Eric Wolstenholme · Douglas McKelvie

The Dynamics of Care

Understanding People *Flows* in Health and Social Care

Foreword by: Jack Homer

Springer

The Dynamics of Care

"Wolstenholme and McKelvie bring two lifetimes of award-winning experience in applying system dynamics to health and care dynamics to the creation of this new book. In spite of amazing advances in all areas of medical science with associated increases in our ability to diagnose and treat complex medical problems, our medical system as a whole is facing multiple crises. These problems arise not from how we diagnose and treat patients on a one-on-one basis, rather from how components of care are organised (or more often not organised) into a coherent overall system of care. Our current dysfunctional system of care is the target of Wolstenholme and McKelvie's insightful analysis. Focused on **flows** and **throughput** as key analytic concepts, this new book condenses and focuses insights from over 80 empirical studies within a coherent analytical frame. All of us interested in and concerned about the cost and quality of maintaining a health population need to read and come to grips with the points that they are making in this important new book."

—David F. Andersen, *O'Leary Distinguished Service Professor, Emeritus, Nelson A. Rockefeller College of Public Affairs and Policy, University at Albany, State University of New York, Albany, New York*

"This very welcome book offers the hope of sound and sustainable solutions to persistent and serious problems that not only cause untold misery to millions but also impose considerable costs in many societies. The exceptional work it reports on illustrates that a fundamental new capability has been reached—it is now both technically and practically feasible to *simulate* most management and policy challenges we face. This is as true for small, local issues as it is for large problems of wide scope. These working, quantified simulations are powerful because they mimic the observable behaviour of the systems we want to better manage, not just the performance outcomes of concern, but everything else of significance. They therefore allow us to experiment, boldly and at trivial cost, with software facsimiles of the real world, rather than (as we have always done until now) on the real world itself. This potential is now recognised in the UK government report 'Computational modelling: Blackett review', which makes clear that every executive, advisor and policy-maker, in every field of endeavour, should understand what such simulations can do and know how to implement and exploit them."

—Kim Warren, *Managing Director Strategy Dynamics, London, UK*

Since its inception more than seven decades ago, the NHS has become one of the great unchanging features of the British landscape. The flip side of such permanence is its inability to move with the times in the way that has revolutionised other industries.

In this timely book, Eric and Douglas peel back the mystique around care delivery. They introduce two key concepts, feedback and flow, and show why any attempt to modernise delivery will fail without carefully responding to these underlying principles.

The strength of this book is the weight of examples culled over many years of practical experience. It is a call to learn to build a better care system and it provides some powerful clues as to how to change care delivery for the better, and in an affordable way.

Happy reading!

—Terry Young, *Professor Emeritus of Health Care Systems, Brunel University, London and Director, Datchet Consulting* (https://datchet.consulting/)

"A recent report in the *British Medical Journal (Global Health)* addressed the issue of health system modelling research, emphasising that models should capture the dynamic interactions between the main health system components and acknowledge constraints. This new book by Eric Wolstenholme and Douglas McKelvie describes a methodology (system dynamics) which eminently satisfies that call. Through a number of examples distilled from their extensive consultancy roles in health and social care, they urge a move away from considering specific departments, to a consideration of coupled health systems which transcend organisational boundaries, where inter-connections, inter-dependencies, flows and stocks become the new perspective instead. Those involved in planning for improved service delivery in health and social care can now learn how to rehearse their ideas in silico by deploying simulations which capture the nuances of health systems and can leverage counter-intuitive policy responses."

—Brian Dangerfield, *School of Management, University of Bristol, UK*

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Foreword

This new book by Eric Wolstenholme and Douglas McKelvie is a very welcome addition and should find a wide audience. Both authors are well known in the field of system dynamics simulation modelling and have been leaders of our field and its UK contingent for many years.

Eric started his academic career in 1976 and taught at several universities (Bradford, Stirling, where he was Professor and Head of the Department of Management Science, Leeds Beckett University and London South Bank). He has published two books before this one and many articles, and was Founding Editor of the *System Dynamics Review* journal, President of the International System Dynamics Society and winner of the Society's highest honour, the Forrester Award, in 2004. He has also been a system dynamics consultant since 1994. With Douglas, as well as David Monk, he formed the consultancy, SymmetricSD, in 2005 to focus on issues of health and social care.

Douglas started as a social worker in his home country of Scotland, serving 12 years on the front lines and 10 years in senior regulatory roles. He joined the consultancy OLM in 2002, where he met Eric and David, and started his study of system dynamics. By 2012, he had won the Gleave Prize for best real-world application of system dynamics in the UK (on alcohol harm), and in 2016 and 2017, he assumed leadership positions in the System Dynamics Society in the UK and internationally.

It is fortunate for us that these two modellers and consultants, with complementary backgrounds and some 16 years working together on more than 80 projects, have gathered those experiences together in writing this book (Some of this work has been published previously, but most has not.). Their broad theme is how health and social care systems—despite good intentions all around—are prone to behave sub-optimally, providing less benefit and allowing more harm than they should, due to perverse incentives or conflicting goals within or between organisations. Douglas is not the first Scot to remind us that "The best laid schemes o' mice an' men/Gang aft agley".

The authors describe how this theme plays out in two UK contexts they know well, hospital care and mental health care. In both cases, persistent or "wicked" problems have been made worse and harder to handle due to ageing of the population. With regard to hospital care, the wicked problem is delayed hospital discharges. A discharge does not take place in the UK until an appropriate post-discharge destination is located that can provide the right level of continuing health and social care. In the USA, the lack of such a destination might result in the patient simply being sent home to fend for themselves. In the UK, the result is instead a delayed discharge, which ties up capacity and increases the risk of a hospital-acquired infection. Numerous attempts to solve such bottlenecking at the hospital level have failed. The authors conclude that a more integrated approach is needed in which social care spending is put in the proper balance with that of hospitals. The need for such rebalancing is becoming even greater with population ageing because of the more complicated post-discharge needs of the elderly.

With regard to mental health care, the wicked problem is lack of access to needed specialty services, such as those for depression, dementia and alcoholism. Long waiting times for such specialty services have persisted despite an understanding that "stepped care", employing intermediate resources for less complicated cases, is the right solution. Although most agree on this desired end state, what has proved challenging is the implementation problem—how to get from here to there. How, during a period of transition, should one deal with existing and transitional backlogs of patients, and how should funding be gradually reallocated from specialty to non-specialty practitioners? These are not easy questions to answer without a model, and trying to muddle through without a model is prone to "Gang aft agley".

There is something universal in an approach to problems that boils things down to flows, capacities and backlogs, and that identifies how attempts to deal with backlogs will prove ineffective or counterproductive if the underlying cause is not addressed. Operations researchers and system dynamics modellers have approached many problems this way since the 1950s. Eric and Douglas are not the first to adopt such a "flow perspective" (to borrow Eric's term), but they surely have been the most persistent and successful during their 16 years together in exploring its many manifestations in the area of health and social care.

You should read this book whether or not you are familiar with system dynamics or with care dynamics specifically. You will find rich description based on real-world cases, logical structuring of the issue and clear presentation of the results. You will also find a general introduction to the concepts of system dynamics as applied to typical care variables such as admissions, discharges and length of stay. Plentiful diagrams and behaviour-over-time graphs are used as needed to help tell the various stories in this book, but no higher mathematics is employed. This is the wisdom gained from hard work by a dedicated team plying the care-modelling trade for 16 years together, and there is much to be learned here.

Barrytown, New York Jack Homer
August 2018

Preface

Unlike many collected works, this book is not an assembly of previously published papers although some elements of some chapters have been published before. Neither, like many systems and system dynamics texts, is it based on applications spread across many disciplines and industries.

It is a focused story of practical consultancy projects[1] in system dynamics modelling by the authors applied to one significant and topical domain: health and social care. The motivation in writing it comes from a desire to reinforce a whole system perspective to the worldwide debate on this topic and to bring the power of dynamic modelling to a wider range of healthcare and social care professionals. To this end, it has to balance the need to be sufficiently technical and rigorous with the need to be sufficiently issue-driven and insightful.

This is achieved by dividing the book into parts. Part I describes simple but rich generic modelling structures which are both important in their own right and providing a glimpse of what is under the bonnet of later project models. While introducing some elements of the languages used to map and describe models, quantitative and mathematical skills are kept to a minimum. It is recommended that all readers assimilated as much of Part I as possible to appreciate the workings of the later project models and to appreciate the helpfulness of even simple models to complex issues.

All our projects in the book are based on models, and it is worth an early comment on this much misunderstood word for those unfamiliar with modelling methods.

We would claim that everyone is a modeller without realising it, but that we do it openly. Whenever people are faced with choice (which is all the time), we all try our best to project and imagine the alternative futures involved. Our ability to think through time, into the past and future, and to create internal simulations is perhaps unique to our species, and our decisions are often based on such ponderings. What we do in this book is to bring managers together around issues of concern to share their implicit mental models and convert them into explicit models. This involves

[1] Hence, some of the chapters contain few references.

them surfacing assumptions and agreeing their different perspectives on how the world around them works and, where ever possible, quantifying it. The aim is to improve understanding and learning, rather than to achieve prediction, and often models still contain judgements. Explicit models may still be difficult to validate but are considerably clearer than mental ones which are almost never subjected to validation (Epstein 2008[2]).

Most models in the book have been created by a facilitation process, and in the course of doing this, we have developed our own understanding of the topics covered. So, a few of our chapters contain models which grew out of projects but were developed out of our own interest. It goes without saying that all views, insights and conclusions are quoted throughout the book and are those of the authors and not any particular organisations or clients.

Like most system-based work, the book will appeal more to people who think visually, spatially and temporally rather than in words. This is because it is hard to see a system or describe it in a sequence of words, and diagrams are an essential aid in helping to make systems and feedback visible. Diagrams provide an invaluable "structure" on which to hang data which is missing in many formal statistical models and from most mental models. Mismatches between structure and data provide an important check on the validity of data, and learning from models comes from understanding mismatches between how people think a structure will behave over time and how it really behaves when subjected to computer simulation. System dynamics models are a very inexpensive approach to policy analysis compared with experimenting on real organisations, and hence, the value added can be huge.

In many ways in a digital age where models can be brought to life on computer screens, it might seem a clumsy and perhaps backward step to write a book about them. We agree that there is no real substitute for "playing" with models. The power and impact of digital models and resultant learning can only really be appreciated by personally experimenting with alternative structures and policies and watching output graphs unfold while you watch. However, it is also important to understand the place of models in the world which is what we try to do here.

We know a few people who say that they simply ignore diagrams and graphs (or anything mathematical) when they occur in texts. Well they have an opportunity here to flip past over 100 such figures. However, we would recommend that they pause a while on some of them and try to understand the rewarding language of stocks and flows and causal maps underpinning them. And for those other who wonder about the relevance of mathematics to everyday life, it is important to point out that, although they do not need to know it, the modelling we do is actually a numerical approach to calculus.

Some of the models from the book and elsewhere are available to run on Web browsers, and these can be accessed via www.symmetriclab.com/models. We cannot provide every model in the book because some models are covered by client confidentiality, some are too big to run in a browser, and several were built using earlier versions of the software that either no longer run or cannot readily be

[2] Epstein JM (2008), Journal of Artificial Societies and Social Simulation vol. 11, no. 4 12.

converted to a browser-based version. Additionally, our axiom has been that any project model represents only the perspective of the modelling team at the time of the project. We provide training and consultancy for professionals wishing to develop their own models.

Finally, the problem with good system modelling is that when it is carried out well, its insights appear retrospectively obvious. In fact, obviousness is our measure of success. However, to pre-empt such insights is often impossible, which makes applying system thinking a journey of abiding discovery and surprise, but often one which is underrated. Likewise, when good system thinking is implemented, it is largely invisible since little goes wrong. A little like taking pain away, solutions are not instantly perceived. When it comes to asking the question have we created benefits, the answer is undoubtable yes in respect of both efficacy and finance. However, quantifying this would involve knowing what would have been incurred without our interventions.

Edinburgh, UK
January 2019

Eric Wolstenholme
Douglas McKelvie

Acknowledgements

Acknowledgements by Eric Wolstenholme

I wish to thank many people for their help in developing my interest in dynamic modelling.

Firstly, I would like to thank my colleagues in the International System Dynamics Society and in its UK Chapter. I am proud to have help found these institutions and to have been Inaugural Editor of the Society journal the *System Dynamics Review*. I am indebted to Geoff Coyle for introducing me to system dynamics at the Bradford University System Dynamics Research Group in the mid-1970s and to Brian Dangerfield, Associate of the group, with whom I shared a lot of learning. I am also indebted to Richard Stevenson with whom I created the management consultancy, Cognitus, which focused on applying system dynamics across a wide range of industries. The Cognitus team of, among others, David Corben, Russell Parsons and Paul Gisborne were all influential in developing my approach to the subject.

I have particularly found memories of my early exchanges with the system dynamic group at the Massachusetts Institute of Technology in the 1980s and 1990s. My encounters with Jay Forrester changed my life, and many students from that time have been influential in my work ever since. A short, but not exhaustive, list would include John Sterman, David Andersen, John Morecroft, Khalid Saeed, Peter Senge, George Richardson, Jack Homer and Barry Richmond, all of whom progressed to become figures of great influence in the field.

My interest in bringing my knowledge of modelling to health and social care started with publications in the late 1990s and arose from discussions with my wife Liz Wolstenholme CBE, Economist, working at the time for Bradford Social Services in the UK. After busy weeks, we would escape from our three children on a Saturday morning to our local village bakery and discuss the links in our careers over breakfast. The outcomes were rewarding. Liz went on to work in health and serve on the first support force to try to bring health and social care closer together before becoming responsible for producing guidelines on the contentious boundary

between health and social care at the Department of Health in London. Our discussions still continue despite her problems with Parkinson's over the last 25 years. I wish to thank her for these contributions. It is interesting and ironic that the healthcare and social care issues she worked on 25 years ago still remain high on the agenda today and are at the heart of this book.

My interest in healthcare and social care modelling deepened through my links with Symmetric, a consultancy company created to develop system modelling work in this area.

In particular, I would like to thank David Monk for his leadership in the procurement and execution of many of the projects described in this book. David has many years of experience in the NHS and has worked extensively with the UK Department of Health and with Chief Executive, Mental Health Networks. Without David, much of the body of work described here would have not existed. I am also grateful to Symmetric colleagues David Todd, now Managing Director of the health consultancy, Synergia, in Australasia, and Steve Arnold, originally one of Symmetric's clients in London. Steve has had an extensive career with one of the former London Health Authorities and played a major role in the projects reported here on alcohol harm, predictive risk, dementia and workforce planning. David Todd helped to procure and execute many mental health projects and in particular the work described here on improving access to psychological therapies. I also wish to thank David Monk and Steve Arnold for their time to read and comment on aspects of the book.

It goes almost without saying that I would like to pay tribute to my colleague and co-author Douglas McKelvie who has over 20 years of experience in social work and social work education. Without doubt, Douglas has taken my original healthcare and social care modelling to new heights and is responsible for most of the detailed models described in this book.

Acknowledgements by Douglas McKelvie

This has been an interesting journey.

My first career was in social work. I qualified in 1980 and worked for 12 years in a generic area team (i.e. including child protection, adult care, supervising offenders on probation and training new social workers) covering one of the most deprived parts of Edinburgh, my home city. In the 1990s, I worked at national level, in social work education and training, regulation and workforce development. I also embarked on part-time study, where I encountered operations research, including modelling and simulation, but not system dynamics. My job included a remit for "workforce planning", which nobody actually believed to be possible (as we describe in the book) and armed only with a spreadsheet and Roger Knox, a database expert, we set out to prove them wrong. Roger was the first person I met who could make the lines on a spreadsheet graph move by clicking on a spinner button.

In 2002, having become fascinated with the idea of using computer models (then, I knew mostly spreadsheets), I serendipitously met Gill Smith and David Monk, then of OLM. They recruited me as a consultant, joining a team that newly included Eric Wolstenholme. We are all indebted to Peter O' Hara, Head of OLM, for being so open to employ such a diverse range of people. Meeting Eric was my first encounter with system dynamics and well worth the wait.

I then had the enormous privilege of learning how to build system dynamics models by being, effectively, Eric's apprentice, a role I still occupy. Model building is in many respects a craft; working alongside one of the giants of the field, a wise teacher and effective communicator, has been a joy. It is impossible to have a conversation with Eric without learning something new or gaining a fresh insight.

System dynamics is all about making connections. Learning from Eric, in a UK context, the major preoccupation was, and remains, taking a strategic approach to balancing capacity across complex care pathways to reduce bottlenecks and facilitate service integration. Meeting colleagues in the international society, especially Jack Homer and Gary Hirsch, I was initially surprised to see that their models looked very different, with more representation of epidemiology and disease progression. Comparing the UK and US health systems, this difference in emphasis makes perfect sense. I have tried to combine both strands (service bottlenecks and the dynamics of illness), wherever a project brief required this.

Eric, of course, introduced me to the wider system dynamics community, and over the years, I have worked on projects with Pål Davidsen, Kim Warren, Sion Cave and David Exelby among others. I have been an active member of the SD Society UK Chapter and Healthcare Policy Special Interest Group.

Like Eric, I am indebted to Symmetric colleagues. David Monk and Steve Arnold managed to communicate the benefits of system dynamics modelling to their peers in the health sector. David Todd brought energy, business acumen and a cutting edge to the modelling approach. Angèle Pieters, from the Netherlands, worked with us for a spell and brought some welcome fresh perspectives. Sarah Nield kept us firmly and kindly on track.

More recently, I have been joined by Donald Scott, who lasted the course in social work and has now become captivated by the potential of system dynamics. Donny is another valuable interpreter, translator and connector, and now an indispensable co-worker. We have been fortunate to work with Sarah Wylie (Boyar), who is doing visionary work using system dynamics in the public sector in Northern Ireland. Expect to hear more about this before long.

Fortunately, my wife, Cathy Sharp, who works as Action Researcher in the same field (public services), empathetically knows and lives the challenges one faces when working on a range of projects using a knowledge base and skill set that are not widely understood, to help dedicated public servants tackle complex problems. We seem to manage literally to walk through most issues when either of us gets stuck, and I would be lost without her.

Joint Acknowledgements

We both hugely value isee systems, whose iThink/STELLA software powers most of our work. Until the mid-1980s, system dynamics modelling was a tedious and time-consuming activity. At that time, Barry Richmond established isee systems and developed the STELLA and iThink system dynamics software working on Apple Mac computers using the first windows, icons, menus, pointer/mouse (WIMPS) interface. This was many years before the advent of Microsoft Windows software and for the first time allowed the development of models from stock-flow structures drawn directly on a computer screen. The STELLA Architect software used in this book is a direct descendent of this original software.

Additionally, both of us wish to acknowledge the help and cooperation from many healthcare and social care clinicians and managers who contributed to the studies reported in this book and would like to thank Springer and our editors for the opportunity to publish this material.

The results reported and views expressed throughout the book are entirely those of the authors and are not necessarily the views of the organisations involved.

Contents

About the Authors

Eric Wolstenholme began his career in engineering in which he holds a first degree and doctorate. Following a master's degree in operational research, he worked in the Operational Research Executive and Purchasing Department of British Coal before becoming an academic in Management Science at the Bradford School of Management. He has held full professorial posts at, Stirling, Leeds Beckett and London South Bank Universities in Management Science and Business Learning as well as helping to establish and direct two management consultancies—Cognitus and Symmetric. He has written two previous books and a wide range of peer-reviewed research articles. He has an international reputation for his academic and consulting work in the application of system thinking and system dynamics and has been President of both the International Systems Dynamics Society and its UK Chapter. He was Founding Editor of the *System Dynamics Review* and in 2004 received the prestigious Jay Wright Forrester Award for his contribution to system dynamics. In 2019 he received an Outstanding Contribution award from the UK Chapter of the System Dynamics Society.

Douglas McKelvie Prior to joining Symmetric, Douglas worked for over 20 years in social work and social work education, including 10 years as a professional adviser for a national regulatory body. He has developed system dynamics models in healthcare and social care services and for the criminal justice system. He works with policy analysts, public health experts, service commissioners and workforce planners, covering adult and children services, including mental health. He is Member of the Policy Council of the UK Chapter of the System Dynamics Society and was President in 2016.

Chapter 1
The Challenges Facing Health and Social Care and the Relevance of Dynamic Models

Chapter Summary
This Chapter outlines the challenges facing health and social care in many countries and the approach and scope of the methods used by the authors to address these issues. The background to and appropriateness of system dynamics models is discussed along with the current state of health and social care worldwide, with a focus on problems which habitually reoccur despite best efforts to contain them.

The Chapter provides an overview of the book, from the early Chapters designed to familiarise readers of the approach by presenting simple but insightful models to issues such as performance measurement; to later Chapters selected from over 80 projects undertaken by the authors. These chapters cover hospital delayed transfer of care (delayed discharges) and the move towards integrated health and social care; a potential theory of how hospitals cope in times of crisis; implementing stepped care for depression; expanding cognitive behavioural treatment capacity; alcohol harm reduction; planning diagnosis capacity in dementia services; enhancing predictive risk tools and developing workforce strategies. Each chapter might be considered as a taster of what is possible by adding flow dynamics to conventional thinking in these areas.

The projects described were carried out in the UK but many of the messages and conclusions are applicable to a wide international audience, particularly those with state provided services.

1.1 Overview

Health and Social Care are vast social, economic and political global industries with multiple, autonomous stakeholders, many millions of customers and both public and private responsibilities.

E. Wolstenholme and D. McKelvie, *The Dynamics of Care*,
https://doi.org/10.1007/978-3-030-21878-2_1

So, it is little wonder that these industries have more than their fair share of serious issues.

The methods of System Dynamics and its associated Systems Thinking used in this book are very apposite to health and social care situations since they are most useful when:

- issues are strategic, complex, fragmented and persistent over long periods of time
- the devil is in the *interconnections* not the *detail*
- issues are made worse by the use of adaptive, unilateral, informal, short-term solutions by powerful players
- obvious solutions are likely to have severe unintended consequences
- good solutions are likely to be counterintuitive and separated in time and space from the symptoms of an issue—and usually on someone else's patch
- it is vital to generate shared learning and understanding between multiple owners of issues
- policy testing needs to be carried out quantitatively by multiple-agency teams in a risk-free environment
- it is required to identify balanced, high leverage interventions as a precursor to applying more tactical tool sets.

1.2 Case Study—Mrs. Jones

We all know Mrs. Jones. Now in her 80s, Mrs. Jones lives on her own in North-East England. She was diagnosed with a long term neurological health condition over 20 years ago, although in retrospect she could see that there was evidence of this much earlier in her life. This condition had taken a turn for the worse over recent years and her situation had not been helped by the sudden death her husband and carer and the development of a muscle wastage condition. However, with help from a range of health and social care services and medication she had gained some stability in the recent past. Her situation became more of an issue 6 months ago when the muscle problem began to progress much more rapidly. Three months ago, she became an emergency admission to hospital.

Unfortunately for her, this personal crisis coincided with a winter admissions crisis at her local hospital. She encountered a long wait for an ambulance and a long wait in the ambulance at hospital. When eventually taken into the emergency department at the hospital she spent a full day on a trolley in a busy corridor, due to bed shortages. She was amazed to find that, over the 2 days it took to be admitted to a ward, she had developed very unpleasant pressure sores. Further, her admission was not to an appropriate medical ward, but to an overcrowded surgical ward, where she arrived without her medical notes. By the time her medical team locating her, the medication regime vital to her condition had been severely disrupted and she and her family were understandably distraught and very confused.

What should have been a 3-day length of stay to assess her and adjust medication had already reached 6 days when she acquiring a hospital infection. Finally, due to her worsening condition she encountered trouble finding a suitable post hospital care package apposite to her needs and affordable and acceptable to her family. Even when all this was sorted she underwent further discharge delays resulting from pharmacy provision and transport problems. Her total length of stay in hospital turned into 20 days, in other words she became a very long stay patient—or 'super stranded' to use the jargon of the day.

1.3 The Challenge

It may seem an exaggeration, but the story of Mrs. Jones is only too typical of the experiences of many older people with multiple conditions needing emergency hospital treatment (Healthwatch UK 2017) and follow-up care. Despite the best intentions to provide the best treatment, in recent years many emergency patients have had to wait in ambulances outside hospitals and in corridors before being accepted into hospital. At the same time many other, particularly frail older people with co-morbidities, have been admitted to inappropriate wards and suffered severe delays in discharge and their problems complicated by infections.

So, it is a challenging time for health and social care services, facing;

- An ageing population, living with multiple long-term conditions and growing levels of complex need
- Growing levels of expectation about service access and provision
- Reduced levels of informal carer support, putting more pressure on formal services
- A background of increasing financial pressures.

These challenges manifest themselves in growing hospital waiting lists, delayed hospital discharges and failure to meet waiting time targets in accident and emergency (A&E); and in poor quality experiences for service users and their families.

1.4 What to Do?

Some would pursue more rationing as an option and much work has been done to look at methods (Maybin and Klein 2012). Rationing means using eligibility criteria to match the level of need to the level of service and is applied worldwide, including insurance-based systems. For example, in USA people have different levels of coverage, and the question is 'will my health plan pay for this type of treatment?'. Some would seek to press for more funding. In the UK the NHS no longer meets the European % GDP average spend and, since the 2008 crisis, Local

Authorities have been dealing with significant cuts in resources (Bounds 2017). So, there would seem to be a good case for allocating additional funding. In the UK additional money has been promised for health in England in the 2019 NHS Long Term Plan (www.longtermplan.nhs.uk). However, many people feel this to be totally inadequate and doing little to address the imbalance between health and social care (Stoye 2018; Rawnsley 2018; Rajeev and Campbell 2018; Campbell 2018). Further, it is estimated that about a quarter of this additional money would be necessary to just pay off current accrued deficits (Campbell 2019).

1.5 A Way Forward—From Mrs. Jones to Dynamic Models

At its basic, balancing growing levels of predictable demand with available resources is not a new proposition for any health and care services. Whilst perhaps currently the pressures are more acutely felt, they are not new and perhaps we can learn from prior experience.

This book describes work we have undertaken over the course of more than 80 projects in Health and Social Care in the UK, to examine the aggregate consequences of individual journeys like that of Mrs. Jones as she navigates her way through the pathways of health and social care services.

We have used an approach that recognises the subtlety of the relationships within and across the services and so employs a whole system perspective. It also takes account of broader changes over time. Working with front line staff, managers and academics we have been able to take the basic experience of using the service —the ***flow*** through the service—and construct computer-based models to represent them. We can then simulate changes—population, dependency, demand or perhaps the impact of introducing new approaches—and look at the net results within the models.

The models are constructed using System Dynamics (SD) and its associated Systems Thinking (ST) principles. These allow for some of the complexity, interdependence and change over time that, regardless of resources, will always challenge health and social care systems. Running the models using real data enables local, regional or even national conclusions to be drawn.

Each project has been specific to its brief, but, in general we have used modelling to;

- Better understand the potential impact of service change without having to wait for the results of its implementation
- Make more informed cases to improve services—understanding the cost of making those changes and of not making them
- Understand the impact of change across the system, and so avoid cost shunting
- Use the process of developing the model as a way of improving mutual understanding of the system amongst its key actors.

The work reported is focused on increasing the visibility of patient flows at a relatively strategic level across the many different domestic, departmental and agency boundaries.

Patient flow and congestion is a growing area of study in health and social care (Rutherford et al. 2017; Karakusevic 2016) and we build on this by taking a *systemic* and *dynamic* perspective of flows to identify the best levers or intervention and improvement.

Unlike industrial systems, where materials mostly flow in one direction, in health and social care people flows are complex and people move in multiple directions, miss out some stages and perhaps repeat others. The same service capacity might be used for different purposes; for example, an 'intermediate care' service which has a single capacity, might be used both as an alternative to hospital admission and to facilitate hospital discharge. In the same system, some people might be waiting in hospital to be discharged to an intermediate care setting at the same time as other people in an intermediate care setting now need hospital admission, perhaps because their condition has deteriorated. Alternatively, people might be admitted to hospital having been users of a home care package, losing that package on or shortly after admission, then, several weeks later, cannot be discharged from hospital until another, identical or more intensive, home care package can be procured. Such eventualities are not only possible, but common.

The work also relates closely to productivity enhancement (Appleby et al. 2014), the many quality and efficiency improvement initiatives being taken in health worldwide (The Health Foundation 2016) and the moves towards Integrated Care between Health and Social Care (Ham 2018).

The projects described were carried out in the UK but many of the messages and conclusions are applicable to a wide international audience.

1.6 The Scope and Insights

The book covers a wide range of example modelling projects. These range from improving basic understanding of the fundamental relationships between variables in treatment and condition pathways to delayed hospital discharges and integrated care. They continue through the coping strategies employed by hospitals in periods of high demand to improving mental health provision, to alcohol-related harm, to dementia, to workforce planning and predictive risk. Whilst many of the projects focus on treatment some do impinge on prevention and complement other work in this latter area in the USA (Jones et al. 2006; Hirsch et al. 2014; Homer et al. 2007, 2016; Milstein et al. 2010, 2011).

Many insights are derived and, because of the systems nature of the work across whole patient pathways, they are generic to many of the topics covered. These insights are listed as a set of messages in the conclusions. Like all good systems messages they are reassuringly obvious in hindsight but elusive to remember and apply to new problems.

Perhaps the most important single message is that much more emphasis needs to be placed on *flows* and *flow data*. It is suggested that improving *throughput* rather than *capacity* is the dominant way to improving the performance of health treatment, whereas increasing *capacities* rather than *throughput* is the dominant way to improve the performance of social care by retaining independent living. Further, that balancing health and social care capacity is a win-win scenario for both and better for patients, staff and costs than not doing so. This is because it eliminates the many risky and costly fire-fighting strategies hospitals have to undertake when faced with high demands.

Perhaps the key meaning in the last paragraph is that much-needed systemic solutions and whole system thinking can never be successfully implemented until organisations are recognised as complex entities and are allowed to articulate and dismantle their most extreme and costly coping strategies and return to working within best practice capacities. This is the ultimate new way of working. Such elimination releases hospitals to realise the full potential of investment and innovation and to enable them to manage the increase in longevity their success creates. However, before such a state can be truly realised money must be found for situations in which large debts have accrued from long periods of not coping. Not understanding this would result in it appearing that future balanced spending was not succeeding.

These messages are followed very closely by the messages that the performance of health services is dependent on better understanding of the dynamics of population ageing, the dynamics of health conditions, particularly the bi-direction of patient flows between different states of heath conditions.

A better understanding of strategic patient flows can also assist with designing information systems and the targeting and realism of more operational performance improvement techniques and health economics studies. It can also assist with highlighting the arbitrariness of many performance targets.

We do not claim that using a systems perspective and dynamic modelling can create more resource; but, time and again, our work has shown that it will help maximise the impact of all resources across the Health and Care system.

1.7 System Dynamics

System dynamics combines two familiar words that are already used extensively in social care, sometimes in combination (for example, when describing the interconnections underpinning family dynamics), and uses them in a particular way. System dynamics in the context here describes a specific approach to dynamic modelling that originated in the 1950s, invented by JW Forrester, an engineer and pioneer of digital computing, at the Massachusetts Institute of Technology (MIT). It can best be described as a way of applying ideas from control engineering to socio-economic and management systems.

Jay pioneered his ideas in industry (Forrester 1961, 1969) and most prominently by his development of world models for the Club of Rome (Meadows et al. 1972, 2004). He was one of the first people to explore the finite nature of the planet and question the implications of the growth of the human footprint. His models demonstrated the major issues of population growth, resource depletion and pollution being borne out today.

In health and social care, System Dynamics is a means of translating mental models of patient flows into computer simulation models using the language of stocks (accumulations) and flows. This notation allows patient pathways to be visualised for the purpose of sharing and communicating how existing pathways work and to redesign new ones. The pathways can then be modelled and their behaviour over time studied in a risk-free laboratory environment, rather than by disrupting the real activity.

Simulation has become an established tool of research, investigation and training for environments where experimenting with the real situation is difficult and risky. It has applications ranging from space exploration to pilot training to managerial and climate policy testing. System dynamics is applicable to any dynamic system characterised by interdependence, information feedback and circular causality (System Dynamics Society Website 2018) and is in use across a wide range of disciplines.

The importance of computer simulation lies in the benefits it brings to thinking.

Humans excel at innovation and action but are not at all well adapted to thinking about the outcomes and consequences of their actions over time. Our internal simulation competence is very limited even in the simplest situations and those people who aspire to prominent positions are often the ones most adept at temporal processing. Computers are the opposite. They are morons but as such have an amazing ability to carry out boring and repetitive calculations without complaint.

The right mix of people-based ideas and computer-based interpretation over time is a powerful combination and software to bring a simulation dimension to more of us is improving all the time. Forrester perceived this nearly 70 years ago and was his motivation for helping to develop digital computer technology. Today we have the capability to capture the essence of complex systems and, when calibrated with the best data, to emulate their behaviour over time. Note the use of the word emulate here—not to mimic or copy but to match or even out do. The quantitative nature of system dynamics ensures a degree of rigour to minimise ambiguity and focusses attention on the laws of physics underlying many of today's problems which many fields of analysis ignore.

For major texts on system dynamics, see Sterman (2000), Vennix (1996), Maani and Cavana (2007), Ford (2009), Morecroft (1994, 2007), Wolstenholme (1990), Warren (2008) and Richardson and Pugh (1981), Richardson (1999, 1996).

For worldwide review texts on system dynamics in health see Homer and Hirsch (2006), Hirsch et al. (2015), Hirsch and Homer (2016), Wolstenholme (2015) and Dangerfield (1999).

For selected specific papers on health projects see Homer (2012, 2017) for the USA, Todd (2018) and McDonnell (2018) for Australasia and Wolstenholme

(1993, 1996, 2008), Dangerfield et al. (2001), Lane et al. (2000), McKelvie (2018) and Lacy (2018) for the UK. A comprehensive bibliography of system dynamics publications across all fields is available on the System Dynamics Society website (www.systemdynamics.org) and on the UK Chapter of the System Dynamics Society website (http://systemdynamics.org.uk).

1.8 Systems Thinking

There are many schools of *Systems Thinking* (Checkland 1981; Checkland and Scholes 1990/1999; Flood and Jackson 1991; Beer 1989; Richardson1999; Lane and Jackson 1995; Senge 1990; Sherwood 2002; Stroth 2015).

Systems thinking as used here is a means of analysing the feedback structures at the heart of system dynamics models. It can assist with conceptualising models and with understanding and communicating their insights. Feedback loops exist when actions travel through a system and eventually return to their origins to influence future action. If the tendency of the loop is to reinforce the original action, the loop is referred to as a positive or reinforcing feedback loop. If the tendency is to oppose the initial action the loop is referred to as a negative or balancing feedback loop. The sign (positive or negative) of the loop is called its polarity. When feedback loops of different polarities work in combination they give rise to many interesting modes of behaviour over time.

Specific combinations of loops responsible for specific types of system behaviour over time are referred to as system archetypes (Senge 1990). These are made up of intended consequence loops and unintended consequences loops (Wolstenholme 2003). They explain how intended actions often fail due to the fact they encounter or trigger reactions which counter them. The consequences usually only become apparent after significant time delays. Also, they can be hidden from consciousness by natural or organisational boundaries. Their appearance can take us by surprise and cause us to react further. Good systems thinking is about anticipating unintended consequences and taking them into account when designing intended actions.

The side effects of treatments and medications are specific examples of the unintended consequences of well-meaning actions and it is well understood in health that the side effects of treatments can be worse that the disease itself. It is perhaps less well understood that the side effects of clinical and management health policies can also be worse that the problems they are intended to solve.

Systems thinking is a powerful method of visualising feedback in systems. However, on its own it is essentially qualitative and where ever possible feedback structures should be quantified and tested using computer simulation.

1.9 Systemic Versus Systematic Thinking

The emphasis in system dynamics and system thinking is on the word *systemic*, which is not to be confused with the word *systematic*, although clearly there is a stepwise sequence involved in applying them.

The power of system dynamics and systems thinking are that they attempt to examine organisations as a whole to help communication, learning and understanding of the real causes of apparently complex issues. They emphasise the notion that the root causes of problems are often contained within the system itself. Of particular interest in health and social care are the interactions between patient pathways and the structure and boundaries of autonomous agencies which operate them.

Being *systemic* requires the definition of an appropriate view of patient pathways in both *space* and *time* and this is determined by the agreed purpose of a study. Spatially, the movement of every individual patient could be modelled and at the other extreme the aggregate of all patients. Temporally, we could model in time increments and over horizons from minutes to years.

In practice, both perspectives must be sufficient aggregate to help simplify complex situations, whilst being sufficiently detailed to be meaningful. Being systemic is finding a useful balance between a 'complete world' view and a 'reductionist' view. The aim is to reduce detailed complexity (the number of elements in a situation) whilst retaining dynamic complexity (the number of interconnections in a situation). In practice, finding the right perspective for a model generally requires starting at a reasonably high level of abstraction followed by some expansion and contraction. This might be summed up by saying that we need to see the situation of interest as a composite whole, since 'wholes have integrity'.

1.10 Systems Messages

There are many important systems messages arising from many modelling studies across many disciplines and these are very appropriate to the situation health and social care find themselves in across the world.

Despite valiant attempts at transformations to make health and social care more joined-up, one prime characteristic of health and social care delivery is that it is remains very fragmented. There are cultural, budgetary and information system boundaries between primary, secondary and community-based health services and between these and social care services. Patient flows across such boundaries are fraught with difficulties.

Further, many transformations are often reactions which have unintended consequences and lead to many of today's problems being yesterday's imperfect solutions, since 'fixing' a problem to satisfy short-term needs does not make a problem go away in the long-term. A major issue inhibiting our thinking over time