

Modelling Intermediate Care Services as part of an Integrated Care Pathway

by

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PART 0: PREAMBLE

1) Abstract

The primary objective of this study is to consider the implications of implementing enhanced or redesigned intermediate care initiatives in the Western Cape of South Africa from 2014/15 onwards. A dynamic simulation modelling methodology will draw on secondary data from the relevant District Health Information Software sources to consider the implications of enhanced or redesigned intermediate care services on hospital admissions, waiting times and length of stay of all patients, as a part of an integrated care pathway. This form of modelling focused on the integrated care provision process represents an original approach to healthcare planning in a developing country (such as South Africa).

2) Acknowledgements

Dynamic simulation modelling methods was a new research technique that I had to learn through the dissertation process with no experience to rely on. It was initially difficult to 'sell' the technique which is not particularly popular research method in health sciences, to academics and key decision makers in the Western Cape Government's Health Department. However, I was lucky enough to get access to secondary data from District Health Information Software sources and work with a stakeholder group comprised of people with operational knowledge of the District Health System during the dissertation process. I would like to acknowledge the technical advice and support from the de-hospitalised care service review participants led by Professor Helen Schneider who looked at the service improvement and redesign for intermediate care in 2011/12, which became the impetus for this study. Regrettably, I cannot acknowledge all the review representatives by name. Most of all, special thanks to Professor Lucy Gilson and Dr Kevin Kotze for helping to shape and clarify ideas, giving critical feedback and moral support when required.

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PART A: PROTOCOL

1) Background

Health sector reform in the Western Cape has been in a constant state of change since 1995. Demand for healthcare services has been increasing steadily during this period of time due to the ever-changing environment, including demographic and socio-economic determinants of health. In addition, the burden of disease and the deterioration in the risk profile, has contributed to a challenging environment (1).

According to the Census 2011 data the total population of the Western Cape is estimated to be 5.8 million currently, with a life expectancy that is slowly increasing. This estimate is largely due to the continuation of urbanisation and migration, whilst the average age is expected to increase as a result of the aging population. This is despite the fact that the province's population is also afflicted with the quadruple burden of disease; TB/HIV, non-communicable diseases, injuries and the conditions associated with poor maternal and child health (2).

"Healthcare 2030: The Road to Wellness" is the Western Cape Government's strategic framework that plots the course of action for the next two decades to a 'reimagined future' health service while recognising the high level of uncertainty and complexity of planning for the medium to long-term. According to Healthcare 2030, there is a need to ensure that planning parameters and tools take into account the impact of developments in one sector of the healthcare service on other sectors of the service. In this way the health service is viewed as an integrated care system (1).

Since 1995, the modelling approach to health system transformation in the Western Cape has focussed on specific targets that have been set at an institutional level and for staff establishments. These targets were dependent on the implementation of service shifts, but without the necessary operational management tools, it proved to be difficult to obtain the stated targets. As an alternative to this 'learning by doing' approach, the provincial government has recognised that norm-based, analytical tools are necessary to embed the integrated care pathway across the service delivery platforms of the various institutions.

The development of these analytical tools need to consider appropriate performance measures/indicators for which baselines can be determined and indicative interim targets can be set for specific points in time. The development of an empirical model will enable the Western Cape Government's Health Department to better deal with uncertainty and complexity within the health system over time, where causal connections

and feedback effects may be identified. This may then give rise to the concept of 'system as a cause' (3).

2) Problem statement

This study focuses on the evaluation of proposed changes to healthcare policy to alleviate shortfalls in service delivery, through the formulation of viable solutions that will facilitate a 'reimagined future' health service for the Western Cape over the next two decades. The rendering of healthcare services is a national and provincial legislative competence in terms of Schedule 4, Part A of the Constitution of the Republic of South Africa, Act no. 108 of 1996. While the South African system of delivering or providing healthcare services has changed over the years, the District Health System (DHS) as a way of providing healthcare services to local communities, was introduced in 1996. The DHS is a self-contained segment of the provincial and national health system that comprises a well-defined population living within a clearly delineated administrative and geographic service area. It includes all institutions and individuals providing healthcare in the district whether governmental, non-governmental, private and traditional health practitioners up to and including the district hospital at the first referral level.

Due to the combined impact of the quadruple burden of disease and the growth in the aging population, the number of people in the Western Cape who require both healthcare and social services is increasing. In addition, there are likely to be more people with 'complex health needs', who require a combination of healthcare and social services. However, as these services find themselves within separate government departments they may not work all that well together. The result of this breakdown in services between the respective departments is that patients may stay in a hospital for too long a period, when it would have been better for them to get care at home (4).

In addition, in certain instances, patients may get the same service on two occasions – from the health and social care organisations. This would result in inefficiencies, which would contribute towards an increase in the burden of taxes on individuals. Alternatively, where a patient is missing an important part in their care pathway (as they and their families do not get the holistic care that they need), they could be in a position of increased risk, which would place them in potential harm.

A key focus of the current provincial strategic health framework is to develop the integrated care provision process, that is, to develop care pathways for specific patient groups. Care pathways are a combination of service components that are unique to a patient group and that may cut across levels of care and sectors (1). The integrated care process also needs to focus on the continuum of care for services that are organised to

satisfy the requirements for treating a particular condition at each level of care within the health system. With more focus being placed on integrated care development in the Western Cape, the respective health and social care providers will need to work better together to ensure patients and their families receive the right services.

However, the Western Cape Government's Health Department is currently experiencing the problem of 'bed blocking' (i.e. delayed transfers in care). Increasing patient volumes are adding to the deepening chaos with accident and emergency centres' occupancy levels well over 100% and attendances continuing to rise by approximately 5% per annum (5). The burden of disease data suggests that these patterns will continue for the foreseeable future (2). Waiting list management and diversion to other services are well known policies to deal with a situation where the need outstrips the available resources (6). Furthermore, rationing less urgent care, cancelling elective surgery and lengthy waiting lists are just some of the ways hospitals have found to cope with demand. The need to improve access to hospital beds from the accident and emergency centre, by increasing the throughput of patients, as well as their discharge into an appropriate continuum of care has been emphasised as a policy imperative. Delayed discharges are leading to accident and emergency centres being 'blocked' with too many patients, but finding alternative care settings for patients who no longer need hospital care is a major challenge.

3) Research aim, question and objectives

Given the importance of the Western Cape Government's Healthcare 2030 proposals for the development of the health system, it would be highly desirable to develop a framework that could be used to model the alternative policy interventions in order to evaluate potential outcomes before they are implemented. Such a model could also be used to aid decision makers in the identification of potential shortfalls, which may be addressed in the healthcare planning process. Mathematical modelling is increasingly used to support healthcare planning globally.

However, despite the recognised importance of integrated care, which seeks to ensure that people receive well-coordinated and personalised care, the empirical modelling of alternative policy interventions to the care pathway has not been widely explored globally (7). Hence, the overarching aim of this study is to develop suitable analytic tools for modelling an integrated care pathway by presenting a case of intermediate care development.

This aim translates into the core research question:

What are the implications of implementing enhanced or redesigned intermediate care initiatives, as part of the integrated care provision process in the DHS?

Finally the specific objectives are:

- 1) To define the linkages, relationships and interactions among service components that describe an integrated care pathway; and
- 2) To analyse the implications of one of the proposed Healthcare 2030 interventions – intermediate care – on the ‘whole system’ of care (from primary care through acute hospitals and community based services).

4) Justification for use of mathematical modelling in analysing integrated care

The use of mathematical models for policy analysis in the healthcare sector is becoming increasingly important, as it facilitates a better understanding of the health system’s functionality (8). These models would usually represent a simplified version of the real world, where the relationships in the model are described by mathematical equations that may be used to answer a specific research question.

A mathematical model allows the synthesis of a diverse range of information and avoids the reliance on intuition, and in some cases, the risk, time and cost of primary research (9). Within healthcare, there are two main areas where mathematical modelling is used to inform policy decisions; viz. the dynamics of *ill health* and the dynamics of *services* (3). The former represents illness states and the impact of interventions on some underlying disease’s natural history to estimate costs and consequences. For example, a range of studies have been conducted that considered the impact of early detection and management of non-communicable diseases, such as diabetes, on rates of deterioration leading to a reduction in the number of people with long-term, irreversible complications (10). The latter application of modelling involves the conceptual and mathematical representation of some part of the ‘whole system’ of care across cross-sectional population groups in order to identify areas for potential improvement. A number of these studies have focussed more on the delays that arise as a results of inefficiencies and the capacity across the ‘whole system’ of care being unbalanced in relation to inflow, waiting times and length of stay (11).

An analysis of integrated care refers to an investigation into the combined services that are provided by various organisations, professionals, clinicians, financing and administrative personnel, as well as those with other resources and responsibilities for maintaining or restoring health. These services could include those provided by both health and social care agencies that seek to promote faster recovery from illness, prevent

unnecessary hospital admissions, support timely discharge and reduce avoidable readmissions. Within this overall set of services, intermediate care is defined as:

“In-patient transitional care, which facilitates optimal recovery from an acute illness or complications of a long-term condition, enabling the service user to regain skills and abilities for daily living, with the ultimate discharge destination being home or an alternative supported living environment” (12, p. 4).

To facilitate this objective, it has been proposed that the DHS in the Western Cape will increase intermediate care capacity, by adding 1,000 beds to their facilities between 2013 and 2030 (for this service). Schneider (13) presents the basis of the service model for intermediate care, which is to be implemented in the DHS of the Western Cape. The research for this report was largely gathered through a number of consultations with key personnel who have operational understanding of the DHS (including those who will be responsible for implementing this aspect of the service model).

Whilst this research has enjoyed strong support within the Health Department in the Western Cape, its implementation could affect the way in which other services are (or should be) delivered, demonstrating that changes in one part of the system will affect the ‘whole system’ of care (from primary care through acute hospitals and community based services). This study seeks to model these dynamic interactions to facilitate appropriate implementation. It makes use of a theoretical model that is conducted as a part of the Systems Thinking approach. Thereafter, the theoretical model is taken to the data as a part of the System Dynamics approach to describe the dynamic interactions that exist between various entities.

Systems Thinking

Within the context of healthcare modelling, Systems Thinking refers to the method of thought that considers the holistic nature of the system, the so called ‘whole system’ of care, and the way in which various parts of the system interact qualitatively. This method may be used to describe various interactions between particular parts of a complex system that could be visualised with the aid of a schematic diagram.

The Systems Thinking approach could therefore be used to describe the qualitative relationships within a system. From a modelling perspective, the Systems Thinking approach is the process of deriving a theoretical model that could be taken to the data, at a later point. One of the major strengths of this approach is that one could describe a number of theoretical competing systems, with the aid of Systems Thinking. Such competing systems could include existing systems, or those that are the result of a proposed policy change that would result in an intervention to the system.

System Dynamics

To quantify the critical relationships in the theoretical Systems Thinking model, one may utilise the System Dynamics modelling technique to predict the result of a proposed policy intervention in the complex system. This technique seeks to quantify the totals as well as the changes to the existing state of the system. These concepts are usually based on the economic concepts of stocks and flows, where a stock refers to the value of a commodity at a particular date, and a flow refers to the total value of a change to a stock over a period of time.

In healthcare terms, the stocks (or totals) may be described by the number of people that require healthcare services and the flow could describe the way in which the person progresses through a care pathway (towards being discharged). From a mathematical perspective the relationship between stocks and flows may be summarised with the aid of differentiation and integration, which is described in the example below.

Example

To describe the use of the mathematical methods, with the aid of a simple model that may be applied to an overly simplistic healthcare problem, consider the following theoretical model that makes use of a Systems Thinking approach. This model could include two stocks for different states of the system. The first could describe the case where we have a total for the number of *people needing treatment*. The second stock could then describe the total number of people that eventually *leave the healthcare facility*. The flow that would link these two stocks would describe the *rate of improvement* in the patients' conditions.

This model may be characterised with the schematic representation in figure 1, where we have included the terms M_t , N_t and α , to describe the respective stocks and flow.

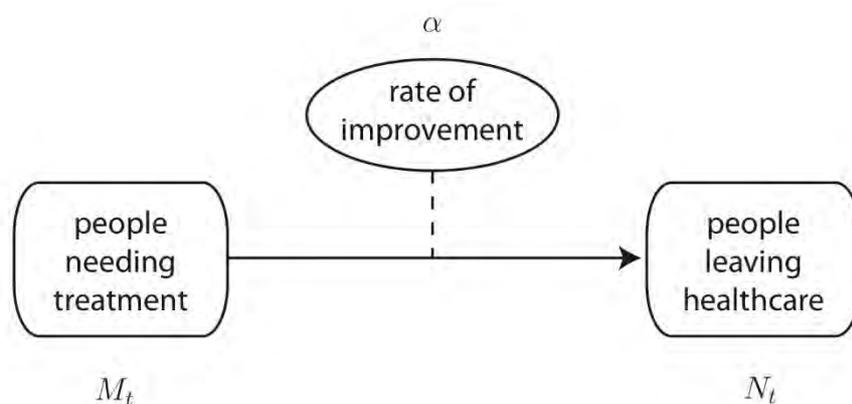


Figure 1: Systems thinking characterisation of basic healthcare model

This model may then be represented by a linear difference equation that is consistent with the System Dynamic approach. In this example, a partial derivative may be used to describe the relationships in the model, where,

$$\frac{\partial}{\partial t} M_t = \alpha N_t$$

Or alternatively, for a given value of M_t , we could use integration to derive a value of N_t , such that,

$$M_t = \int_0^t N_t d\alpha$$

While the above expressions could be solved analytically, one should appreciate that the *rate of improvement* could be influenced by several factors, which may be described by other stocks and flows. This would extend the single difference equation into a system of difference equations, not all of which would necessarily be linear. This would make α , an extremely complex function, which would be difficult to solve analytically. In such circumstance, one could employ symbolic computation or numerical approximation methods to derive the solution to the model.

The advantage of employing symbolic computation is that one could derive the equivalent analytic solution, however, this procedure would usually require a great deal of time and computational power. As an alternative one could make use of a numerical approximation, which would usually derive an approximate solution in a more time efficient manner (in the majority of cases).

Once we are able to characterise the functional form of the respective α parameters, we would then be able to perform a simulation to investigate how changes to the *rate of improvement* would impact on people *leaving the healthcare facility* over time (i.e. over periods $t+h$, where $0 < h < \infty$).

Disadvantages of the System Dynamics approach

Before concluding this basic example, it is perhaps worthwhile to consider an important possible disadvantage to the System Dynamics approach when applied to healthcare planning. For example, while this approach provides an admirable overall summation of a health system, it is not particularly good at describing the nuances that may affect individual patients that may have complex health needs. In these cases one may wish to employ techniques that focus on the detail. One such method would include Discrete Event Simulation that incorporates micro aspects of the care pathway. Discrete Event Simulation is particularly useful in healthcare to capture the changing attributes of individual patients, and

to characterise processes in which there is an emphasis on the use of resources.

5) Modelling of an integrated care pathway

While there are relatively few examples of studies that employ the System Dynamics approach for the modelling of healthcare systems (particularly for cases from the developing world), one such local study that focuses on proposed interventions to manage Human Immunodeficiency Virus (HIV) is provided in Nienaber (14). The framework that was used in this report will be largely followed to investigate the implications of implementing enhanced or redesigned intermediate care initiatives as part of the integrated care provision process on hospital admissions, waiting times, and length of stay (for acute hospitals).

The following sub-sections outline the key decisions and steps that have been and will be taken in developing the model.

i. The purpose of the model

“A System Dynamics model is built to understand a system of forces that have created a ‘problem’ and continue to sustain it. To have a meaningful model, there must be some underlying problem in a system that creates a need for additional knowledge and understanding of the system” (15, p. 8).

The purpose of the model is to understand the linkages, relationships and interactions among service components that describe an integrated care pathway and to examine the implications of implementing enhanced or redesigned intermediate care services on ‘bed blocking’ (i.e. delayed transfers in care) within the ‘whole system’ of care from primary care through acute hospitals to community based services in the Western Cape.

ii. Define the modelling level

The model will represent one of the proposed Healthcare 2030 policy interventions – intermediate care – and its implications within the ‘whole system’ of care from primary care through acute hospitals to community based services in the Western Cape.

The reason for choosing to model the system at a district level is due to the fact that the Western Cape Government’s Health Department has implemented a DHS delivery model based on Primary Health Care (PHC) and the envisioned Healthcare 2030 delivery model retains this service configuration. The PHC service of the DHS is the most critical component, as it serves as the entry point into the care continuum and caters for a large number of patients. It comprises of two distinct but inter-related care settings.

- 1) Community based services which include:
 - a. Home and community based care, as well as residential care homes (i.e. domiciliary care) and,
 - b. Intermediate care
- 2) Primary care services at health facilities

PHC forms an integral part of the health system, of which it is the first level of contact and constitutes the first element of the continuum of care. To ensure a seamless continuum of care along the care pathway, key decision makers are concerned with 'how to plan capacity' across a 'whole system' of care to improve integration by minimising delays in care transitions. One of the reasons for such delays, which are frequently cited, is due to 'bed blocking' at district level. An additional reason for choosing to model the system at a district level is that current baseline data from the District Health Information Software (DHIS) is available at this level.

iii. Define the modelling scope

The scope of the model is based on the specific objectives of the research question, after considering the resources available from primary care through acute hospitals and community based services, as well as the areas of possible influence on hospital admissions, waiting times and length of stay (for acute hospitals).

Service components will be selected on the basis of their ability to generate and properly represent the continuity-related problems when patients move from one service to another, particularly at the organisational boundaries between the sectors. Various forms of aggregation are appropriate, where such aggregation does not change the nature of the problem being modelled (15).

iv. Define the modelling level of detail

The model is an over simplification of the various care pathways through the DHS. It only represents the necessary level of detail to show the proportion of patients flowing, their lengths of stay, and the capacities of each pathway. This might also facilitate a better understanding of the linkages, relationships and interactions among service components, which will enable one to investigate the effect of intermediate care services on admission avoidances and delayed transfers in care.

v. Identify the components of the model

A key principle of this model building process is that it will be used to improve our understanding of a complex system and it will take the form of an iterative process (3).

The modeller will work closely with a stakeholder group comprised of people with operational knowledge of the DHS, to guide the selection of service components necessary for creating a model of the 'whole system' of care (14).

In Healthcare 2030, the concept of embedding a continuum of care and establishing an integrated care pathway across service delivery platforms is emphasised (1). Intermediate care, constituting just one part of the patient's overall care pathway, is linked to the more curative, therapeutic and specialised components of the service platform that would include the primary care services, as well as acute and specialised hospitals. Important continuity logic also exists between intermediate care and the other components of health and social care services; namely home-based care, as well as residential care for people with disabilities and for the elderly. Interactions between the proportion of patients that flow through the system, their length of stay, and the capabilities of each service component lead to a certain degree of complexity in the care pathway. This is often influenced by the fact that various agencies own different pieces of the pathway and take a particular course of action (informal policy decision) if a patient's movement affects their particular resources and performance targets. Computational modelling and simulation may assist with our understanding of the resultant behaviour that may induce a change over time in the operation of the whole system, which would clarify the need for joint capacity planning across organisational boundaries to improve integration and minimise delays (3).

The framework developed by Nienaber (14) for System Dynamics models in low resource settings suggests that performance measures/indicators could be used to guide component identification, together with other qualitative and/or quantitative approaches, to further validate the model content. The advantages of using performance measures/indicators include:

- Trends in performance measures/indicators are frequently reviewed and may influence the commitment of key decision makers to the model building process
- Components selected using performance measures/indicators, as a guiding mechanism, will be easier to model and validate through data from academic research, as well as secondary analysis of supporting data
- Translating the results of this study to all interested parties will be easier, as key decision makers will be familiar with these performance measures/indicators

vi. Group components as endogenous or exogenous

To further clarify the scope and level of detail that will need to be modelled, the components are grouped into two categories:

- endogenous or dynamic variables involved in the feedback loops of the system
- exogenous components whose values are not directly affected by the system

vii. Create a casual loop (influence) diagram

Causal loop or influence diagrams emphasise causal connections or relationships between the service components. A schematic representation will support thinking and learning to help understand how the service components interact with each other (which will include interaction through their feedback effects). Often causal loop diagrams are employed in System Dynamic modelling exercises to represent either reinforcing (positive relationship) or balancing behaviour (negative relationship) between two or more variables. The possible disadvantages that are associated with causal loop diagrams is that one cannot discover the implications of alternative policy interventions, locate leverage points, or investigate how a complex system might behave under different conditions (15).

viii. Create a stock-and-flow diagram

The building blocks of any System Dynamics model include the allocation of stocks (also known as levels, accumulations or totals), flows (or rates/changes in stocks) and feedback loops (3). Building a model from the influence diagram has two steps. The first is to draw a stock-and-flow diagram and the second is to derive the equations that govern the relationships in the model.

Mapping out the stock-and-flow diagram starts with defining the components as stocks and flows. A stock is associated with quantity, or a level, at a particular time, while a flow changes/influences the total value of a stock over time.

ix. Define the equations for stock-and-flow diagram

The relationship between stocks and flows can be expressed with differentiation and integration, where the value of each stock is determined by the changes to the flows that impact on the stock. An important consideration is that the dimensions of the variables need to be consistent to ensure that the relationships are mathematically compatible. In some cases the variables may need to be transformed or in other cases alternative proxies (instruments) will be used (16).

x. Model validation

The model will be validated in the sense that we need to develop a degree of confidence that may be used to infer that the model is of sufficient quality, to ensure that it will be used for its stated objective (16).

Therefore to validate the model, we will need to ensure that:

- The model is well designed.

The structure of the model will describe the salient features of the integrated care system, including all the main drivers of the system. If key decision makers believe that some of the key features are missing then they are unlikely to express confidence in the results that are

produced. In addition, the greater the use of real data in the model (for parameterisation), the greater the audience's confidence in the model. Peer review will also be used to build confidence in the model.

- The model is implemented correctly.
Basic tests may be used to ensure that the probability of an event is between zero and one, and that certain elements do not spiral to levels that are no longer feasible. Such tests will be conducted periodically, on either a subset of the model or on important interactions between various parts of the model.
- The results from the model are accurate.
To convey confidence in the model one should be able to show how expected results are achievable. Out-of-sample forecasting exercises will also be used to justify the results of a model, where data for a particular period (say between 2005 and 2010) is used to accurately forecast observed data for a subsequent period (say 2011).

Unfortunately, these types of tests are not always useful as there may be a relative scarcity of data, as well as a number of exogenous structural breaks, that may result from policy interventions. As a result, the use of observed data that is used to parameterise the model may differ from expected future behaviour. Model uncertainty will also be explicitly included in the model, by including distributions for the respective variables/parameters. Doing so will not only express the results in terms of their higher moments, but it will also provide the researcher with the degree of confidence with which these results can be interpreted.

xi. Model implementation

Where the purpose of the model is to compare various structures that may be implemented through policy reform, one could use the model to identify the potential benefits and shortfalls of an existing system before proceeding to show how various undesirable events/behaviour could be mitigated or eliminated. Different policies or operational procedures could be tested to investigate how one could go about making improvements to the system.

6) Ethical considerations

This study will draw on secondary data from the DHIS to perform a simulation-based analysis to describe the implications of enhanced or redesigned intermediate care services on hospital admissions, waiting times and length of stay of all patients, as a part of an integrated care pathway. Permission to access the DHIS service component data will be obtained from the Western Cape Government's Health Department, once ethical approval is granted. No identifying information of healthcare services/facilities will be included in the manuscript resulting from this

study. Feedback sessions on the study results will be conducted with the key decision makers in the Western Cape.

7) List of abbreviations

DHIS	District Health Information Software
DHS	District Health System
HIV	Human Immunodeficiency Virus
PHC	Primary Health Care
TB	Tuberculosis

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PART B: STRUCTURED LITERATURE REVIEW

1) Objectives

The total population of the Western Cape is estimated to grow significantly each year, due to natural births (although at a slower rate, with fertility levels declining) as well as migration. The nature and extent of migration, both internal and trans-national, are the most prominent unknown variables. The number of refugees and displaced persons is expected to increase adding to population growth. The mortality rate is lower than previously predicted as people with HIV and AIDS live longer and this is also likely to influence population growth.

The use of simulation modelling in the health and social care sector is not new and its ability to deal with uncertainty, handle complexity and communicate the proposed solution is especially relevant in the context of a constant state of change. The aim of this review is to describe and analyse the application of System Dynamics, which provides dynamic simulations of future outcomes, to the health and social care systems, where special attention is paid to research that has been conducted on resource allocation across an integrated care pathway. The reasons outlined by Squires & Tappenden (1) for using such an empirical model include but are not limited to; a simulation ensures that policy recommendations do not merely rely on intuition. In the case of dynamic simulation modelling methods, these allow for the synthesis of diverse information and the ability to test innovative ideas like a 'reimagined future' health service for the Western Cape, where the implications of alternative policy interventions could be tested without experimenting on an actual population.

There have been a number of literature reviews on various aspects of simulation applied to health and/or social care (2) (3) (4) (5) (6) (7). While the aforementioned reviews cover a range of simulation applications in health and/or social care, the purpose of this study is to focus on the potential of System Dynamics to deal with the uncertainty and complexity in the Western Cape's Healthcare 2030 planning context. Therefore, we specifically concentrate on the sole use of simulation techniques within integrated care systems. This particular area of study, which comprises of multiple interdependent agencies and care pathways that cross organisational boundaries, is most amendable to a System Dynamics study. In addition, this research methodology may also be used to describe the nonlinear relationships that exist between various stocks (for example, the relationship between those receiving intermediate care and those being able to resume living at home is not proportional).

The objectives of the literature review are:

- 1) To identify published studies that investigate integrated care pathways using System Dynamics; and
- 2) To consider the implications of findings and the barriers to implementation for integrated care provision processes.

2) Search strategy

A review of the use of System Dynamics to model integrated care systems was undertaken to identify relevant published studies with a particular focus on the potential barriers facing the implementation and uptake of System Dynamics within the health and social care sector (which fulfils the aforementioned objectives). The literature review methodology was not an exhaustive 'Cochrane type' systematic review but was influenced by the approach adopted by Eddama & Coast (8); where databases are searched using a process of refining and revising search terms. The articles are then screened and selected if they meet certain criteria which are based on the reading of titles and abstracts. Those articles that we retained are then reviewed.

The initial articles selected for this study were identified from a widely used academic electronic database, the Web of Science®, which contains studies published from 1962 onwards; with related bibliographic information from approximately 12,000 high impact research journals from over 250 disciplines. The objective therefore was to identify published System Dynamics studies on integrated care which have an accredited impact factor.

Our search strategy was defined by the simulation technique used in a particular application area within relevant published studies. To identify published studies that use System Dynamics to investigate the integrated care pathway, the following search terms were used: inclusion of the words, 'simulat*' OR 'health*' AND 'social' OR 'community care' in the article's title. In addition, we stipulated these words/phrases ('System* SAME 'Dynamics' AND 'health*' AND 'social' OR 'community care') needed to be in the abstract or keywords of the article. Note the syntax that has been used here refers to that which is applicable to the Web of Science® database. The first term should find articles that use simulation modelling and to increase the relevance score for articles they should contain the words/phrases 'System Dynamics', 'health*' and 'social' or 'community care'. The search was limited to articles written in the English language with no restriction on the date range. Results obtained from the initial database search (n = 436) were screened based on their titles and abstracts to see if they met certain inclusion criteria, which required that the selected published studies should apply a dynamic simulation modelling method to an integrated care system. Based on a reading of

the abstracts and titles, 432 articles were excluded, because the term 'System Dynamics' wasn't used in relation to the integrated care system in some way, and 4 retained. Articles that were not accessible were also excluded from the analysis. Upon reviewing the content of the remaining articles to assess if they answer the stated objectives, 2 were identified and used in the analysis. The other 2 were excluded as the focus was on demand for social care of an ageing population and how to better target services to specific patient needs.

Wolstenholme et al. (9) noted that while System Dynamics has been used widely in healthcare, its use in social care has not been extensive. This study searched articles from the Web of Science®, including more than 12,000 journals covering the sciences, social sciences, arts and humanities, yet found a limited number of articles, which is consistent with the comment made by Wolstenholme et al. (9). Due to the limited number of studies that were found using this systematic sampling method – the other being Wolstenholme (10) – we employed a more general search strategy using Google Scholar. While such a review may be regarded as less systematic it does at least incorporate items of 'grey literature', such as conference proceedings and details of consulting projects that have been carried out in this area of research study.

Ultimately, the review of the literature presented next provides an overview of the range of literature relevant to work on modelling integrated care provision processes rather than only focussing on the two papers identified through the formal search strategy.

3) Summary of literature

This literature review is structured as follows: the range of topics to which System Dynamics has been applied in the health and social care sectors are discussed. This is then followed by an overview of the relevant papers drawn from the systematic sampling method that addressed integrated care pathways. Finally, papers reporting the challenges of dynamic simulation modelling methods and of implementing the model results are summarised.

System Dynamics aims to identify causal connections and feedback effects within systems by firstly drawing diagrams that indicate the relationships between various parts of the system. Thereafter, it makes use of differential equations to consider how the stocks and flows might influence the behaviour of a complex system over a period of time (11). Feedback loops and time delays are typical features of dynamic systems and are often incorporated in causal loop (influence) diagrams that may actually complicate the connections between variables within the system. Wolstenholme (12) has proposed a set of generic two-loop system archetypes that are composed of an intended and unintended

consequence feedback loop, where there is a delay before the unintended consequence manifests itself and an organisational boundary that 'hides' the unintended consequence from the 'view' of those initiating the intended consequence. It is very important to understand the existence and nature of organisational boundaries, and to make them as clear as possible, so that the unintended consequences are not concealed. Successful system thinking aided by an empirical model could help to develop integrated care pathways by working across organisational boundaries and sharing information to recognise the unintended consequences of well-intentioned actions.

Applications of System Dynamics in the health sector have typically have been used to evaluate public health policy and economic models for TB/HIV and tobacco harm reduction (13) (14) (15) (16) (17) (18). System Dynamics has also been used to better understand the management of non-communicable diseases such as diabetes (19). Taylor & Dangerfield (20) used System Dynamics to model the feedback effects of service reconfigurations by providing cardiac catheterisation 'closer to home'.

System Dynamics also has the potential to model several parts of the entire health system, such as emergency and on-demand healthcare to identify delays (21). Furthermore, Lane et al. (22) made use of a System Dynamics study to emphasise the need to consider the 'whole system' of care, when planning capacities of differing kinds. Their analysis of an accident and emergency department shows that the 'spill over' effects from this department have a large effect on the admissions for elective procedures. Solving real-world problems in healthcare for improving patients' experience is a growing area for System Dynamics application (23). In addition, a number of studies have investigated the possibility of reducing delays in emergency care experienced by patients (24) to improve the patient turnaround and hospital throughput (25).

While applications of System Dynamics in the health sector often have implications for social care at the boundaries between the sectors, there are few studies of System Dynamics modelling that have been used to understand the interface between health and social care systems (26). For example, System Dynamics modelling examined how patients flow through the health and social care systems in Australia; where the federal government funds healthcare and social care through local government (27). Further studies in the United Kingdom have explored the interaction between health and social care services to improve integration and minimise delays, by utilising intermediate care to reduce admission rates and accelerate the discharge processes (28).

The Wolstenholme et al. (29) review of System Dynamics modelling being applied to the local health and social care communities in the United Kingdom from 2003 – 2004 generated five core insights. The first related to

the existence of informal managerial policies that are used to accelerate the discharge processes and to ration the supply of scarce resources, placing patients in potential harm, while the hospitals' existing performance measures/indicators stayed on target. Secondly, inconsistencies between the perceived structure and data of organisations are perhaps an indicator of the informal managerial policies that are being used and therefore the perceived structure and/or data is likely to be wrong. In the search for an alternative structure, the third insight was that all the stakeholders in the modelling process need to share any informal managerial policies in order for them to be incorporated into the model. Additionally, the informal managerial policies often have more unintended consequences and feedback effects on system behaviour than formal policies – this being the fourth insight. Lastly, model policy testing exposed the consequences for patient care and costs of working beyond safe design capacity and identified the capacity additions needed to eliminate the use of informal managerial policies.

Wolstenholme (10) previously applied 'models as learning' to improve understanding of complex systems and demonstrated that computer simulation is a powerful tool for testing policies relating to multiple interdependent agencies and care pathways that cross organisational boundaries. In the case of the policies tested, the application of intermediate care initiatives had a much greater impact on the rate of admissions, waiting times and length of stay of all patients; when compared to capacity additions to acute hospitals. The main implication of the author's findings was that adjustments to 'rate' (or flow) variables have greater feedback effects on system behaviour than a change to 'stock' (or capacity) variables.

However, whilst System Dynamics modelling provides an excellent overall summation of a health system, it is not particularly good at describing the nuances that may affect individual patients that may have complex health needs. In these cases one would usually need to employ techniques such as Discrete Events Simulation that are able to focus on micro aspects of the care pathway. Discrete Event Simulation is particularly useful in healthcare to capture the changing attributes of individual patients, and to characterise processes in which there is an emphasis on the use of resources. Furthermore, a problem that doesn't have a time dimension would not be amenable to a System Dynamics approach (11).

More broadly, Onggo (30) reported that the common data challenges that affect the quality of a simulation model are as follows; (1) data availability, (2) missing observations in the data set, (3) inconsistency in translations of the data definitions, (4) separate data sources, (5) bias in the data, (6) data are not in the required format, and (6) data cleansing required due to missing data, duplications, etc. Fortunately, these can all

be overcome by collecting data, estimating data, or making assumptions in the absence of data. Moreover, the data requirements for System Dynamics modelling are typically much less demanding than Discrete Events Simulation. This is usually due to the fact that the model represents a higher and more aggregated-level of the system of interest (31).

System Dynamics modelling is associated with much uncertainty, including inconsistencies in the perceived structure and data of organisations, as well as the assumptions used during the model building process. Models or simulations have been suggested as the 'third branch' of science (after traditional quantitative and qualitative research designs) and are as yet underutilised in public policy and management settings where dynamic complexity is common (32).

An early survey of 200 simulation projects (2), conducted at a time when personal computers weren't particularly powerful found only 16 were successfully implemented when judged against specific criteria. These include cases where their recommendations and suggestions were applied to real world systems, the model validity was demonstrated after implementation, and the results from the simulation were quantified (usually in the form of financial savings). Wilson (2) also suggests that key decision makers should participate in model development to gain a better understanding of the decision problem, which would facilitate the use of more appropriate model parameters that may be derived from appropriate data, while increasing the chances of implementation.

A more recent systematic review of the use and value of simulation in health care, found few studies that could be judged as successful, due to lack of reporting on the implementation of results (4). In a later study by Brailsford et al. (33), there was hardly any change in overall levels of implementation of results. They suggest that possible reasons for the low number of implemented studies is due to the complex decision making structures in health care, the high cost of developing models, the data challenges, the suggestion that researchers are eager to publish before the implementation of results, and a demand for personalised simulation models (34). A more recent review by Katsaliaki & Mustafee (7) also finds few implementation results are reported.

However, 'implementation' and/or a decision to change the real world systems, as defined by Wilson (2), is not a reasonable measure for success for work on integrated care systems (35). The purpose of modelling such systems is to support 'joined-up thinking' through shared information and to use 'models as learning' via improved communication between modellers and stakeholders, so that joint capacity planning across organisational boundaries might achieve a seamless service. The lessons learned from Eldabi et al. (28) can be summarised in relation to two aspects; viz. the integrated care perspective and the collaborative

approach to the modelling perspective. The authors emphasise that the complexity of the integrated care provision process needs a participative modelling and iterative processing approach to support systems with multiple stakeholders. It is more important to build consensus amongst multiple stakeholders at the expense of model accuracy for the success of the exercise. Model assumptions need to be fully disclosed and open to challenge, which is difficult in the case of different stakeholders who might actually be competitors that are reluctant to share information openly and honestly in the model building process. However, a collaborative approach to model building facilitates certainty in the policy direction that is to be determined.

Yet, operational research studies aren't always conducted in partnership with the real stakeholders (particularly key decision makers) and therefore there is a relatively low chance that the results will be implemented. Brailsford et al. (33) compare the low rates of implementation in statistical methods to high rates of implementation that are experienced in those that make use of qualitative methods, which almost always involve real stakeholders. Although, simulation doesn't require a real stakeholder to work with, if key decision makers don't have an interest in the model then regardless of the result it's unlikely to be implemented.

Eldabi (35) suggests that barriers to implementation of System Dynamics modelling results can be categorised into three main classes, viz. conflicting interests of stakeholders, lack of relevant tools and mismatching expectations. Conflicting interests of stakeholders arises from the multiple ownership of various service components of the health and social care system with their associated complex decision making structures. Therefore, a model building process that aims to achieve a unified goal; for example, joint capacity planning across organisational boundaries and/or various agencies, requires the multiple stakeholders to identify which aspects of their respective systems are integrated with the other systems in the model (28). Secondly, the lack of relevant analytical tools within the health and social care sectors – usually based on templates from other industries – has undermined the trust of healthcare stakeholders in the potential use of modelling tools. Thirdly, there is a mismatch of expectations between modellers and stakeholders, as a result of their lack of understanding of the most appropriate modelling approach to a particular healthcare problem. In addition, it has also been noted that modellers have a tendency to overcomplicate their models, which extends the modelling timeframe, and key decision makers will not commission a model that they believe takes longer to build than the problem requires.

4) Conclusion

The challenge for the Western Cape Government's Health Department is to bring the 'Healthcare 2030 Vision' to life. One of the key strategic

initiatives of the reimagined future is the proposed implementation of integrated care (36). Within this context integrated care includes two perspectives. From the patient's point of view, it seeks to facilitate a 'continuous caring, personalised relationship' with an identified healthcare practitioner. Whereas from the providers perspective it is the premis of delivering a seamless service through linkage, coordination and sharing of information across time, place and provider, to ensure that care is uncompromised, effective and efficient. Since some people with 'complex health needs' may require a combination of health and social care services these ought to be integrated too. However, it is not usually the norm for health and social care providers to work in an integrated manner (28). Moreover, such integration ensures that people receive well-coordinated and personalised care (37). In this section we considered whether the articles reviewed address the complexity of integrated care provision processes through System Dynamics modelling (in particular the need for joint capacity planning across organisational boundaries).

Joint capacity planning is imperative if the Western Cape Government is to achieve its 'Healthcare 2030 Vision'. Therefore, there is a need to develop suitable analytical tools to aid integrated care provision processes. Planners and managers need to focus on understanding and improving the linkages, relationships and interactions among service components rather than just being concerned with their own objectives and targets. Given that System Dynamics modelling is mainly concerned with finding and testing alternative policy interventions related to multiple interdependent agencies and care pathways that cross organisational boundaries (10), building an empirical model should be a key stage in healthcare planning in order to identify potential unintended consequences for patient care and costs. Importantly, planners and managers need to recognise that high-leverage policy testing can connect and influence multiple stakeholders within the system, and provide insights into the systemic problem from the point of view of different agencies (29). The key point is that where various agencies own different pieces of the integrated care pathway, the upstream agency implements informal managerial policies when parts of the pathway are capacity constrained with resultant behavioural effects for both agencies (26).

As mentioned previously, the barriers to implementation of simulation models are well known (34). Wilson (2) reported four common factors to successful implementation, including: the incorporation of at least one member in the modelling team who worked in the respective system, timeliness (a high priority problem), some form of external funding, and a detailed description of the data collection process. A difficult challenge to overcome is the divergent agendas and timescales that exist between academics and key decision makers, which could be overcome by identifying the 'building blocks' or common components of integrated

care systems that are acceptable to all users. In addition, it is also advisable to seek to deliver an outcome that is easily modifiable to each provider of health and social care to secure buy-in (34). Similarly, providers need to work together and pool resources in order to overcome silo-based or departmental mind-sets and implement robust, practical data collection systems along the integrated care pathway and across multiple agencies.

The literature shows that modelling initiatives arise out of real-world problems and solving them should drive the modelling requirements. The stakeholders go through a process of problem structuring and gathering information, which may involve talking to people and observing the real-world systems. By doing so, they would determine what additional information is required before they build and validate their model. Once this has been completed they could then develop scenarios for experimentation, document the process and make their recommendations on the basis of a well parameterised model (5). However, since ethics approval requires the exact modelling methodology and data collection process to be specified in advance, the participative modelling and iterative processing approach that has been proved to be effective, is in most cases an elusive goal (38). It is also worth noting that simulation modelling is not like traditional health sciences research, as it is aimed at service improvement, system redesign and finding real-world solutions. This means that it is not always useful for the research question, methodology and protocol to be specified in advance of any sight of the data.

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PART C: MANUSCRIPT

1) Abstract

This study explores the implications of implementing enhanced or redesigned intermediate care initiatives in the Western Cape of South Africa from 2014/15 onwards. Using a dynamic modelling methodology, we developed an empirical model of an integrated care system to explain the linkages, relationships and interactions among service components and analyse the implications of one of the proposed Healthcare 2030 policy interventions - intermediate care – on hospital admissions, waiting times and length of stay of all patients. We tested and compared a number of alternative intervention points using a simulation model parameterised with service component data from the District Health Information Software. The findings from the study show the inconsistencies between the perceived structure and the available data from the respective service components that describe the resultant behavioural effects on an integrated care system, especially when care pathways cross organisational boundaries. The main managerial learning was around the existence and nature of organisational boundaries that require joint working and sharing of information. We conclude from the simulation results for the alternative scenarios tested that the implementation of enhanced or redesigned intermediate care initiatives can moderate the rate of growth in the demand for hospital services by reducing a percentage of hospital readmissions.

2) Key words

Integrated care, dynamic simulation modelling, capacity planning, system redesign

3) Introduction covering background and problem statement

South Africa is a middle income country that faces a burden of disease and a high risk profile (in term of healthcare requirements), which is in many respects unique to the developing world. In the Western Cape, the province with the highest population growth rate (20.9%) according to Census 2011, adult mortality is a more significant cause of years of lost life, than childhood mortality. In particular, chronic illnesses such as TB/HIV and non-communicable diseases predominate (1). Most healthcare practitioners now refer to the quadruple burden of disease in South Africa, with non-communicable diseases contributing significantly to the overall mortality profile. The other sources include the impact of TB/HIV, the injuries sustained that result in medical complications and finally maternal and child health related illnesses. These factors that influence mortality give some indication of the dominant care burdens faced by the health and social care systems.

These findings were confirmed in an unpublished household survey conducted as part of the Western Cape Government's de-hospitalised care services review in 2011/12, which examined the profile of chronic illnesses within households in Oudtshoorn (2). The review was commissioned by the Health Department and undertaken by a consortium comprised of the Universities of the Western Cape, Cape Town and Stellenbosch, working closely with government managers. Of the 957 households included in the survey, nearly two-thirds (63.5%) reported the presence of someone with a chronic illness in the household. Forty three percent of households had someone with hypertension, 17% with diabetes and 12% with asthma. In these cases, the households' care needs were first and foremost related to non-communicable diseases and the resultant complications. Of the 3,565 household members, who were greater than 5 years of age, 3.7% had some difficulty with walking or climbing steps. Just over 2% had difficulties with self-care, and 1% had severe difficulty in self-care (2).

In 2013, the Western Cape Government's Health Department released a discussion document on '*The Road to Wellness*' which is a strategic framework that establishes a set of planning parameters and tools, to further reform health services in the province (3). The Healthcare 2030 strategic framework derived from this document encapsulates the new intermediate care initiatives and illustrates how de-hospitalised care, as part of Community Based Services, will be conceptualised in the future. Essentially this document suggests that these services will include two care settings: (i) Home and Community Based Care, and (ii) Intermediate Care.

In the Western Cape context, intermediate care is defined as:

"In-patient transitional care, which facilitates optimal recovery from an acute illness or complications of a long-term condition enabling the service user to regain skills and abilities for daily living, with the ultimate

discharge destination being home or an alternative supported living environment" (4, p. 4).

The name change from de-hospitalised care signifies a desired shift in the orientation of these services from a passive to more active and rehabilitative approach. This approach is one in which patients are assisted to function independently, and where necessary, with appropriate support in their home environment. Therefore, intermediate care is to allow for a seamless transition from 'hospital-to-home', especially when the patient's ability to self-care is significantly compromised. A supported discharge becomes crucial to a successful recovery process and the focus of intermediate care is to improve functioning, so that patients can resume living at home and enjoy the best possible quality of life.

In the Western Cape, there are currently a number of different models for the provision of intermediate care services. In addition, a number of variations in capacity of care suppliers, and rural-urban differences exist. Most of these services were established because of the differing prevalence of HIV in various localities, and commissioners sought to respond to the associated demands for HIV and AIDS-related care in accordance with the prevalence of this disease. Some of the intermediate care providers have integrally linked their home-based care services with patients that are referred from inpatient services to post-acute treatment that is provided by the home-based care team. In some instances these care workers will follow up on discharged patients. Appropriate and timeous referral from hospitals to intermediate care seems somewhat tenuous, with referral patterns appearing to be less seamless than what has been suggested in the Healthcare 2030 vision for well-coordinated and personalised care (4). Particular concerns have also been raised regarding the application of these strategic objectives within an environment that currently experiences continuity-related problems when patients move from one service to another. It has been noted that these concerns are particularly prevalent when patients move from health to social care services (2). Since these services find themselves within separate government departments they may not work all that well together. The result of this breakdown in services between the respective departments is that patients may stay in a hospital for too long a period, when it would have been better for them to get care at home (5).

In a global context, efforts to improve coordination between health and social care services have improved service efficacy, where dramatic improvements have been experienced in the integrated care provision process from the providers' perspective (6). However, the first principle of 'integrated care' is that it should be organised from the patient or service user's perspective (7). National Voices, an alliance of health and social care agencies in England, also use the term 'person centred' to

emphasise that integrated care should meet the needs of individuals and their families in a well-coordinated manner. In addition it has been suggested that services should be delivered by well cared for staff to improve the patient experience. Although the concept of integrated care has not been clearly defined, it generally refers to the seamlessness with which individuals and their families move ('flow') through the health and social care systems in order to meet their needs (8).

With an escalating burden of chronic, non-communicable diseases the number of people who have 'complex health needs' that require both health and social care, is increasing at a relatively rapid rate globally. Hence, there are likely to be additional people with more than one healthcare problem, which requires a combination of health and social care services. However, as noted above, these services often don't work together very well. For example, a patient's stay in hospital might be longer than required, when it would have been better for them to receive home-based care. In addition, in certain cases, people will get the same service twice, from the health and social care agencies, or in other cases an important part of their care is missing, for example the provision of intermediate care services. This implies that individuals and their families do not get the joined-up care that they need, leaving them at increased risk. It has also been noted that where there is poor continuity of care, staff may miss out on opportunities to improve the service from a patients and taxpayers perspective.

The Western Cape provincial government has recognised that joint capacity planning is imperative if it is to ensure that integrated care is delivered to individuals and communities. The Healthcare 2030 strategic document seeks to establish a framework where the organs of the state are able to think and act in a united way, as a 'whole society' and 'whole government', around common objectives (3). In this way those responsible for commissioning health and social care services should be working together to adopt a 'whole systems' approach to improve health for all.

Given that very few studies have explored integrated care systems modelling (9), the aim of this study was to simulate an integrated care pathway by developing suitable, analytical tools populated with the best data available. These tools were then applied to the current health and social care system to demonstrate the key dimensions of the system's performance over a period of time. Thereafter, we consider the implications of changing capacity across the integrated care pathway. Modelling the system with the aid of the proposed System Dynamics model was used in this context to understand how resource allocations across a 'whole system' of care influence performance measures/indicators, while testing one of the proposed Healthcare 2030 interventions (i.e. enhanced and redesigned intermediate care services at the interface between the health and social care sectors). The effect of

alternative policy interventions (and the implications of such interventions) was evaluated in terms of bottlenecks at transition points over time, where it was not necessary to experiment on actual patient flows in the various facilities.

4) Methods

The development of a conceptual framework, as part of the modelling process for the proposed delivery of integrated care, was conducted in tandem with the de-hospitalised care service review in 2011/12. This study seeks to evaluate this framework with the aid of a simulation model that was developed to suit the 'reimagined future' for healthcare service delivery in the Western Cape.

The development of the framework that has been proposed for future healthcare service delivery took on a series of iterative activities that incorporated three phases; starting with a 'rapid appraisal' which synthesised current thinking based on key informant interviews. Thereafter, site visits were conducted to consider the current practice, while document and literature reviews considered alternative strategies. The final phase included an analysis of service component data to understand the current difficulties with care transitions across agency boundaries and development of a simulation model.

Phase 1 also involved identifying the purpose, level and scope of the framework in order to define the population (number of people requiring intermediate care), interventions (integrated care provision process), context (socio-political dimensions) and outcomes of alternative policy interventions. Once the initial requirements were identified a theoretical model of the 'whole system' of care was produced. Some core members of the de-hospitalised care service review project team, who looked at the service improvement and redesign for intermediate care in 2011/12, became the modelling group for this study. Additional support was provided to the core group by people with operational knowledge of the District Health System during the group model building process

During phase 2, an in-depth analysis allowed the modelling group to assess and fill in any further gaps based on the emerging findings from a surveys of the current ('what is') service platform and of the population-based needs. A workshop was held with the members of the modelling group for the preliminary analysis of data obtained from a variety of datasets. This allowed for alternative interpretations of the data to be shared, linkages, relationships and interactions among service components to be made and triangulation between the different data sources to be considered.

In the final phase, the working simulation model (i.e. a mathematical model) was created in Simulink® to test future ('what if') scenarios. The mathematical model represents a highly simplified version of the actual framework for service delivery as one of the purposes of this study is to conduct an initial investigation into the use of simulation models for the evaluation of integrated care systems. At this stage we wanted to ensure that the results are easily translated to all interested parties who may get lost in the complexities of a fully articulated framework. Throughout the model development process, the key parameters and their influences on the model outputs were analysed to assess validity. In certain cases, concerns that relate to the validity of certain data sources have been highlighted, as they would appear to be inconsistent with other aspects of the health system.

a) Model overview

The essential features of the System Dynamics model for the Western Cape integrated care pathway are depicted in Figure 1.

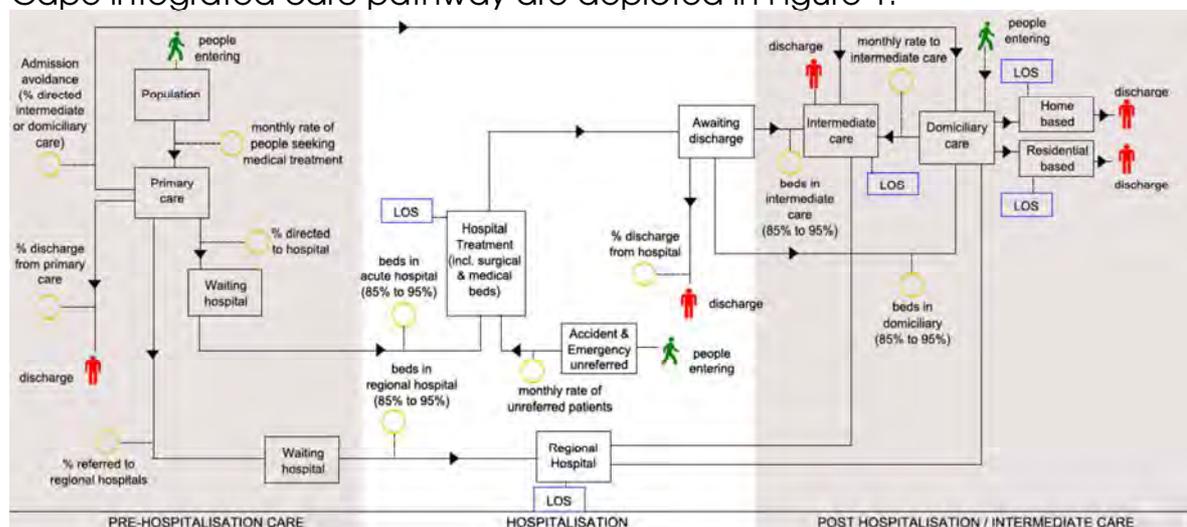


Figure 1: Overview of Model

Figure 1 shows a theoretical or 'typical' care pathway model/map of the health and social care services in the Western Cape. The theoretical model describes the potential pathways through the 'whole system' of care but doesn't represent the factors influencing the rates of flow of people along the care pathway. The flow variables could be influenced by several factors, such as capacities, budgets, and the number of people flowing through the different sectors of the 'whole system' of care. Flow variables allow for the change in a stock over a period of time, as people progress along the care pathway.

i. Primary care

This component of the health service represents the main entry point into the continuum of care for patients with a range of healthcare problems and illnesses. Patients needing hospital treatment are referred for either medical or surgical (emergency and elective) admission.

The proposed 'pre-hospitalisation' care shown in Figure 1 provides alternative treatment for people who are chronically ill (avoiding some of the medical admissions to hospitals). Certain groups of patients will be directed – via triage – to other services, which may include intermediate and domiciliary care, if they don't need the acute hospital care package. However, this is dependent on the capacity of these alternative services, such that if these alternative services experience a lack of capacity, it would also impact on the length of stay in hospital for patients that need supported discharge.

ii. Hospital treatment

The concept of 'capacity' is simplified in the model as the total number of places (i.e. beds or care packages) of a particular kind. This simplification masks some of the limiting factors that may affect hospital capacity, for example staff shortages and operating theatre efficiency. Generally, the bed occupancy of hospitals is set at between 85% and 95% to ensure a safe environment for patients and staff (10).

In the model, patients can only be admitted if there is space available. If medical beds are at full capacity, one of two things happens; patients are discharged early or they are admitted to and treated in surgical beds (if spare capacity exists). If the length of stay is reduced to expedite discharge from hospital, this creates additional space for new admissions. However, since the length of stay is partially based on an informal managerial policy, rather than the patient's need and condition, it's likely that some of those patients discharged early may need to be readmitted to hospital in the near future. Secondly, if emergency medical patients are moved to surgical beds, then operations may have to be cancelled and the elective surgery waiting list increases.

Those patients that need supported discharge from hospital care move into the 'awaiting discharge' stock until the onward service is available. Once the onward service (intermediate or domiciliary care) becomes available, they move on and free up a hospital bed for someone else to be treated.

Admissions into surgical beds are one of three types; namely emergency surgical, elective surgery and emergency medical patients. Again, these medical patients are only admitted to surgical beds if there are no other beds available. There is an order of priority for the different types of surgical bed admissions: firstly, patients needing emergency surgery are always admitted; then emergency medical admissions are taken up if there is spare surgical capacity and lastly, elective admissions are taken in as surgical beds become available. The elective surgery waiting list is subject to considerable variation as surgical capacity is utilised by emergency medical patients at times when the medical beds are full. The bed occupancy rate may exceed the target set when beds are fully

utilised and, like medical patients that need supported discharge from hospital care, surgical patients wait in a hospital bed until the onward service (intermediate or domiciliary care) is available.

Waiting list management and diversion to other services are well known policies to deal with a situation where the need outstrips the available resources. Rationing less urgent care, cancelling elective surgery and lengthy waiting lists are just some of the ways hospitals have found to cope with demand. The need to improve access to hospital beds from the accident and emergency centre, by increasing the throughput of patients, as well as their discharge into an appropriate continuum of care has been emphasised as a policy imperative.

When the demand for hospital beds exceeds capacity due to the growing numbers of people with 'complex health needs', decision makers generally react by increasing capacity. The intended consequence is to improve access to these services for the unmet need, while an unintended consequence of this course of action is to create more demand for supported discharge or an onward service (intermediate or domiciliary care).

iii. Intermediate care

In the model, intermediate care is the integrated provision of inpatient services formerly referred to as sub-acute, step down, respite, palliative, and some forms of chronic care under the de-hospitalised care services. It is time limited, promotes successful recovery, supports timely discharge and prevents unnecessary hospital admissions (4). The aim of intermediate care services is to create a restorative and rehabilitative environment in which patients are assisted to function independently, and where necessary with appropriate care and support, in their home environment (2).

The introduction of intermediate care in the Western Cape is geared towards speeding up discharge processes and reducing readmission rates. Another potential benefit of this intervention is improved functioning so that people can resume living at home independently, thereby reducing the average length of stay in domiciliary care. Once patients have received an episode of intermediate care, they either go home or are discharged with an appropriate domiciliary care package.

iv. Domiciliary care

There are two types of domiciliary care – home-based care and residential care for people with disabilities and for the elderly that need maximum assistance in terms of activities of daily living and are bedridden most of the time. Acute hospitals and intermediate care providers may discharge patients to domiciliary care or refer them directly as an alternative to inpatient services. Capacity depends on inputs, such as

average length of stay (residential care facilities) or duration of care package (home-based care).

As part of this study the theoretical model, which has been described above, was converted into a simulation model by inclusion of the relevant data. The major strength of developing a simulation model is the possibility to then describe a number of theoretical competing systems and identify alternative intervention points to improve service delivery. Using mathematical integration, changes in stocks, as determined by flow rates over time, could also be calculated.

b) Model parameterisation

i. Population growth and the need for healthcare

The model has been parameterised to the Western Cape at a monthly frequency and focuses on the five year period 2010M1 to 2014M12. During this period of time the population estimates for the Western Cape grew from 5.6 million to 6.1 million (11). To obtain monthly approximations from the annual estimates we interpolated the data with the aid of log-linear filter.

For the simulation exercise we make use of the estimated growth rates for the population of the Western Cape, which is expected to grow between 1.88% and 1.61% per annum over the next five years (12). These figures were also interpolated with the same method as was used above, to derive consistent monthly estimates.

ii. Primary care entrants

The average monthly primary care total headcount in the Western Cape for the last five years is 1.25 million, which would equate to a total number of headcounts of 75 million between January 2010 and December 2014. This information was obtained from the District Health Information Software (DHIS, 2014). This amounts to 21.19% of the population who made use of primary care services over the last five years during each month. It is assumed that this rate would remain constant over the simulation period.

To derive values for the stock variables for entrants into primary care services we take 21.19% of the expected future population in the Western Cape. As there are no beds in these facilities, there is no length of stay, as patients are either discharged, sent to district or regional hospitals; or alternatively they may be directed to intermediate or domiciliary care facilities.

During the first month of the simulation period we have a total of 1,296,049 entrants into the primary care facilities. From the admissions data to hospitals, intermediate and domiciliary care facilities (as discussed in more

detail below) we are able to determine the percentage of individuals who are discharged.

	<u>%</u>
Transferred to regional hospitals	10.71
Transferred to district hospitals	23.47
Transferred to intermediate care	0.00
Transferred to domiciliary care	0.00
Discharged	<u>65.82</u>
	<u>100</u>

Where there are less than 20 individuals that are referred from primary to intermediate care facilities, and less than 3,000 individuals referred from primary to home-based care, these percentages are close to zero. The result of this is that 65.82% of the individuals who make use of primary care facilities are discharged on the same day.

iii. Primary care to Intermediate and Domiciliary care

The DHIS (2014) dataset contains estimates for the number of individuals that are directed to home-based care and intermediate care facilities. To calculate the number of patients that were admitted from primary care facilities we make use of the once-off survey of intermediate care providers, which was conducted in 2014 (13). This survey data suggests that 3% of the patients in intermediate care facilities were admitted from primary care facilities. Similarly, 54% of the patients receiving home-based care packages were admitted from primary care facilities.

Figure 2 shows how the numbers of admissions to intermediate and home-based care packages has changed over time, where we note that the referrals to intermediate care (which relate to the right-hand scale) are very small. In addition, it is also worth noting that the linear trend would suggest that these numbers are decreasing over the entire sample. These patients are not incorporated in the model, as the numbers are so small.

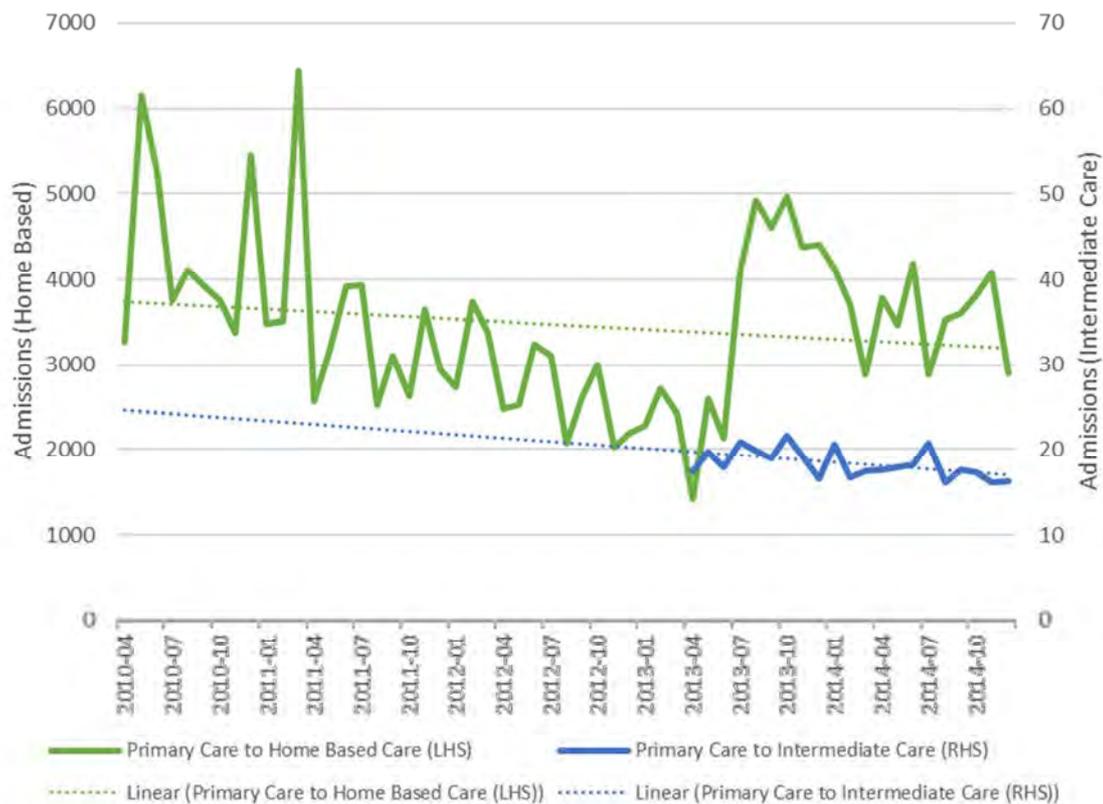


Figure 2: Primary Care to Post-Hospitalisation Care

The average monthly referrals from primary care to home-based care packages between April 2010 and December 2014 amounts to 3,474. For the purposes of the model, we assume that this amount does not grow in the future.

iv. Primary care admissions to District and Regional Hospitals

Using the Clinicom (2015) dataset we are able to determine the number and source of the admissions for the hospital level of care. For the purposes of this exercise we classified the fields in this database for community health centre, local authority clinics, maternity & obstetric unit, and out-patient department as primary care facilities. Available data was provided at a monthly frequency over the period April 2013 to December 2014.

Those directed from primary care to district hospitals currently amount to 284,811 per month (as at December 2014). This number has grown at a rate of 6.8% over the last year. Similarly, the total number of individuals admitted from primary care to regional hospitals during December 2014 was 138,240. This number has remained relatively constant and has only grown by 0.36% over the last year.

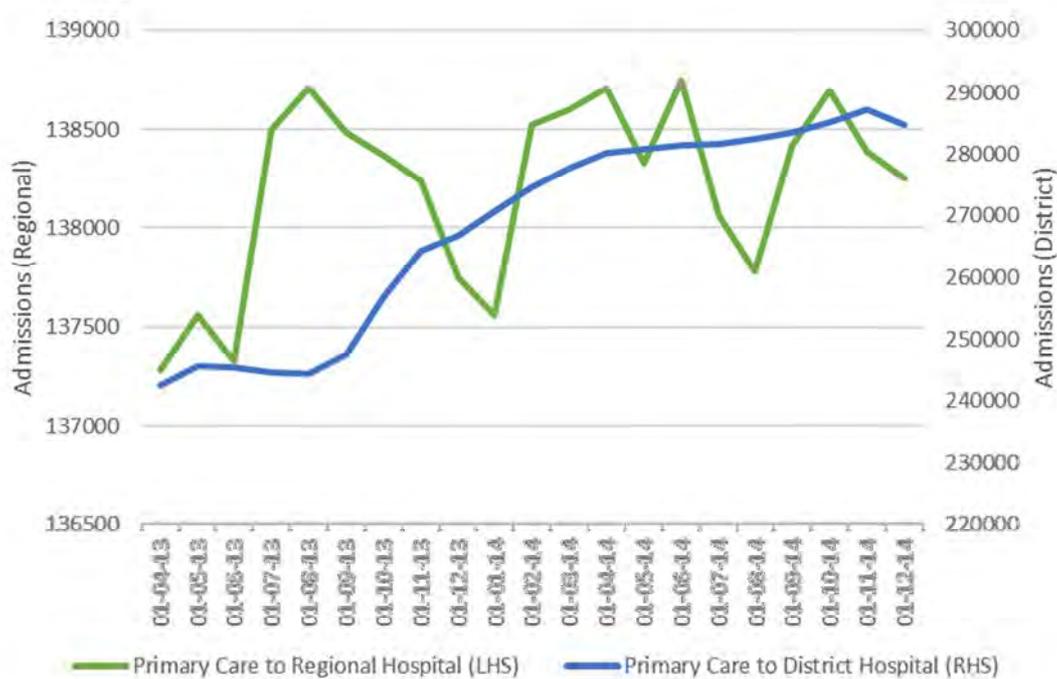


Figure 3: Primary care to District and Regional Hospitals

The increase in admissions to the various hospitals in the Western Cape from primary care facilities is depicted in Figure 3, where we note that growth in entrants has increased over time.

v. Emergency admissions to District and Regional Hospitals

Using the Clinicom (2015) dataset we are then able to consider the number of unreferrred entrants into the hospital facilities through the accident and emergency centres. The classification system that we have employed reports on the total number of individuals who sought to enter from their respective homes through the accident and emergency centres as the total number of new unreferrred accident or emergency patients.

It is worth noting that the regional hospitals have experienced little growth in the number of entrants to this channel. This could possibly be due to the suggestion that they are operating at a level that is very close to maximum capacity. In addition, the number of individuals that enter district hospitals through the accident and emergency centres has grown significantly over this period, which could partially be due to diversions from regional hospitals that are operating close to capacity (10).

The annual rate of growth in unreferrred accident and emergency entrants at district hospitals amounts to an approximate annualised rate of 19% over the entire sample. The result of the increase in the total number of entrants to these hospital facilities is depicted in Figure 4, where they grew from 20,642 to 27,481 (between April 2013 to December 2014).

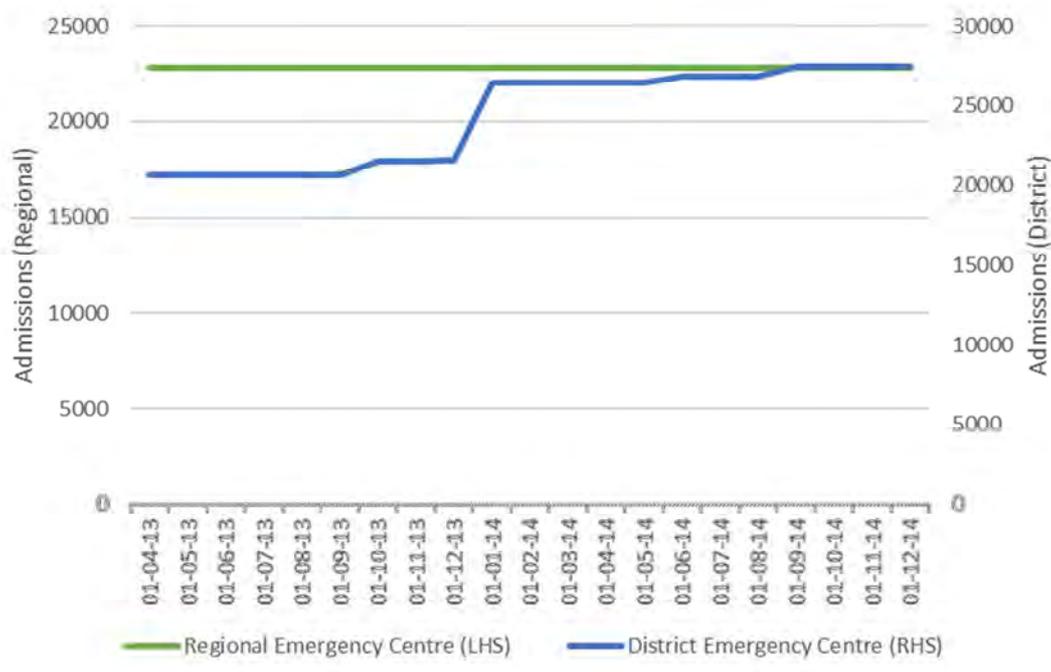


Figure 4: Unreferred Emergency Admissions to District and Regional Hospitals

vi. Transfers between District and Regional Hospitals

Most transfers between district and regional hospitals take place from regional to district hospitals. During December 2014, a total of 2,829 patients were transferred from district to regional hospitals, while 4,688 patients were transferred from regional to district hospitals. The net transfer of 1,859 patients per month is relatively small, particularly when compared to the total number of admissions from primary care facilities. In addition, these transfers have also remained relatively stable over time (Clinicom, 2015). Hence, this feature of the data has not been explicitly included as a separate channel in the model.

vii. Intermediate and Domiciliary care admissions to District and Regional Hospitals

The Clinicom (2015) dataset suggests that these numbers are very small and as such they have not been included in the model. For example, in December 2014 the total number of admissions from intermediate care facilities amounts to 7 and 0, into the respective district and regional hospitals. In addition, those originating from domiciliary care facilities amounts to 552 and 334, respectively. There has also been little change in these numbers over time.

viii. District and Regional Hospital Treatment

After entering these facilities, the patients are prioritised according to the practice of triage at both district and regional hospitals. This practice ensures that those patients who require emergency surgery treatment will be prioritised ahead of emergency medical and elective surgery treatment. Thereafter, emergency medical patients would receive the second highest priority with elective surgery patients receiving the lowest priority. For the purposes of this model we have not distinguished between these different categories as this research question is focused on the general dynamics of the entire system at a relatively high-level. In addition, it is also worth noting that there is no data for the Western Cape hospitals that would describe this practice in sufficient detail, at a more segregated level.

Estimates for the total number of beds in hospital facilities were obtained from DHIS (2014). It suggests that the number of beds in regional hospitals amounts to 1,387 in December 2014. The annual growth in the number of beds is approximately 0.76% per annum, as it has not been a key area of development. According to the objectives of the Western Cape Government's Health Department, as described in the Healthcare 2030 document, the department has a stated preference for improving the district (as opposed to the regional) health services. The length of stay in the regional hospitals is approximately 3.9 days, which is slightly higher than that of district hospitals. This would have allowed for a total possible number of 10,669 overnight admissions into regional hospitals during the month of December 2014.

Similarly, for district hospitals the total number of beds amounts to 2,758 (DHIS, 2014). This number has been growing at approximately 2.5% p.a. over the last five years, or almost 0.2% per month. Since the monthly average length of stay for the district hospitals over the period, April 2010 to December 2014 has been 3.11 days (DHIS, 2014), the total possible overnight admissions for the district hospitals is approximately 26,605 during the month of December 2014. This number is consistent with what is to be expected, as the total hospital separations equates to an average of 24,080 per month, between January 2010 and December 2014 (which is within the 0.9 percentile of total possible admissions). Note also that it would not be feasible to have a 100% bed utilisation rate as there will be times when a bed is left vacant for a portion of the day, possibly when the bed census takes place.

For those patients that remain in the system, they would either be treated in the hospitalisation or post-hospitalisation/intermediate care stages. Those in the hospitalisation phase would be admitted to a bed (if available), while a relatively large number of patients would wait for a vacancy in either intermediate care or domiciliary care facilities. After making use of the information relating to the admissions to intermediate

and domiciliary care facilities, we are then able to determine the total number of patients that are discharged from the hospital facilities.

ix. District and Regional Hospitals to Intermediate and Home-based care

As with hospitals, the amount of patients that may be admitted to intermediate or domiciliary care facilities is dependent upon the total number of available beds (or the care packages when referring to home-based care services).

Most of the intermediate care services in the Western Cape are provided by non-governmental organisations and as such they are not under the complete control of the provincial government. To establish an estimate for the total number of admissions that are currently in the system, the Health Department conducted a once-off survey in 2014 (13). This data indicates that approximately 70% of the total number of patients in intermediate care were admitted from district or regional hospitals. Using this method we assume that 17% of the patients receiving home-based care services were admitted from district or regional hospitals.

From the DHIS (2014) data, we note that of the 37,274 (i.e. 10,669 + 26,605) monthly overnight admissions into both district and regional hospitals in December 2014, an average of 427 patients are transferred to intermediate care facilities over the course of a month. This is equivalent to 1.15% of the total hospital overnight admissions. Similarly, an average of 1,074 patients are transferred to home-based care over the course of a month, which is equivalent to 2.88% of the total hospital overnight admissions.

Unfortunately, there is no equivalent data for the residential care facilities. We assume that this is largely due to the fact that the number of patients that are transferred to these facilities each month from hospitals is very small.

This would imply that the total amount of patients that are discharged from regional or district hospitals is approximately 95.97% of the total number of admissions. This is a rather large proportion and would include those where their condition has been resolved, where the patient has been referred back to a primary care facility, or where the patient left the healthcare facility as a result of death.

	<u>%</u>
Transferred from hospitals to intermediate care	1.15
Transferred from hospitals to domiciliary care	2.88
Discharged	<u>95.97</u>
	<u>100</u>

Figure 5 shows the total number of admissions from hospitals to the respective post-hospitalisation facilities. Note that the linear trends suggest that these have been diminishing over time, where the admissions to home-based care packages have been decreasing at a faster rate.

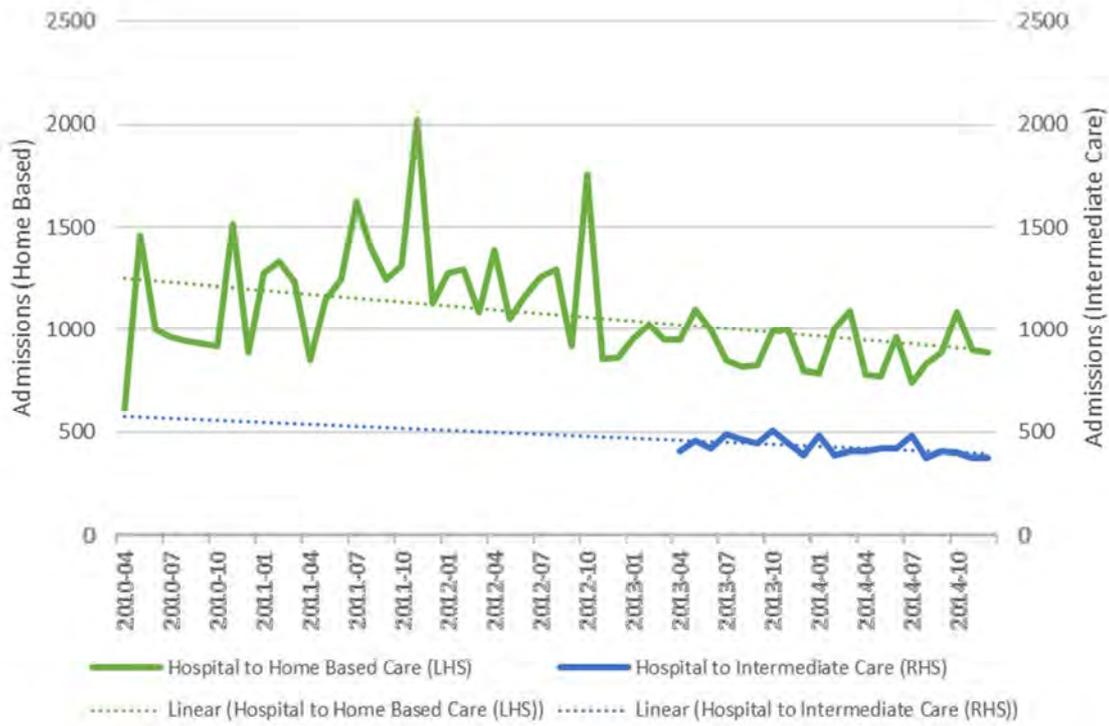


Figure 5: Hospitals to Post-Hospitalisation Care

Using the Sinjani (2014) dataset, we note that the total number of beds in intermediate care facilities currently amounts to 769 (as at 30 November 2014). This number has declined slightly since April 2013, from a number of 785. Hence, in this study we initially assume that this decline is going to continue at the present rate of 3.1% per annum.



Figure 6: Number of Beds in Intermediate Care Facilities

The length of stay in intermediate care facilities is estimated to be 32 days or 1.07 months, which has been increasing steadily over time. This is depicted in Figure 7 and could possibly be attributed to an increase in patients that require more time to recover (i.e. increase in the proportion of patients that have rehabilitation needs).

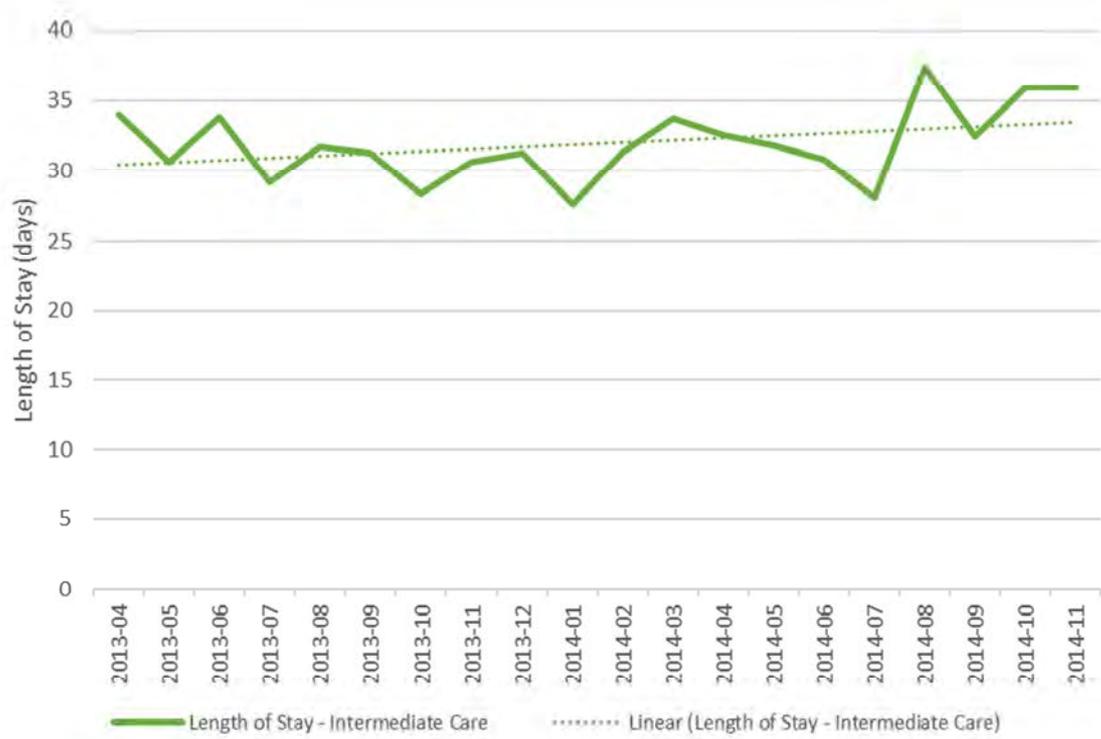


Figure 7: Length of Stay in Intermediate Care Facilities

Within the domiciliary care facilities, there are the equivalent of 8,753 beds that are provided by the home-based care packages as of December 2014. This was derived from the total number of clients who are entered into the home-based care register that need maximum assistance in terms of activities of daily living and are bedridden most of the time. As noted in Figure 8, the growth in beds has been relatively high and was approximately 3.12% between April 2010 and December 2014 (Sinjani, 2014).

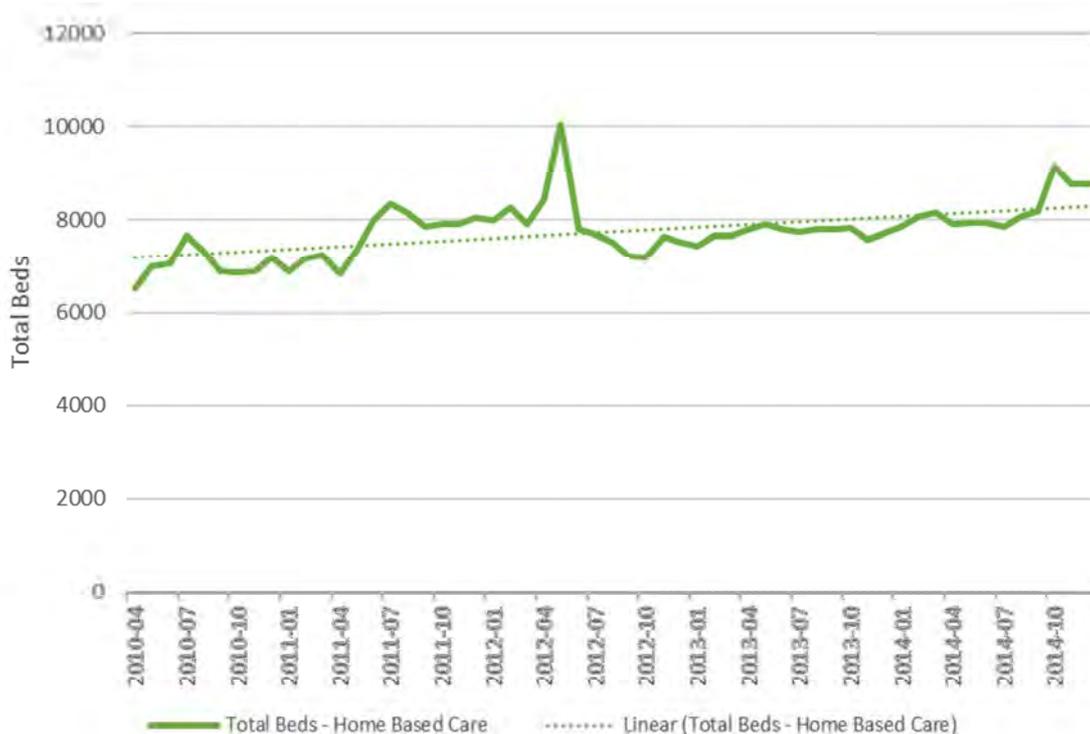


Figure 8: Number of Beds in Home-Based Care

Unfortunately there is no data presently available for the duration of home-based care packages. After considering various values that were used in the simulation exercise, we assume that the length of stay is 6 months and we expect that there is little change in this estimate.

In the case of the residential care facilities these services are not explicitly funded by the Health Department, but rather by the Department of Social Development in the Western Cape. It is estimated that there are the equivalent of 11,569 beds based on the Western Cape Government's Department of Social Development Annual Report (2013/14). Unfortunately, there is no data on the average length of stay and we assume that this is equivalent to 36 months. The growth rate of the beds in both the domiciliary care facilities is assumed to be equivalent, which is an average of 1%.

In addition, there is also no data on the number of admissions to these residential care facilities from hospitals, intermediate or home-based care services. It is assumed to be such that they exhaust the maximum available beds in residential care facilities, after considering various possible numbers in the context of the model based environment.

x. Home-based care to Intermediate care and vice versa

According to the once-off survey (13), the total number of patients that are admitted to intermediate care facilities from home-based care

packages is 25% (of total admissions to intermediate care facilities). Similarly, using the Sinjani (2014) dataset we are able to note that the total number of patients that are admitted to home based care packages from intermediate care facilities is approximately 29%.

Figure 9 shows, that while the percentage of admissions from each source are similar, the actual number of admissions are somewhat different as the total number of admissions to home-based care packages is much larger than the admissions to intermediate care facilities. This is partly due to the fact that home-based care services have a much larger capacity.

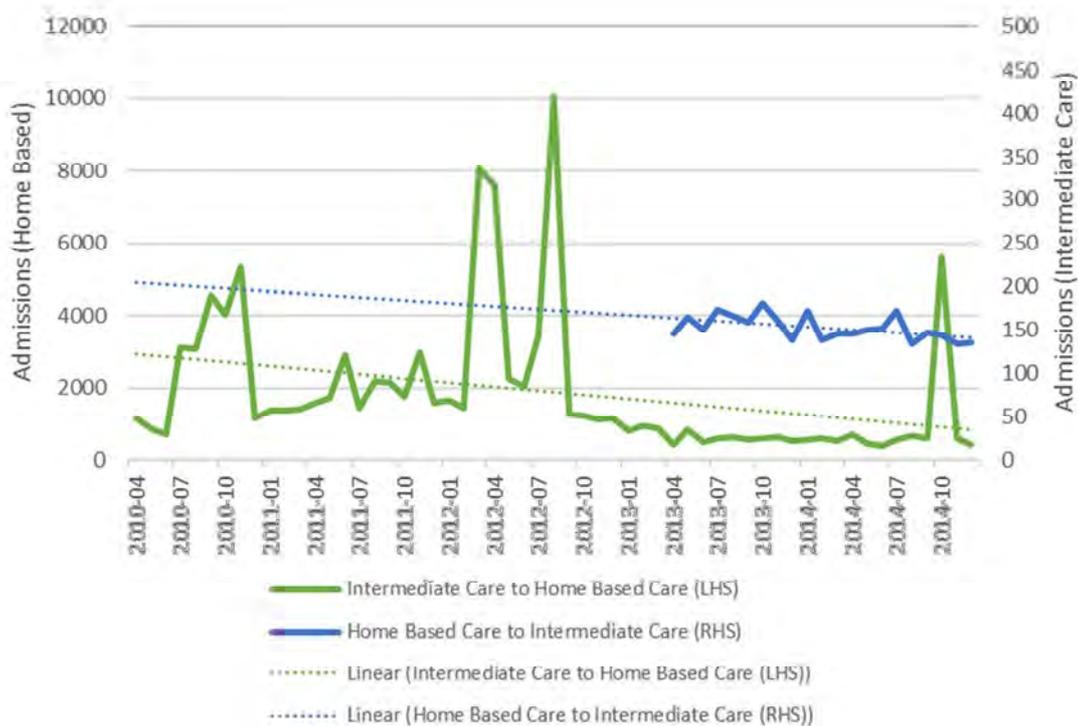


Figure 9: Exchange between Post-Hospitalisation Care Facilities

When considering that the number of admissions to intermediate care facilities amount to less than 800 per month, it is extremely unlikely that almost 62,000 individuals have been transferred to home-based care packages over the last three years. For the purposes of the model, we have started from the last observation of 396 patients that were transferred to home-based care packages and have assumed that the decline in the rate of transfers is 5% per annum, which will continue into the future.

For the transfers to intermediate care facilities from home-based care packages, the average over the last 21 months (for which we have data) is 153. This has been declining somewhat and is estimated to be

approximately 9.5%. However, as it is unlikely that this decline is less than the transfers to home-based care packages, we maintain an equivalent 5% decline.

5) Model simulation and results

The static version of the model that makes use of the above parameterisation is utilised to produce an initial simulation. Thereafter, we consider a number of alternative scenarios, where the number of beds in intermediate care facilities increases at a rate that is equivalent to that of the district hospitals, as well as the case where the number of beds increases at a rate of 9% to account for past shortfalls. Lastly, we also allow for a reduction in the number of hospital readmissions of 10%.

i. Base case scenario

The integrated care pathway model simulates the operation of the 'whole system' of care outlined above over a period of four years assuming that there is no change to the respective rates that are discussed above (where the time step in the model is months).

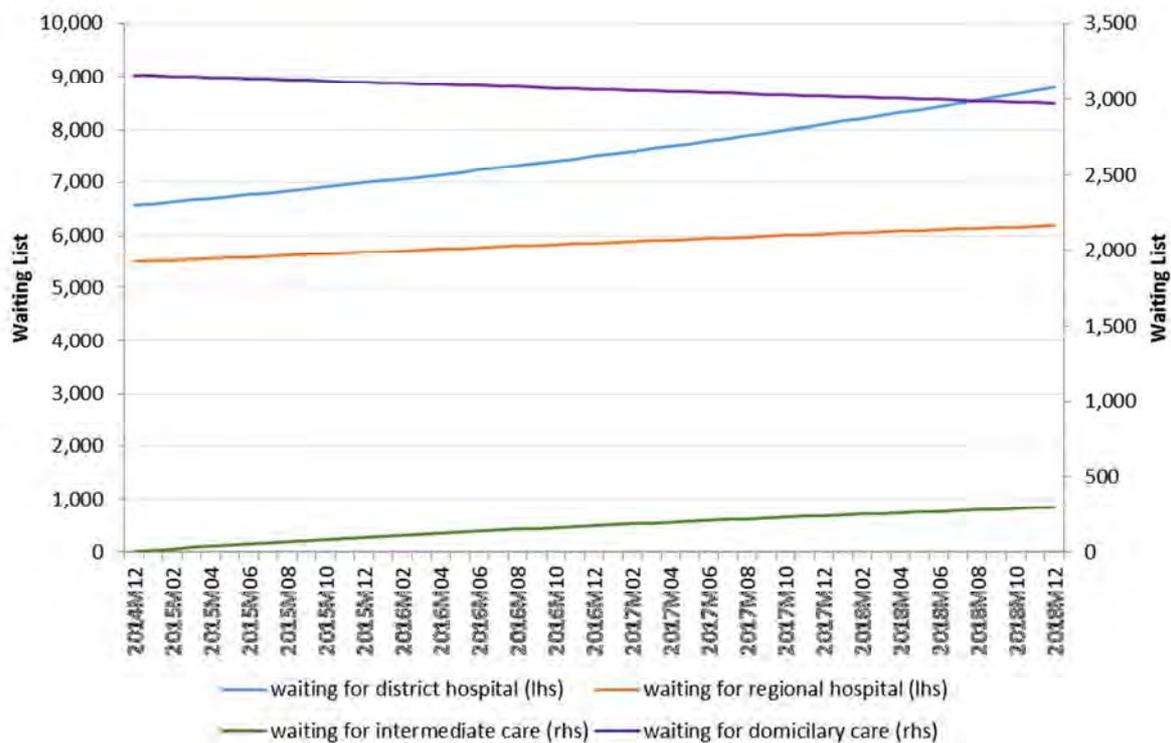


Figure 10: Model simulation in base case scenario

The model shows that the 'whole system' of primary, hospital, intermediate and domiciliary care in the Western Cape could be characterised as a series of services each having their own capacity, rate of admission and

average length of stay. Whenever there is a mismatch between the rate at which people are being referred to care from one service to another, and the rate at which people are leaving a service-stage, there could be problems such as increased waiting times and delayed discharges.

For example, the elective waiting list for hospitals is high and increasing over the period despite increasing hospital capacity (i.e. 2.5% annual growth in district hospital beds). By contrast, intermediate care is one of the more flexible forms of post-hospitalisation care, since it could be provided as an alternative to hospital admission or to facilitate supported discharge. Based on the purpose of the model which is to aid decision makers' understanding of an integrated care pathway and the implications of enhanced or redesigned intermediate care services, one of the most insightful findings is to see how demand will exceed capacity over the period. Using the model with the best available data for demand and supply there appear to be inconsistencies between the perceived structure and the data that has been provided by the various organisations. Generally, agencies have more data about stocks (for example, how many hospital admissions there are per month), instead of flows (i.e. the rates people move between service-stages), which have been estimated for the purpose of this model.

While the Health Department in the Western Cape does not collect routine data relating to waiting lists in the district and regional hospitals, the results that have been presented in Figure 10 suggest that these are relatively large. Note that both of the waiting lists for the hospitals are provided on the axis on the left-hand-side, which is greater than the values on the right-hand-side axis (which pertains to intermediate and domiciliary care). What is also worth noting is that the slope of the lines suggest that there is an alarming increase in the rate of growth in the waiting lists for district hospital services, although there is also an expected increase in the waiting lists for regional hospital services.

The waiting list for intermediate care facilities is also expected to increase over time, although it should be noted that the absolute size of these waiting lists relative to hospitals is much smaller. The results for domiciliary care suggest that as a result of the strong rate of growth in the number of available beds or care packages (which are projected to continue in this model) the waiting lists for these services will decrease over time.

In terms of how these results relate to the literature that considers the use of System Dynamics modelling in healthcare scenarios in developed world economies, we note that these results are somewhat different. In the case of developed world economies, the results largely suggest that the waiting lists for post-hospitalisation care are expected to increase, whilst those for district and regional hospitals are relatively flat (or decreasing). In this case, the likely outcome in such a developed world economy is that the

increased pressure on post-hospitalisation facilities will create bottlenecks in district and regional hospitals (14).

In the case of healthcare services in the Western Cape, the demand and subsequent pressure on district and regional hospitals is increasing at a rate that is much greater than the pressure on other services (as reflected by the slope of the line for waiting lists for district hospitals). This is possibly due to number of factors, which would include the suggestion that there is a managerial policy to discharge patients within three days, which may result in a person being discharged if there are no beds available in an intermediate care facility. Such a scenario is unlikely to occur in a developed world situation, where intermediate care facilities are more extensive and there is better access to post-hospitalisation care.

To conclude our discussion of these results, we would like to highlight the finding that the demand for district hospital services is expected to increase at a relatively large rate. To alleviate the pressure on these particular services, decision makers may need to consider addressing both the supply and demand side of the problem. In terms of supply side considerations, these could include increasing capacity (i.e. beds, staff, etc.); while the demand side consideration could include reducing readmissions, increasing preventive care, etc.

ii. Increasing beds at the rate that is equal to District Hospitals

After including a number of dynamic features to the model, we can then perform a number of simulations for different assumptions relating to capacity, rate of admission and average length of stay. In this case we consider increasing the number of beds in intermediate care facilities by 2.5% per annum, which is equivalent to the rate of growth in the beds of district hospitals. The results are shown in Figure 11.

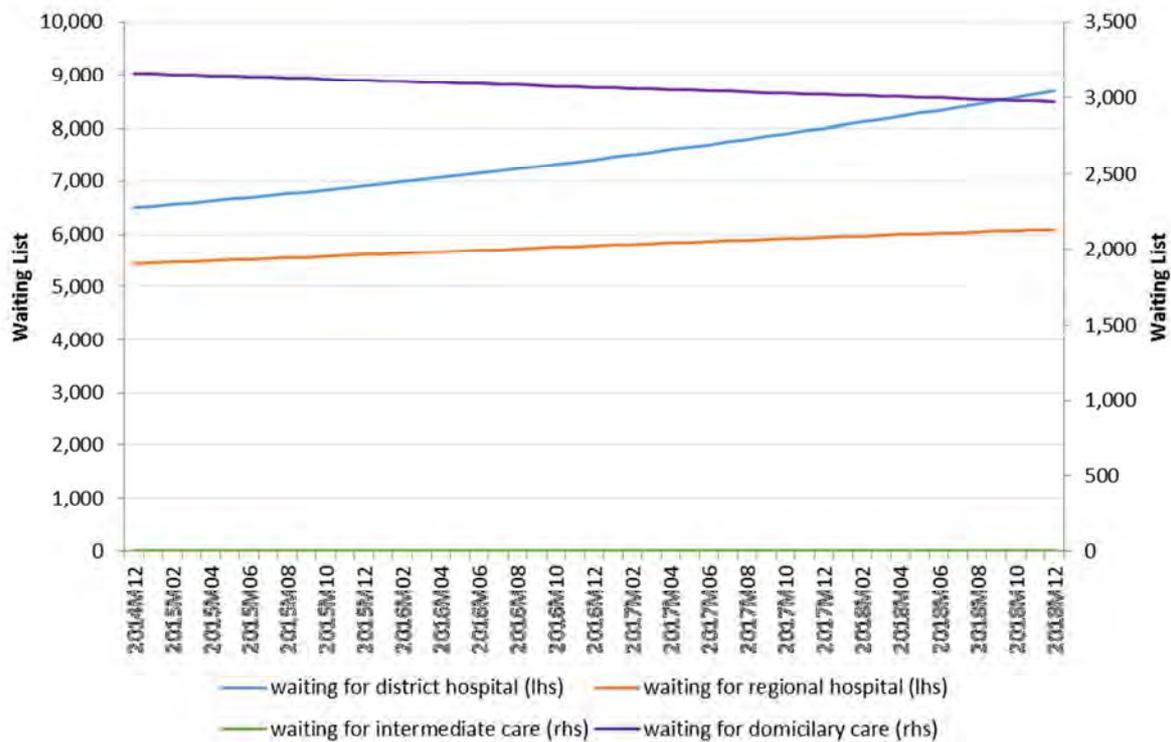


Figure 11: Model simulation with increase in intermediate care beds (2.5%)

In this case the waiting list for intermediate care beds reduces to zero, which alleviates some of the pressure on the waiting lists of district and regional hospitals. The increase in the capacity of services in intermediate care facilities may allow for admissions from both district and regional hospitals to be redirected to intermediate care services (as appropriate). Alternatively, this could also result in the reduction of delayed transfers in care, as access to post-hospitalisation care increases over time.

Note that in this case the reduction in the waiting lists for intermediate care services has a negligible effect on the waiting lists for hospitals, as there is a stark contrast in the respective capacities of hospitals and intermediate care facilities (where the ratio of intermediate care admissions relative to hospital admissions is 1:98).

iii. Increasing beds at the rate to account for past shortfalls

In the second of these proposed interventions, we consider increasing the number of beds in intermediate care facilities by 9% per annum, which has been suggested by policymakers to correct for the recent decline in intermediate care beds (3). The results of such a simulation are shown in Figure 12.

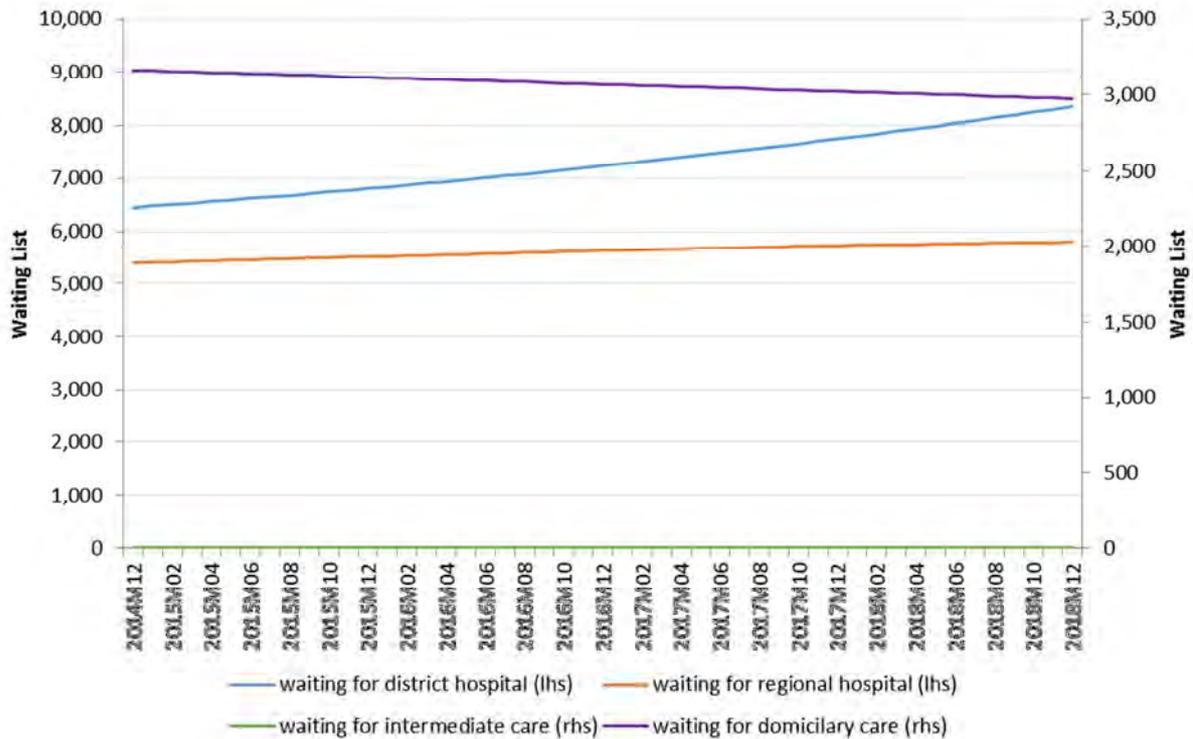


Figure 12: Model simulation with increase in intermediate care beds (9%)

In this case the waiting lists for intermediate care services would remain at a level of zero. Once again, this would allow for district and regional hospitals to either redirect patients seeking admission or reduce the extent of delayed transfers in care within these facilities.

The results of this intervention are somewhat similar to those that have been presented under the previous intervention, where we see only a very small change in the waiting lists for hospital services. This could again be attributed to mismatch in the relative size of the respective intermediate care and hospital facilities.

iv. Decreasing the readmissions into Hospitals

In the final simulation, we consider the case where we increase the number of beds in intermediate care facilities by 9% per annum. However, in this case we also allow for a reduction in the number of hospital readmissions of 10%. The rationale for including this additional feature is motivated by the premise that patients in intermediate care facilities would receive more extensive rehabilitative care. Such patients are less likely to be readmitted to a hospital, as they would have received extended healthcare support (as the average length of stay in intermediate care facilities is significantly longer than those of hospitals).

This intervention would characterise a feedback loop in the terminology of the System Dynamics literature, as discussed in Wolstenholme et al. (15). The results of such a simulation are shown in Figure 13.

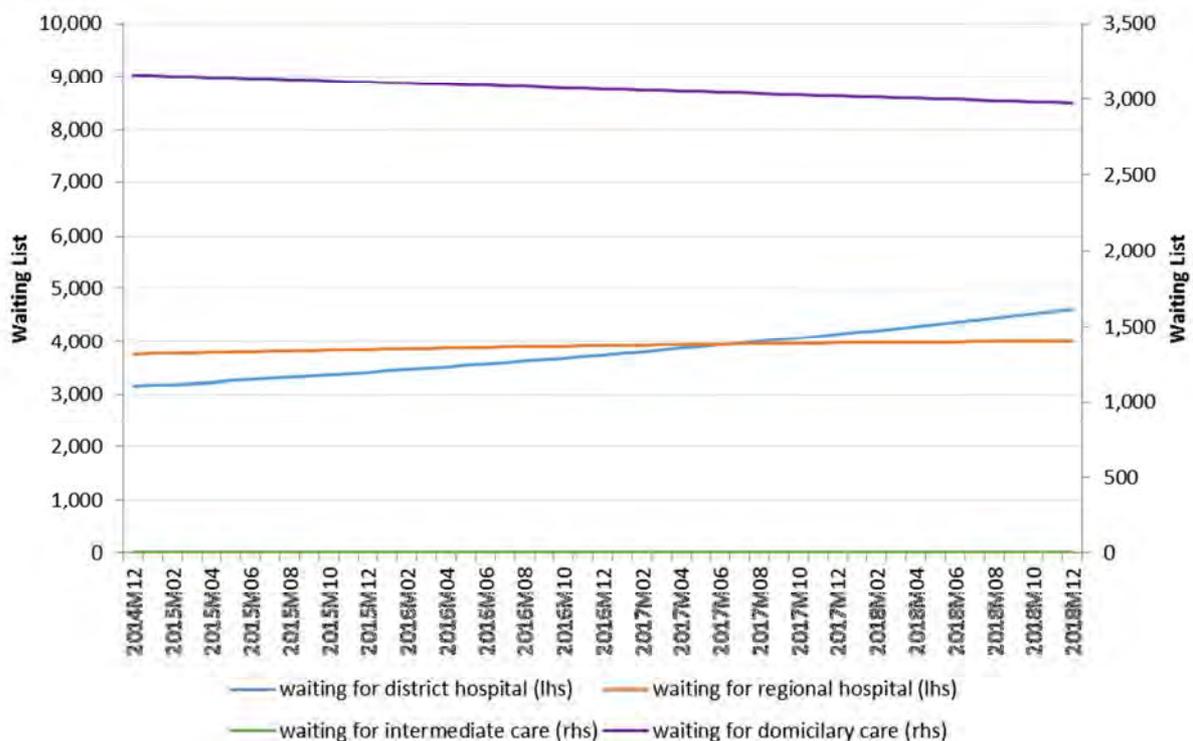


Figure 13: Model simulation with decrease in readmissions (10%)

This intervention would have demand side effects, which would decrease the rate of growth in the demand for hospital services. Note that in this case, Figure 13 suggests that the waiting lists for regional hospital services is relatively constant over time, while the rate of growth in the demand for district hospital services has declined (somewhat).

6) Discussion

In the survey of population-based needs conducted for the 2011/12 de-hospitalised care service review in the Western Cape, nearly two-thirds of the 957 households surveyed in Oudtshoorn reported someone with a chronic illness; and roughly one in ten people, who were older than five years, in Oudtshoorn (8.6%) have a disability (when using a standardised screening instrument). Among this group of individuals, the self-reported access to health and social services received a reasonably good rating. However, the group also suggested that there was a need for additional rehabilitation services (2). While it is not possible to quantify the unmet care needs from the survey conducted in Oudtshoorn, it is highly likely that a sub-set of people who reported extreme activity limitations and participation restrictions could benefit from the more intense rehabilitation

environment of implementing enhanced or redesigned intermediate care services.

Drawing on the findings from the first and second phases of the de-hospitalised care service review, as well as feedback from the multiple stakeholders consulted as part of this participative modelling and iterative processing approach, the modelling group communicated directly with review commissioners (key decision makers) to develop a theoretical model of the integrated care pathway. The envisaged service model represents a more dynamic, integrated care system than the current disjointed service delivery platform. Intermediate care outcomes and activities were enhanced and redesigned to prevent unplanned/inappropriate use of acute hospitals and to enable successful discharge into the domiciliary environment. Even before the theoretical model was taken to the data and converted into a simulation model, the main managerial learning was around the existence and nature of organisational boundaries that require joint working and sharing of information for the majority of patients to experience seamlessness through the health and social care systems. Although a theoretical model can improve understanding of the complexity of the integrated care provision process, where there are different agencies that own various pieces of the pathway, it cannot test and compare the alternative intervention points. In the search for the implications of one of the proposed high-leverage Healthcare 2030 interventions, a simulation model was created from the actual framework for service delivery using parameterisation with service component data and mathematical integration to calculate changes in 'stocks', as determined by 'flow' rates over time.

The simulation results for the alternative scenarios that were tested, suggest that the implications of implementing enhanced or redesigned intermediate care services on 'bed blocking' (i.e. delayed transfers in care) within the 'whole system' of care are negligible, if the proposed changes are only to adjust the 'stock' (or capacity) variables. This is largely due to the mismatch in the relative capacities of the respective inpatient services. However, increasing intermediate care beds would also have a number of dynamic effects, which could include the stimulation of demand for this type of care and support. For example, it may encourage practitioners to refer more patients with unmet care needs to the available services. In addition, reducing a percentage of hospital readmissions would involve a change to a 'flow' (or rate) variable, which has a more substantial effect on the waiting lists for hospitals. Without a simulation model, it would be difficult to show how capacity additions across a 'whole system' of care influence these various performance measures/indicators. It is also difficult to predict the outcomes of even small changes to service components – ignoring the influence of elements that could resist any changes made – with the result that well-intended

actions fail or complicate the connections between multiple stakeholders and different agencies within the system (16).

This study contributes to the growing field of integrated care systems modelling by reporting on the use of an iterative model building process and dynamic simulation to assist the Western Cape Government's Health Department in analysing the implications of implementing enhanced or redesigned intermediate care initiatives on hospital admissions, waiting times and length of stay of all patients. By using the framework proposed by Nienaber (17) for developing System Dynamics models in low resource settings, one could investigate the way organisations possibly cope with demand for care that exceeds capacity. In the case described of the Western Cape, the System Dynamics framework was able to show the inconsistencies between the perceived structure and the available data from the respective service components that describe the resultant behavioural effects, as well as the unintended consequences of informal managerial policies, on the 'whole system' when parts of the integrated care pathway are capacity constrained.

The proposed high-leverage Healthcare 2030 policy intervention – intermediate care – that could be seen as an alternative to increased hospital admission through the implementation of supported discharge was shown to be beneficial because it moderates the rate of growth in the demand for hospital services. The significance of this insight is that the waiting lists for both the hospitals must be relatively large and implementing different interventions that increase capacity alone to 'unblock' hospital beds without any intervention that focuses on decreasing hospital readmissions or demand for hospital care are likely to have less impact over time.

One of the limitations of this study is that the modelling process relied on aggregate data and the use of estimated values to represent waiting times, which may under or over inflate the true values of this critical variable. In addition, the hospital admission values are based on population projections and any changes observed in the population may alter the numerical values of the simulation. A fair amount of preparatory work was conducted to ascertain the state of service delivery indicators within the health sub-districts of the Western Cape. The modelling group sought and obtained access to a variety of datasets. These data sources were supplemented with reference to a number of additional reports and information drawn from the Census 2011 and StatsSA population projections (2014).

The data collection and analysis process culminated in indicative baselines for these performance measures being formulated and used in the parameterisation of the model. Despite the collection of this information with respect to service delivery indicator baseline levels

significant concerns present surrounding the use of collated datasets in a formal scientific study. Concerns about the suitability of the data for use in simulation modelling research hinge primarily around the following limitations:

- *Accuracy*: data collection processes for some indicators are not adequately standardised and quality assured. For instance data entry on Clinicom is delegated to receptionists/clerks who may be poorly motivated, inadequately trained on capturing indicators or simply not capture the information as intended by the service provider.
- *Homogeneity*: data is aggregated on a facility and/or sub-district level and significant levels of variability can be observed across districts. Such heterogeneity also presents concerns when trying to infer local area baselines based on district level measures.
- *Timeliness*: a number of indicators can only be established with reference to surveys that are conducted irregularly meaning that baseline data may be significantly outdated.
- *Completeness*: certain data sources some facilities reporting more timeously than others and coverage is uneven.
- *Consistency*: metric definitions are at times revised over time which may confound trend analysis. This is especially relevant to the DHIS.
- *Geographic isolation*: indicators that are more likely to hold relevance for secondary and tertiary facilities have relatively wide drainage areas which can distort the understanding of local area indicator levels.
- *Appropriate denominators*: in some cases trying to establish percentages based on official population figures for an age segment leads to estimates in excess of 100%.

7) Conclusion

As the population lives longer and there are more people with 'complex health needs', the Health Department in the Western Cape recognises that there will be rapidly rising levels of demand for healthcare services. This may necessitate that the provision of healthcare services may need to be in done a slightly different manner. To investigate whether this would be necessary, decision makers need analytical tools that capture complex and nonlinear relationships within a 'whole system' of care to undertake joint capacity planning. Dynamic simulation modelling methods allow decision makers to experiment with and test policy interventions in a safe environment, where these models may be used to learn about or ultimately identify aspects of policy resistance within the system. For successful implementation, health and social care providers need integrated health information systems for tracking performance measures/indicators reliably. The bulk of provider metrics largely pertains to the number of patients attended to (i.e. admissions/headcounts) and cannot serve to inform estimation of baselines for unmet care needs within the local areas they work in.

In the case of interventions to intermediate care, which were considered in this study, the possible effects of three scenarios are analysed. However, many other alternative policy interventions could also be explored. The use of System Dynamics methods would enable organs of state to consider the effects of interventions, where the various government departments could seek to address 'whole society' needs, particularly where these consider the interface between various health and social care systems.

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Part D: APPENDICES

- 1) Letter of approval from UCT Human Research Ethics Committee**

- 2) IJIC guidelines for “Research and Theory” Papers**