Making an impact with System Dynamics in the health and social care system

A compendium of case studies of the winning entrants for the Steer Davies Gleave award for System Dynamics

Making an impact with System Dynamics 001 – January 2016
Produced by the UK Chapter of the International System Dynamics Society
Foreword

The idea for the Steer Davies Gleave prize for system dynamics arose during a discussion at one of the UK System Dynamics Society’s conferences. The mood was mildly despondent; there was, we were sure, lots of good System Dynamics work being used to make real, practical, changes, but it wasn’t being made visible to a wider audience, especially outside the SD community; if SD was to grow, many more people needed to see how effective it can be; how could we do that?

Establishing a prize seemed fairly obvious, but what, I believe, distinguished the Steer Davies Gleave prize, was its focus on practical outcomes and the wider interest. The criteria for entry stipulated that the prize was for ‘the best application of system dynamics modelling to a topic of wide public interest’, and asked for evidence of real changes that had been made as a consequence of the work. This was about showing System Dynamics making a difference in the world.

A call for entries went out, and our early confidence about the existence of good practical work was quickly vindicated. What we had not foreseen was how rich a seam of SD work the health sector was. Over the years, four of the prizes were for work in health, all addressing real, practical issues of wide public interest: exactly the kind of work the prize was set up to recognise.

Time moves on, and after eight years, the prize has been superseded. However I am very pleased that Sion Cave and his colleagues took the initiative to produce this document, bringing together four excellent pieces of work, showing System Dynamics in action.

John Swanson
Steer Davies Gleave

The System Dynamics Society is an international, non-profit organization devoted to encouraging the development and use of Systems Thinking and System Dynamics around the world.

With members in fifty-five countries, the Society provides a forum in which researchers, educators, consultants, and practitioners in the corporate and public sectors interact to introduce newcomers to the field, keep abreast of current developments, and build on each other’s work.

The UK Chapter of the System Dynamics Society is constituted as a registered Chapter of the System Dynamics Society. The objectives of the chapter include:

- Identifying, extending and unifying knowledge contributing to the understanding of feedback systems;
- Promoting the development of the field of System Dynamics and the free interchange of learning and research in all related fields;
- Encouraging and developing educational programmes in the behaviour of systems.

Whilst this document focusses on health and social care studies, the structures and lessons learned can be transferred to other policy or industry sectors. This common language and ability to learn from other sectors is for me one of the key features of System Dynamics and was what attracted me to the approach in the first place. We hope that the case studies presented here inspire others to apply System Dynamics to a whole new set of problems.

Professor Simon Shepherd
President of the UK Chapter of the International System Dynamics Society
Introduction
Siôn Cave, Decision Analysis Services Ltd

Improving Access to Mental Health, both Locally and Nationally
Eric Wolstenholme & David Todd, Symmetric

Implementing of the Comprehensive Spending Review in home care for older people
Peter Lacey, Whole Systems Partnership

The “Alcohol Systems Model”
Douglas McKelvie, Symmetric

Strategic planning of England’s medical workforce
Graham Willis, Centre for Workforce Intelligence
Siôn Cave, Decision Analysis Services Ltd
Making an impact in the health and social care system using System Dynamics modelling

Introduction

How System Dynamics has been used to save the health and care system millions of pounds whilst improving care outcomes

The health and care system is complex and interdependent, affects the population of the UK on a daily basis and costs the UK tax payer over £120 Billion a year to run. System Dynamics has been successfully used numerous times to make better and more robust decisions in the health and care system. The case studies in this report demonstrate that System Dynamics can be used to support investment decisions that save millions of pounds without compromising outcomes.

Background

We are all affected by the health and care system, which is large, complex and serves the needs of a population of over 60 million people in the UK. The UK system costs the taxpayer in excess of £120 Billion pounds a year to run, and employs over 3.5 million people. The health and care system has an impact on each and every one of us on a daily basis.

Making improvements to a complex system is difficult. Changes can have unforeseen consequences, take time to manifest themselves and may occur at a place distant from the original intervention. It is inherently difficult to predict how a complex system will change over time and there may be resistance to change due to the way the system is organised. A system will often involve many people, each with, each with different perspectives on the system, with different ambitions and fears. The UK health and care system exhibits all these properties, and we need innovative methods to continue to improve how it functions.

System Dynamics – a tool for managing complexity

System Dynamics is a collaborative approach that has been used for many years to support significant decisions in the health and care system. It enables complex systems to be better understood and their behaviour over time to be projected using computer simulation. The application of System Dynamics has been diverse and impactful. Amongst its many uses it has been used to model public health initiatives, improve the management of hospitals and to support the provision of better care for older people. In short, it has been successfully applied where the implications of decisions within a complex system need to be understood and quantified.

The System Dynamics approach is composed of two key components. The first is mapping the system to better understand it, and the second is using computer simulation to calculate system behaviour over time.

Mapping the system to understand behaviour

The first stage of a System Dynamics based project involves mapping the cause and effect relationships that drive system behaviour.

System Dynamics uses specific diagramming notation such as stock and flow diagrams or causal loop diagrams to map the system. The sample stock and flow diagram (left) conceptualises the population as a series of stocks. Activities such as therapy and prevention affect the flows between the stocks which represent health and wellbeing status.

The maps are created with the system stakeholders, who best understand how the system of interest works. The completed map represents the shared understanding of the system, which can then be used in many ways, for example to investigate potential points where interventions could be made.
Simulating the system to quantify behaviour

Once we have an agreed map of the system, specialist software can be used to quantify the relationships. The completed simulation model can be used to rapidly test system interventions in a risk free environment.

The simulation model provides a means to calculate change over time depending on the underlying assumptions and proposed interventions. System Dynamics models simulate rapidly and can use management information data sources. The models can be developed to produce outputs using desired performance measures, and can be validated against historic performance.

How System Dynamics has been used to improve the health and care system

The best way to demonstrate the benefits of System Dynamics is through practical examples. This document draws together case studies for four projects that won the Steer Davies Gleave prize for System Dynamics. The prize was awarded four times between 2008 and 2014 for work that had a real impact. These examples demonstrate work that has had significant impacts on the delivery of healthcare, social care and public health in the UK.

The first case study describes the winner of the first Steer Davies Gleave award in 2008. The award was presented to Symmetric and the Department of Health for a piece of work that explored improving access to mental health services at a national and local level. The project contributed to savings in excess of £400M whilst improving access to mental health services.

The second Steer Davies Gleave prize was awarded to Whole Systems Partnership in 2011 for their work on implementing the comprehensive spending review in home care for older people. The project enabled one Council to realise around £1.5M of savings whilst securing better quality care for its clients, with a team of professionals who understood and were committed to the proposed changes.

The third Steer Davies Gleave prize was awarded once again to Symmetric in 2012 for their development of the Alcohol Systems model. Their modelling showing that a modest investment in a high-volume, low-intensity, brief intervention would result in reduced hospital admissions due to ‘alcohol attributable’ reasons. Over a million hospital admissions per annum can be wholly or partly attributed to alcohol consumption.

The final Steer Davies Gleave award was presented in 2013 jointly to the Centre for Workforce Intelligence and Decision Analysis Services Ltd. On this occasion the prize was awarded for the long term strategic analysis of national medical workforce numbers that took into account inherent uncertainty. Supply of a single specialist doctor costs the UK Government approximately £250K to £550K in training and over £2 million in lifetime salary so decisions on future training intakes must be robust.

In short, these case studies demonstrate how System Dynamics has been used to save the health and care system millions of pounds whilst improving care outcomes.

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“Complex systems defy intuitive solutions.”
Jay W. Forrester
Improving Access to Mental Health Services in England, both Locally and Nationally

Symmetric

Two linked projects on improving access to mental health contributed to savings of over £400 million. The Stepped Care project, supported the introduction of stepped care services for mental health across the North West of England. The Wellbeing project carried out for the Department of Health, analysed the case for improved national access to psychological therapies. The contribution of System Dynamics to the debate on improving treatment in mental health has been substantial.

Background

In 2007 Mental Health services in England were offered by a range of teams under Primary Care Trusts (PCTs) and specialist Mental Health Trusts (MHTs). Mental Health services could be described as consisting of two steps. Patients presenting to GPs with mental health problems either got drug therapies or were referred for specialist services from MHTs where they might wait for up to two years for treatment. Essentially, they either got caught in a ‘revolving door syndrome’ with multiple presentations to GPs or a long wait during which there was no treatment.

In 2004 the National Institute for Health and Care Excellence (NICE) published a new set of guidelines for MH treatment which consisted of a new five-step service. The NICE work did not cover the economics and resource allocation issues of introducing the new pathways. This left local health communities wondering how they might realise the wider client access and overall improvement in clinical benefits. This resulted in the Stepped Care Project whose remit was to work with the Care Service Improvement Partnership (CSIP) North West Development Centre. The requirement of the project was to create a model supporting the implementation of stepped care which would avoid some of the unintended consequences associated with past mental health reform.

In parallel to the thinking on stepped care the Department of Health was performing a cost benefit case for investing £600 million per year on 10,000 additional therapists for the treatment of 1 million people per year using psychological therapies. The benefits after 7 years arising from extra output would include reduced absenteeism, extra quality of life years, savings in medical costs associated with these conditions and increased tax payments. The potential net benefit was put at over £2 billion per year. The Wellbeing Project was created to convert the static cost benefit analysis into a System Dynamics model to aid dynamic understanding of the case.

Approach

The Stepped Care project work involved the creation of a model to aid the implementation. The model was structured and parameterised using data from pilot sites and included individual care pathways. The model allowed examination of alternative resource staffing under a variety of conditions, such as the prevalence of mental health, numbers achieving remission of symptoms, numbers referred and service productivity. Performance measures included waiting times, numbers treated and quality of life.

The model was built into a programme of collaborative workshops for stepped care implementation. Ten workshops were run and attended by people from ten PCTs. The workshops involved mapping and describing their existing services, experimenting with the new model, contrasting alternative ‘what might be’ situations and defining initiatives by which they might move to full implementation, as illustrated in the figure (left).
The Wellbeing project involved the construction of a System Dynamics model centred on the flow of people from the labour market and into treatment, the build-up of therapy capacity, therapist case load, treatment time and the source and destination of patients - both downstream to where patients go after treatment, and upstream from where patients originate in the labour market.

Results

The Stepped Care project demonstrated that stepped care in North West England was beneficial both clinically and economically.

Model conceptualization: A broader overview of the labour market

The Wellbeing project questioned the magnitude of the claimed benefits from the change in the number of therapists. The economic analysis showed that the static cost benefits claims were optimistic, highlighting that the return would depend on the number of employment opportunities for people after treatment, as well as the capacity and treatment effects, as shown in Figure Left.

The System Dynamics model allowed the dynamic factors excluded from the static model to be represented without masking model clarity.

Impact

In the Stepped Care Project it was demonstrated that in the North West of England significant increases in the numbers of people treated for mental illness could be achieved along with reduced wait times with a smaller investment. Only half of the £40 million from the NW share of the DH money from the Wellbeing Project would need to be directed at new steps in mental health treatment. The rest could reinforce existing specialist services. This represented a contribution to savings of £20 million in new stepped care services.

The Wellbeing Project helped to demonstrate that a more feasible and realistic investment of £200 million in a 2 channel system using 3000 therapists would yield similar numbers treated, contributing to a direct investment saving of £400 million.

Further information

Both of the above projects, described more fully in published papers [http://www.symmetricpartnership.co.uk/resources/index.html](http://www.symmetricpartnership.co.uk/resources/index.html), contributed to significant tangible benefits.

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The prize-winning team was Professor Eric Wolstenholme (Director, Symmetric), Dean Repper (Director, CSIP Northwest), David Todd (Director, Symmetric), David Monk (Director, Symmetric), and Douglas McKelvie (Associate, Symmetric)
Implementation of the Comprehensive Spending Review in home care services for older people

Whole Systems Partnership

This project demonstrated the value of using System Dynamics as an aid to strategic change. With this support one Council was able to move forward confidently in realising around £1.5M of savings whilst securing better quality care for its clients and a team of professionals who understood and were committed to the changes.

Background

The Comprehensive Spending Review announcement by the UK Government in 2010 finally brought the financial crisis home to roost for local councils, and to those who depend on them for care and support. The care sector for older people in the UK was at that time estimated as being worth £23bn. Population needs were and are increasing through demographic trends and increased co-morbidities.

However, Councils traditionally struggle to understand a system that is, by definition, fluid and multi-factorial. The inter-relationships between the perception of care needs, eligibility and the acceptability of seeking support from the Local Authority are complex. The sort of factors that are at play include cultural expectations, socio-economic trends, the nature of assessment and eligibility criteria and the underlying health of a given population.

The Council in this case study had been tasked with reducing this bill by £5.2M – a significant challenge in the context of underlying demographic pressures. The Council’s response to this challenge was to re-commission all home care provision on a locality basis, where there had previously been competing providers in each part of the Council area leading to additional travel time for staff and poor continuity of care for clients. This would lead to efficiencies and improvements in the continuity of care. At the same time all clients currently in receipt of care and support would be re-assessed against a new set of eligibility criteria. Together these represented a complex set of changes with potentially different delivery timescales with the twin goals of meeting important financial deadlines whilst keeping the client’s needs central.

Approach

The Council approached the Whole Systems Partnership to develop a simulation model that would inform and guide them through this process at an aggregate ‘population’ level.

The model considered that an initial ‘stock’ of people would be transferred to a new provider at the start of the new contractual arrangements (top left of the diagram). There would then be a ‘top-slicing’ of 10% of the value of currently contracted hours to invest in prevention. There would then be a transitional period during which people with high levels of need would be reviewed but would largely retain their current levels of support. Finally there would a period of development during which a new mix of support for people with lower levels of need would be put in place.

The developed model was robust in that it reflected the full spend on home care services as well as the current numbers and future anticipated ‘flows’ of people through the service that enabled “what-if” analysis. The variables that informed scenario generation included contract start dates, contract costs, cost recovery and tier allocation.
Results

Without the introduction of new model of care the cost of home care would be set to increase by nearly half a million pounds over the subsequent 3 years.

The diagram (left) is an illustrative model output showing the alternative planned scenario with the introduction of Neighbourhood contracts from month 21 and no worsening of underlying assessment outcomes. This shows the significant historic rise in the total hours being delivered – line 2 (mirrored in costs – line 3), despite the level or slightly reducing numbers receiving a service.

The introduction of the service model was shown to secure a recurrent gross saving on expenditure of nearly £900k over a 3 year period.

An alternative scenario generated through engagement with the client suggested a tightening of controls on eligibility and assessment outcomes in terms of hours of care provided. This gave the potential for an additional £660k savings each year in the longer term.

Impact and learning

The use of System Dynamics modelling, and the engagement process that is an essential component of the approach, supported this Council to identify and subsequently implement a programme of change that delivered £1.5M of recurrent savings whilst ensuring that services to clients remained of high quality.

The modelling work also helped the client to improve their understanding of the local care system, for example by taking the expectations and contributions of carers into account, involving those tasked with delivering the new service model and enabling the redesigning of the system whilst it is ‘on the move’.

The importance of strong relationships and trust between participants in the learning process – sharing assumptions and being willing to have them tested within the modelling environment has led to greater local ownership of the direction of travel, now increasingly informed by this and related System Dynamics project work.

Further information

The full report can be downloaded from:


For a Good Practice guide on the use of System Dynamics follow this link:


For further information on the work of WSP visit www.thewholesystem.co.uk

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The Alcohol Systems Model

System Dynamics was used to represent the impact public health interventions could have on alcohol attributable hospital admission, which can amount to over a million hospital admissions per annum. The model enabled time profiled cost-benefit to be calculated, clearly showing that a modest investment in a high-volume, low-intensity, brief intervention would result in reduced hospital admissions.

Background

The Department of Health (DH) engaged Symmetric to build a simulation model exploring the case for commissioning innovative, low-cost services designed to reduce harmful alcohol consumption, and to support capacity planning at local level. The model was intended to replace an established spreadsheet ‘ready reckoner’. Using group model-building, the model drew on expert opinion, integrated research findings from a range of sources, and highlighted a familiar, non-linear, commissioning conundrum that ‘things may have to get worse before they get better’. The model was approved as a commissioning tool, and made available for use by Primary Care Trusts.

Approach

The model was developed by an expert group comprising clinical and academic experts in alcohol abuse and the adverse impacts of alcohol, health economists, social and operational researchers and policy makers. A further strand was an academic evaluation carried out by management scientists.

The issue addressed here was not alcohol dependence, alcoholism, or anti-social behaviour, but the much wider problem that 20% of the adult population regularly drink at a level that increases their risk of being admitted to hospital for a wide range of ‘alcohol attributable’ reasons. At the time of the study, this amounted to over a million hospital admissions per annum, wholly or partly attributable to alcohol consumption, in England, across a range of conditions such as various cancers, diabetes, heart conditions, liver disease, and accidents. Providing as little as four sessions of ‘brief advice’ to people admitted to, or attending, hospital, or in primary care settings, where alcohol consumption might be a factor, has been shown to help individuals reduce alcohol consumption. Because there is a time-lag between a change in alcohol consumption and an improvement in health, it may take some time for investment in low-cost ‘brief interventions’ to translate into a saving in occupied bed days.

A population-level System Dynamics model was developed, model conceptualisation shown below. The entire adult population is represented as four stocks, Consumption groups from the government’s annual General Lifestyle Survey (abstainers, drinking at low risk, drinking at increasing risk, drinking at high risk). People move (flow) between these stocks in both directions, not necessarily stepwise.

These flow rates had not previously been measured; an analysis which became an informative by-product of the project. To estimate the underlying flows between consumption groups, DH researchers conducted a secondary, longitudinal analysis of household data, drawn from two consecutive years of the General Lifestyle Survey. This involved making assumptions about individual behaviour based on household-level data. When these estimates were used to drive flows in the SD model they produced a good fit with the Department’s own assumptions about consumption distribution.
The distribution by consumption group produces a rate of Hospital Admissions. By commissioning Services, over time there is an increase in flow rates in the direction of reduced consumption. This change in consumption, after a time lag, manifests itself in fewer hospital admissions. The time lag varies for different conditions; for example, there is an immediate change in people’s propensity to have accidents, but liver damage takes longer to heal. Another part of the model is Policies, such as strategies to reduce alcohol sales, and hence, Consumption.

**Results**

The model contains much detail representing multiple medical conditions and several types of intervention, but its basic dynamics are shown on these two graphs, showing change in admissions and cost, over time, comparing each run against a Base run (do nothing) over a 20 year period in days.

A new intervention is introduced at the five year point (day 1827). Run 1 is the Base Run - there is no ‘change in’ anything, so it takes the value 0. Run 2 and Run 3 show two different interventions (brief advice provided in primary care, and in secondary care). Finally Run 4 combines both interventions modelled in Runs 2 and Run 3.

The left hand graph shows clearly the time lag between the intervention point and a gradual reduction in hospital admissions. The right hand graph shows the cost implications. There is an initial increase in expenditure but it takes time for savings realised from reductions in hospital utilisation to be realised. It takes more than two years for total expenditure to reduce and around five years before cumulative spend is lower.

Worth noting is the unique contribution of System Dynamics. Because the behaviour of the whole system depends on the dynamics of the consumption chain, where, at all times, people (treated or not) flow between consumption groups, the impact of treatment on reducing hospital use is significantly muted, compared with the Department’s spreadsheet extrapolations. The spreadsheet forecasts of the impact of brief interventions were shown to be unrealistically optimistic.

**Impact**

The model provided for the first time a means of integrating a range of research findings (population consumption, impact of brief interventions on consumption, impact of change in consumption on hospital use) at population-level, over time, in the form of a model that could be used to support local commissioning.

**Further information**

At the time of writing, the model is available to download and use from Public Health England.

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The prize was awarded to Douglas McKelvie, Steve Arnold, Eric Wolstenholme and David Monk from Symmetric.
Strategic planning for the medical workforce in England

Centre for Workforce Intelligence and Decision Analysis Service Ltd

A System Dynamics based review was carried out on the medical workforce across England. The purpose of the review was to ensure an adequate and affordable future supply of good quality trained doctors for the next 25 years. The review found that there was a potential future oversupply of doctors in total and a potential imbalance between hospital doctors and GPs. As a result, the medical training inflows for these workforces have been adjusted accordingly.

Background

The Centre for Workforce Intelligence (CfWI) is a key contributor to the planning of future workforce requirements for health and care in England. The Department of Health, as well as Health Education England and Public Health England, engage the CfWI to inform national and local workforce planning and policy decisions. The CfWI is supported by Decision Analysis Services (DAS) who provide specialist System Dynamics consultancy.

The CfWI was commissioned by the Department of Health in 2012 to carry out a detailed review of doctors in England. The purpose of the review was to advise on future intakes to undergraduate medical training in order to ensure an adequate and affordable supply of good quality trained doctors. In 2013, the NHS in England employed 148,000 doctors, which includes hospital consultants, registrars and general practitioners. Supply of a single specialist doctor costs the UK Government approximately £250K to £550K in training and over £2 million in lifetime salary.

Approach

The project was carried out using the Robust Workforce Planning Framework, which was developed specifically for this project, and has been used for all subsequent workforce reviews carried out by the CfWI.

The framework consists of five linked stages and integrates horizon scanning with scenario generation, System Dynamics modelling and simulation. A major feature of the framework is the high degree of stakeholder involvement, which is critical to arrive at a shared view of future challenges, and in making robust policy decisions. Key stakeholder groups involved in this process included the Department of Health’s Workforce Data and Analysis Team, the Health and Social Care Information Centre, the British Medical Association, the General Medical Council and specific Deaneries, University and Colleges Admissions Service, and NHS Pensions.

Four plausible, but challenging scenarios were created with the stakeholders in order to test the future supply and demand for doctors. Uncertain variables were determined using formal elicitation methods with the system stakeholders.

A System Dynamics model was then developed to enable rapid quantitative policy analysis within a risk-free environment. The model calculated the demand for, and supply of, doctors over a thirty-year period. The supply component of the model represented the workforce by age and gender to enable societal factors such as retirement changes and gender differences to be factored into the analysis. The training and career pathways were mapped out with stakeholders from the medical system using stock and flow diagrams. These were presented at a series of national road shows hosted by the CfWI, which enabled over 80 people to comment and amend them. The demand component considered the impact demographic and service changes would have on demand in primary and secondary settings.
Results

The System Dynamics model was used to calculate the supply and demand for doctors for each of the four scenarios generated with stakeholders.

The results of the simulation model were shared with stakeholders to ensure the model was producing realistic dynamics based on real-world behaviour. The sensitivity of the model results to each of the input parameters was tested. In addition, the Monte Carlo analysis was carried out to determine the uncertainty of the model results.

The results of the modelling work suggested that there would be a future oversupply of doctors for each of the scenarios considered, and a misbalance between the availability of GPs and hospital trained doctors.

Impact

The review informed decisions taken by the Department of Health to adjust the numbers of doctors being trained in order to prevent a future under or over-supply, and to rebalance the numbers of GPs and trained hospital doctors. Decisions that were taken based on this work included a 2 per cent reduction in medical school intakes which was introduced in 2013, and a rolling cycle of reviews to be undertaken every three years.

The System Dynamics modelling approach meant that robust, evidence-based supply and demand models were developed for the medical workforce that could be used to test potential policies and their impact. It also meant that the model was ‘transparent’ and enabled capture and synthesis of the expertise of several hundred stakeholders from the healthcare system.

Further information

Since winning the award in 2013, the CfWI, supported by DAS, have produced System Dynamics models that have been used for over 20 workforces from across the health and care system. These have included pharmacists, specialist doctors, speech and language therapists and the social care workforces. They have also collaborated on the Horizon 2035 project, a whole system review of the health, care and public health workforces using a unique skill based approach. Further information on these projects is available at www.cfwi.org.uk.

The CfWI and DAS have also produced a best practice guide for developing workforce based System Dynamics models. In addition, DAS have produced a document providing their perspectives on System Dynamics modelling.

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Acknowledgments

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Finally, the Chapter would also like to express its gratitude to John Swanson and Steer Davies Gleave for sponsoring the award between 2008 and 2014.

This document has been produced by the UK Chapter of the International System Dynamics Society

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