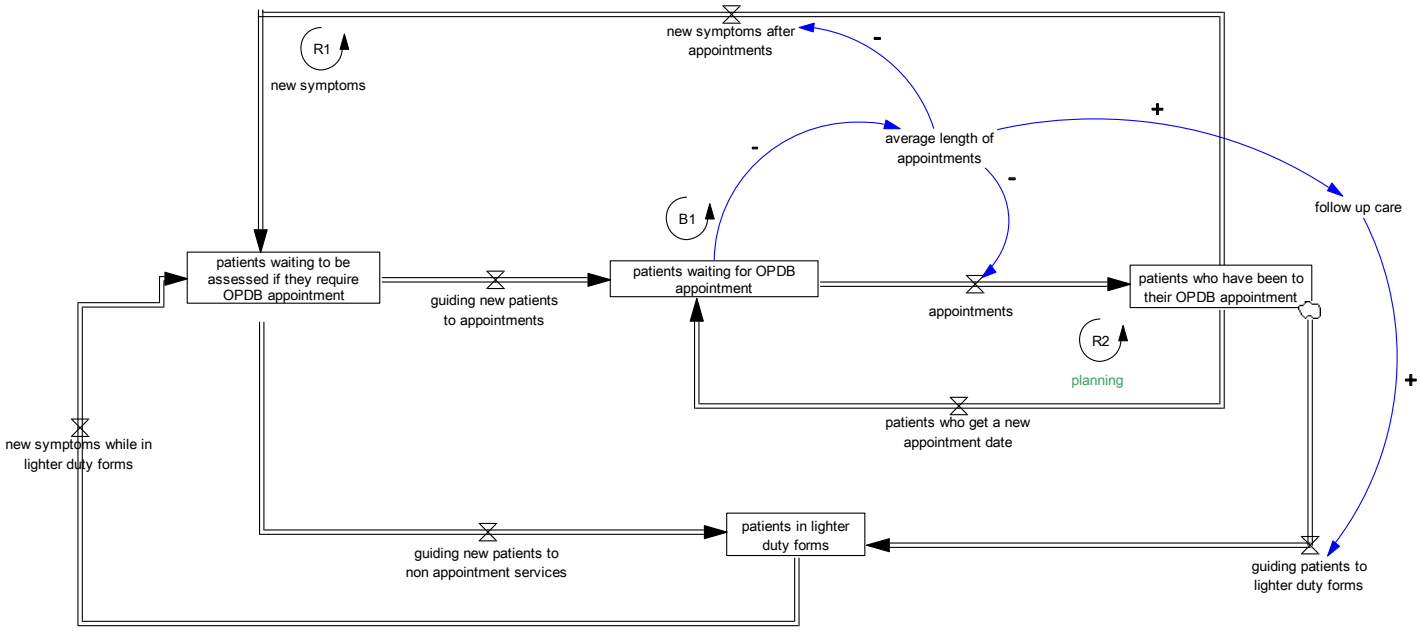

Figure 2. Model of patient flows in the outpatient department (OPDB)

systematic health directives. The former is the initial contact point with the patient and the latter plays a major role in long waiting periods for an OPDB appointment. To understand how the system could be developed further, we dissect through the various factors influencing these areas.

In *Figure 2*, we first model the need-of-care assessment point, where we have identified two main groups of crucial factors: 1) the quality of the assessment, and 2) the willingness of personnel and patients to utilise lighter services.

Another category of patients seen at OPDB are those with long-standing chronic problems, for example requiring a total knee replacement. Their details are recorded in an elective waiting book and patients are personally contacted once a theatre slot is available. Due to the high bed occupancy rate of acute trauma patients, many elective patients wait long periods of time for a favourable bed occupancy rate in the wards. In the meantime, those patients may go on to develop further complications of their condition and carry an increased risk of morbidity.

Flow of the system – orthopaedic wards

Figure 3 represents the various pathways which patients utilise to access orthopaedic care. The stock-flow diagram depicts points at which potential bottlenecks may occur.

Factors limiting flow in the ward elicited during interviews:

- The ancillary multidisciplinary services play a role in influencing length of hospital stay, i.e. when physiotherapy is delayed, length of stay is lengthened.
- Length of stay varies based on diverse factors besides hospital factors, severity of illness, age and socioeconomic status.
- The role of systemic crippling issues arising from lack of theatre services, namely unavailability of theatre, lack of theatre drapes, absence of basic radiology services, insufficient basic orthopaedic supplies, such as theatre shortage of crutches, are all contributing factors to increased length of stay.

To accommodate the increased length of hospital stay, the total number of beds needs to be unblocked. While patients requiring

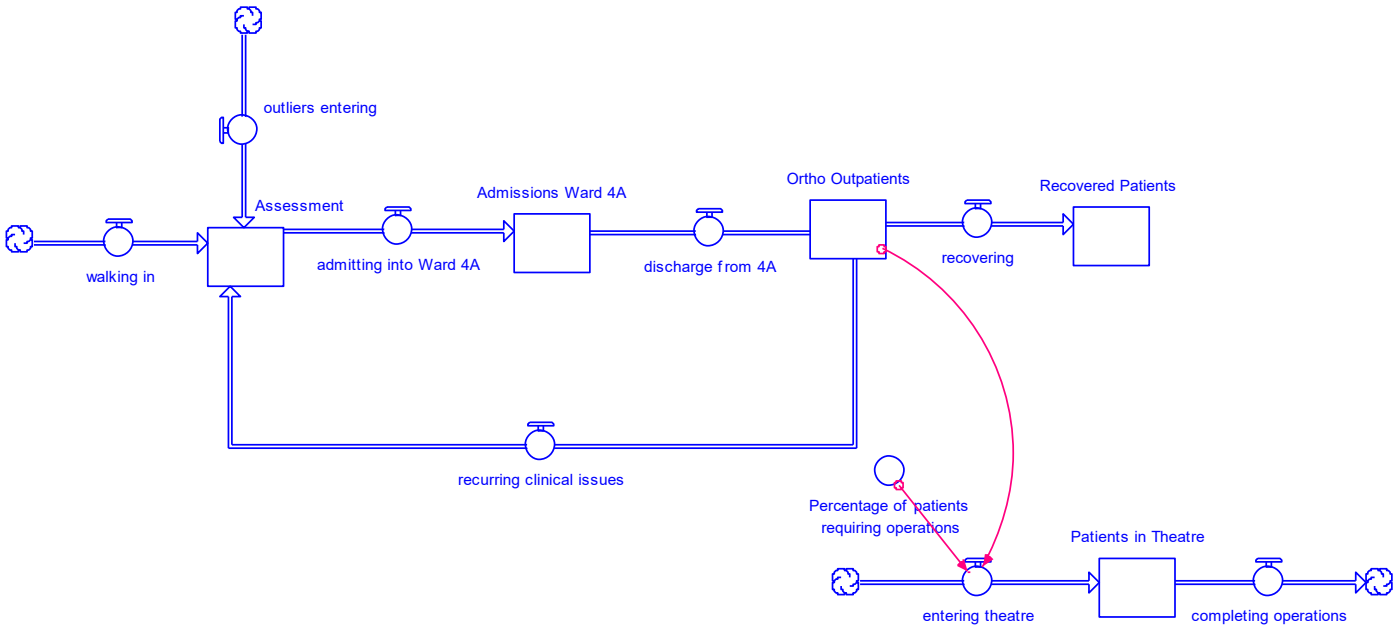

Figure 3. Flow of patients through the orthopaedic ward

admission may not always secure a place in an orthopaedic ward due to bed occupancy at maximal level, they often end up as 'outliers'. These patients occupy beds in wards designated to other departments, for example internal medicine. It is the observation of the practitioner researcher that this action does to some degree compromise their care as they are not being tended to by nursing staff that are trained to manage their condition, for example meticulous care of wound dressings and monitoring of traction alignment. Hence, retaining orthopaedic patients in highly specialised ward settings is ideal.

Information obtained from the semi-structured interviews revealed that outlier patients are often the last to be seen and receive a different standard of care. This has been confirmed in another South African study which can be compared to a similar situation at the hospital resulting in compromised patient care when porters need to fetch patients for theatre; precious time is lost when searching for them in the various wards.[1,14]

Flow of the system – theatre

During the December festive season, when the hospital experiences a high burden of acute trauma admissions,[16] only one theatre for orthopaedic surgery is allotted to the department. An unacceptable delay is created preventing patients from receiving operative interventions on time. In certain clinical cases, surgery is required within six hours as per international guidelines; however, this policy is not adhered to due to a dire shortage in resource allocation.

Outside the festive season, two theatre slates are made available until 4pm, after which there is only one emergency board which is utilised by general surgeons, obstetrics and gynaecology, and orthopaedics. Orthopaedic emergencies are often set aside for obstetric and surgical emergencies. This creates a backlog in patients awaiting emergency theatre while there is a constant stream of new patients. The average waiting time on the emergency board is approximately ten days. During this waiting period, patients are often kept in fasted states. Information gleaned from patient interviews revealed an important variable related to patients who are on chronic medication, namely antiretroviral medication. Hence patients risk missing scheduled times of medication, predisposing them to viral resistance. Data from interviews conducted reveal the shortage of nursing staff as one of the principal obstacles of effective running of theatre facilities.

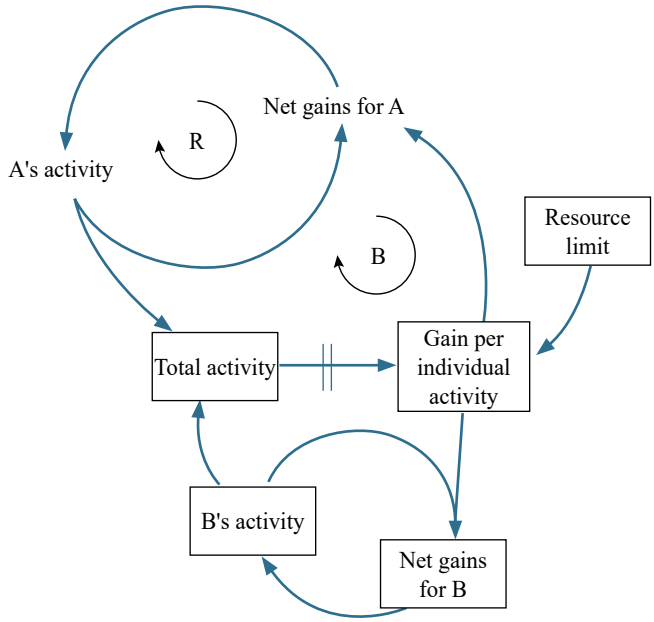

Figure 4. Tragedy of the commons archetype (Source: Construct adapted by researcher[8])

The situation of the shared theatre after hours is representative of the systems archetype, 'tragedy of the commons'.[8,31] The causal loop diagram in *Figure 4* – the 'tragedy of the commons' – represents an arena where parties A and B utilise a shared resource such that party A pursues actions which are individually beneficial captured in reinforcing loop (R), but which eventually result in a worse situation for everyone by overutilisation of the shared resources (B).

By overutilisation of theatre as a common resource, each department seeks to gain benefit individually. This gives rise to what is known as the tragedy of the commons.[31] The tragedy of the commons archetype illustrates how the system is affected when individual entities act independently, protecting their own self-interest as opposed to having the best interests of the entire corpus of users utilising the same resource in mind.

The tragedy of the commons was first described by author Garrett Hardin by way of a theory to express what the ramifications are when different individuals share a common resource. In Hardin's original piece, he refers to the case of farmers grazing cattle on a common pastoral land, each to their own gains and benefit. Ultimately there is soil erosion and the land cannot accommodate everyone much to the peril of all the parties. Hardin did not propose that each farmer was to blame; rather he directed attention at the system which allowed such choices to be made without rigorous accountability.[32]

The tragedy of the commons scenario has found widespread accountability in the contexts of healthcare.[31,33] In the complex realm of healthcare, diverse service providers seek to accomplish what they deem to be in their own interests without giving full credence to the overall consequences of their actions. Healthcare providers in this case, for example general surgeons, take a course of action which is in the best interest of their patients. Indeed, while this is a required ethical domain of responsibility, this action necessitates utilisation of resources and adds incremental costs to the system. In a hospital setting familiar to the researcher, the shared resource of theatre is finite. What arises is somewhat of an ethical dilemma for theatre users, who must find the balance between their responsibility to the patient and their stewardship to protect limited resources.[31]

From a contextual healthcare perspective, resource allocation will have to be carefully audited and studied. The researcher has suggested to management that a dedicated orthopaedic theatre needs to be available, which should prevent the many adverse reactions of not taking patients propitiously to theatre. The senior management of the hospital is currently unable to agree to this costly intervention and the scenario of the tragedy of the commons still plays out on a daily basis. The solution will require a deeper overhaul of existing structures and a review of resource allocation and sources of expenditure, with multiple strategies by all invested stakeholders.

Conclusion

The viewing of patient flow factors through the lens of an SD framework shed light on areas which were at first not comprehensively understood. Careful analysis of the patient flow process, from the initial assessment in the emergency department through to their admission into the orthopaedic ward, their discharge and follow-up at the OPDB, revealed bottlenecks in the system. These have been uncovered by means of applying SD heuristics of stock-flow diagrams to qualitatively dissect through the challenges. At each stage of the patient-flow process, insights have been generated in terms of achieving a better quality of service delivery to patients. By understanding the rate-limiting factors, the researcher was able to apply the relevant PAR reflection points to circumvent and navigate around these flow blockages.

The ever-evolving topography of healthcare data collection methods along with the derivatives of the complex interactions above, necessitate a thorough systems-based review, hence the research adopted an SD PAR perspective. This offered the potential to facilitate decisions which are coherent with the best interests of the system as a whole taken into account.

This data provides important feedback in terms of ascertaining factors related to patient flow, such that the researcher is able to better elucidate which areas require the greatest intervention. Recommended further research to address matters of patient-flow perspective needs to be addressed with a view to implementing systematic, holistic organisational improvements that can increase productivity and service excellence.

Patient flow management within the precincts of the KwaZulu-Natal public healthcare paradigm has not been stringently assessed, as evidenced from the quality and nature of orthopaedic referrals on the Vula mobile app. It is thus recommended that the KwaZulu-Natal Department of Health generate guidelines pertaining to patient flow within the contexts of securing patient-flow efficiency, regulated by clearly defined performance measures. Included within this recommendation is the development of a patient-flow audit tool which can serve as an interface between the various referral facilities to support an enhancement of patient flow at regional level. This can serve as a springboard to discuss logistical challenges as well as sharing of formal reporting and statistical analysis. It would be ideal if a system dynamics paradigm were applied to the above to comprehensively address dialogue around patient flow and thus advance into an evaluation of patient-flow performances against the set mandate for growth and development as recommended by the National Strategic Plan (NSP).

The researcher encountered the process of acquiring quantitative data to be rather tedious and cumbersome at Addington Hospital. There was no standardised method by which the data was captured. Other studies which have engaged SD modelling also echo the same challenges.

This led to the analysis of the data being more challenging, and hence more concerted efforts had to be undertaken to collate all the different sources and analyse them cohesively in order to draw conclusions. Therefore, one of the recommendations is an overhaul of the main hospital data gathering processes, standardisation of data capturing and application of sophisticated techniques in data science to quantitatively analyse the data in the South African healthcare setting.

Ethics statement

The authors declare that this submission is in accordance with the principles laid down by the Responsible Research Publication Position Statements as developed at the 2nd World Conference on Research Integrity in Singapore, 2010.

Prior to commencement of the study, ethical approval was obtained from the Social Sciences Research Ethics Committee, University of KwaZulu-Natal, HSSREC/00000192/2019.

All procedures were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Consent was obtained from patients for the use of clinical photographs, and these images were adequately anonymised.

Declaration

The authors declare authorship of this article and that they have followed sound scientific research practice. This research is original and does not transgress plagiarism policies.

Author contributions

MMFA: study conceptualisation, data capturing and analysis, first draft preparation, manuscript preparation
CGP: manuscript revision
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