IPACS MODEL

Context and scope
v1.0

IPACS Team

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Table of contents

Introduction

The IPACS project – 'Improving the Flow of Patients between Acute, Community and Social Care' – was a project funded by Health Data Research UK. It ran from May 2020-March 2023 and was one of four projects funded in south-west England. The project was undertaken by a research team of six from Bristol, North Somerset, South Gloucestershire Integrated Care Board (BNSSG ICB) and the Universities of Bath and Exeter (see appendix I).

The IPACS project aimed to investigate what might constitute an 'optimal balance' of capacity along different parts of the complex care discharge pathways from acute hospital to community health and social care, and to assess how responsive total spend in the local health and social care economy might be in relation to community-based care capacity.

There were several aspects to the research around this theme including capacity requirements under different Covid 19 scenarios, and implications arising from attempting to reduce delayed transfers of care from acute hospitals to zero (see appendix II). Both of these strands of work made use of a simulation model – the IPACS model – which was specifically developed in the project to address these issues as well as being applicable more generally to issues of complex care pathway capacity planning.

It was always intended from the outset of the project to develop the IPACS model as a user-friendly, decision support tool to assist analysts and managers in modelling different forward planning scenarios concerning the complex care discharge pathway capacity (also known as 'Discharge to Assess', or D2A). With this in mind, the research team worked closely with colleagues in the BNSSG Clinical Commissioning Group (CCG, latterly ICB) system throughout the project to develop and test the model and to introduce it into the local planning and decision-making process. This included working with colleagues at the ICB, the community health provider for the area (Sirona Care & Health), and the three local authorities covering the ICB area: South Gloucestershire, Bristol City, and North Somerset.

Furthermore, the IPACS model was designed from the outset be transferable to other localities to explore capacity issues in similar D2A pathways elsewhere and, as of March 2023, a number of ICB locations have embarked on local applications.

- Section 1 provides a brief overview of the D2A capacity issue.
- Section 2 outlines the scope of the IPACS v1 model.
- Appendix 1 introduces the IPACS research team and contact point for further information.
- Appendix 2 contains a list of publications arising from the IPACS project

1. Discharge to Assess – the capacity issue

The D2A pathway focuses on the management of complex care patients following an acute care phase in hospital. Complex care patients are defined as those over the age of 65 who have had an emergency acute hospital admission, and who have complex post-acute care requirements (such as an extended period of rehabilitation, or a formal long-term care needs assessment). The D2A pathway requires planning and management that is both efficient (from a system and resources perspective), and effective (in terms of the impact on patient and carer health and wellbeing). The process is often characterised by delays and capacity issues which are linked to issues of availability of suitable care capacity in the right place at the right time.

The D2A pathway umbrella (NHS England, 2020) comprises three distinct routes involving combinations of health and social care services. These take place either in the patient's own home, or in a short-term, non-acute bed setting (usually a community hospital, or a care home bed designated for the purpose). In all of these settings community health and social care can be provided and a detailed care needs assessment conducted more thoroughly and with less pressure and stress than if it were to be carried out in an acute setting. The community health care is typically rehabilitation-related (for example, recuperation from the acute care episode, or rehabilitation arising from a specific condition (eg. following a fracture). An additional challenge is that many patients with complex care needs have more than one co-morbidity, are often physical frail, may have cognitive impairment issues and poor levels of informal care support from family and friends.

Figure 1 below summarises – in a simplified form – the flow of patients from acute hospital beds into the three D2A pathways:

- P1 (visits-based care where the patient is in their own home and receives care inputs in that location. Funded by the community health provider)
- P2 (non-acute, bed-based care funded by the community health provider)
- P3 (non-acute, bed-based care funded by local authority social care provider)

While in the acute hospital, and as they near the point at which they are deemed medically fit for discharge, an initial decision as to the appropriate care pathway is made and a 'transfer of care' responsibility to the community health provider is made. This should usually coincide closely with the patient being transferred into P1-3 pathways as appropriate. Patients on P1 have the lowest relative needs and are capable of receiving their health and care inputs in their own home with health and care professionals going to that location.

Patients in the P2 and P3 pathways transfer to designated short-term care bedded placements where they receive health and social care before either returning home (expected of the majority of P2 patients), or a long-term care placement is identified (P3 patients are most likely to move into this form of care). Decisions vary according to individual needs but, in principle, this is the general scope of the complex care pathways operation.

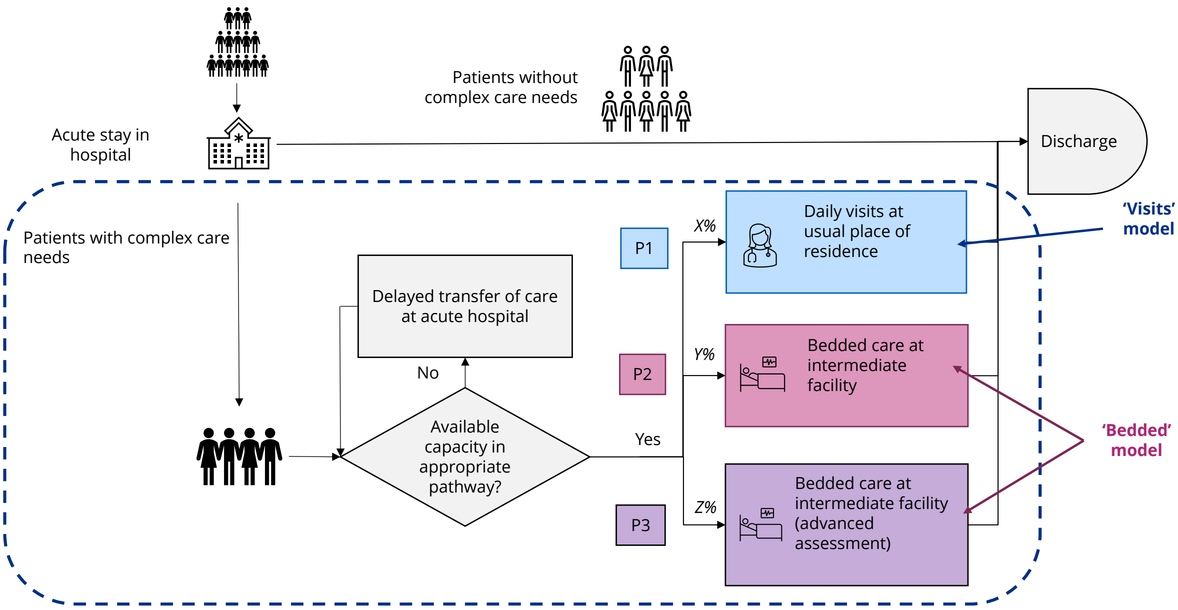


Figure 1: The IPACS model scope

The problem occurs when there is insufficient capacity in any of the pathways for the number of referrals made to it. Common reasons for this can include high volumes of referrals from the acute sector, or patients not being discharged from P1-3 into long-term care options sufficiently quickly. This, in turn, can cause a backlog of patients in the acute sector who are otherwise medically fit for discharge and for whom a transfer of care has been established but who cannot physically be discharged into the P1-3 pathways. They become acute 'delayed discharges' which is neither good for the patient nor health and care system efficiency.

Bedded care

- Care is provided in community or care home beds
- Length of Stay (LoS) is variable
- Each admitted patient consumes one service channel (bed) from admission to discharge
- There are a fixed number of service channels (bed capacity)

Visits-based care

- Care is provided at the patient's own home through daily visits
- LoS is variable
- Each patient consumes a <u>different (reducing) number of daily home visits</u> over their LoS
- Capacity (max daily home visits) cannot be exceeded by demanded home visits for patients 'admitted' by the service

Figure 2: Care pathways described in the IPACS model

2. IPACS Model aims and scope

Model aims

The IPACS project takes issues to do with the flow of patients from acute to community care settings as its main focus, and the D2A pathway is central to this, particularly in terms of how it impacts on the use of resources across the system.

A central ambition of the IPACS project was to develop a decision support modelling tool which would enable NHS decision makers to explore implications of different planning strategies simply and effectively. It is not possible to incorporate every single possible aspect of the D2A system into a single model - the complexity of the system and data availability and quality issues are too great for that - but replicating the system to that level of detail was never the intention behind the model in the first place. Key aims of the IPACS model are to:

- describe the D2A system at a more simplified, strategic level focused on how the most important elements of that system interact over time, and the resulting potential resource implications.
- develop a stand-alone, portable, decision support tool capable of being used by local analysts and decision makers to support their resource planning and management remit and which easily accommodates local variation in data sources or geography. In other words, a model which can address similar D2A planning issues elsewhere across the NHS.

Model scope

The scope of the IPACS model, focuses on modelling patient discharges from acute care into the three D2A care pathways (P1 – 3) – see figure 3 below. The model estimates the following four key output parameters:

1. The number of patients in a particular P1-3 pathway on a given day within the planning horizon
2. The number of patients queuing in acute beds who have been assigned to a P1-3 pathway but have yet to be transferred into it.
3. The average number of days a queued patient is waiting in the acute setting.
4. A total average cost (cost per day of an acute bed for a delayed patient, plus the average cost per day of their stay in a P1-3 bed.

Users can explore the effects on these model outputs by changing different key input parameter assumptions:

- Daily referral rates into the D2A pathways from acute hospital settings
- Average (mean) lengths of stay in each D2A pathway, and in each locality
- Variations in those D2A pathway lengths of stay
- D2A capacity (number of P2 and P3 beds; caseload capacity of P1)
- Variation in the number of visits required to patients in P1 (only)

Technical details of the IPACS model are described in the accompanying Technical Manual, but it is useful to note here that as the IPACS model is stochastic, the estimates modelled allow for variation in the system (not every patient has an identical simulated 'length of stay' for a given pathway). And, while the model cannot account for every possible D2A patient journey (for example, some patients may be switched between pathways or be assigned to a different pathway than that originally intended for operational reasons), its scope has been deliberately designed to address a strategic perspective, so specific operational nuances have less direct relevance.

This means that the scope of the IPACS model is clear to see and, if required, more detailed site-specific aspects could always be considered separately and in more depth alongside the results produced by the model.

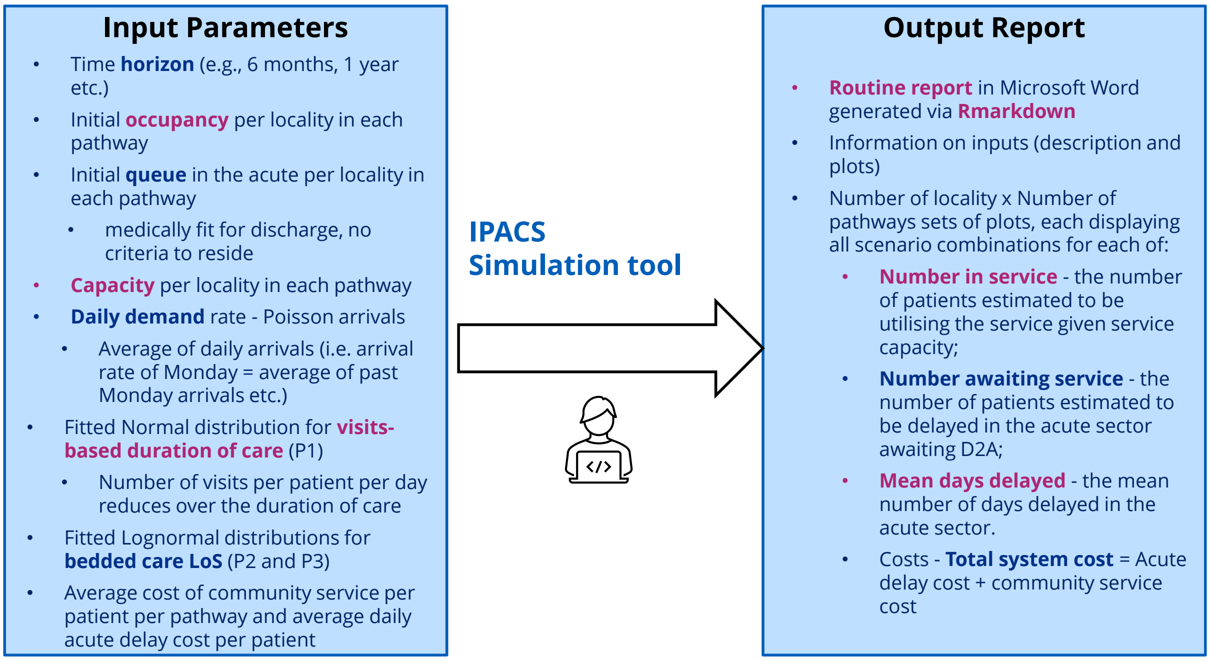


Figure 3: The IPACS model: summary of inputs and outputs

Adapting the model to another locality

By focusing only on key D2A pathway elements, this provides a 'generalised case' IPACS model structure which is more easily portable to other geographical locations. Section [] provides more specific detail on how to change model inputs; it is sufficient to note here that data input requirements are small in number, routinely obtainable, and at an aggregate level (which avoids any information governance issues as patient-level or identifiable data are not needed). The model can be configured to reflect the local organisational geography (and assumes that data, or estimates, can be obtained for those defined areas. For example, in BNSSG where the model was developed, there were three localities which corresponded to the local authorities within the ICB and, for planning purposes, this was seen as an appropriate structure for the model which meant estimating capacity across the P1-3 pathways for each of the three localities. Another ICB might be structured entirely differently; whatever is meaningful for planning purposes can be accommodated in this way.

The same goes for the location of the capacity under consideration. In BNSSG, for example, P2 beds are located in either community hospitals (of which there are few), or in care homes; all P3 beds are in care homes. In other ICBs the number of beds and proportions of patients in different pathways will depend on local circumstances. All of these variations can be accommodated by the IPACS model, as this is automatically taken into account through the structure of the input data supplied.

3. Model overview and description

The IPACS model is a stochastic discrete time simulation model which means that it simulates patient flows and generates results for each day of the overall time period selected. So, given starting values and assumptions about the key parameters, the model will then produce estimates for each day of the forward planning time horizon required (for example, daily for 6 months). This is covered in more detail in the accompanying Technical Manual.

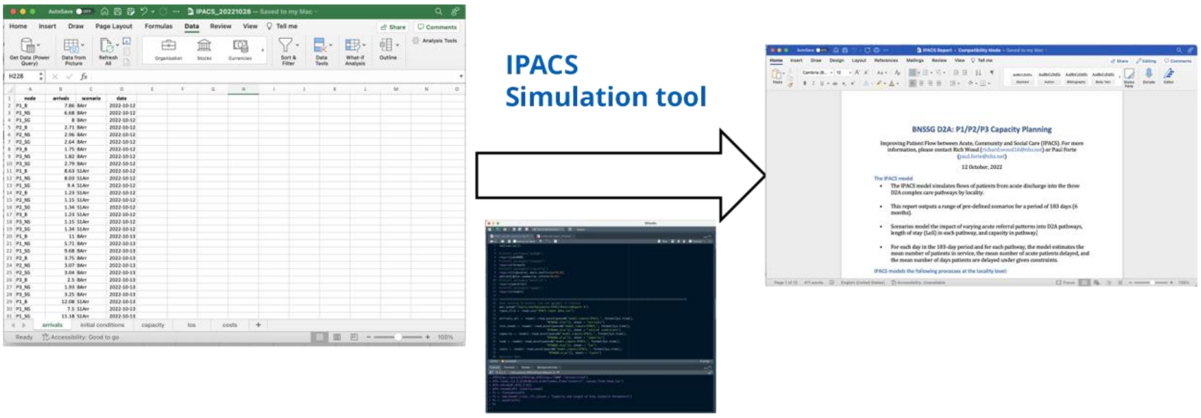
Health care processes are variable by nature and modelling solely using a mean length of stay tends to underestimate capacity requirements and other related outputs. The IPACS model is a *stochastic simulation* model. This means it incorporates variability in some of its key input parameters. As noted above not every patient will have an 'average' length of stay in a pathway so, for any individual patient, the model generates and assigns a random length of stay taken from a given distribution of lengths of stay based on the input parameters provided. For the P1 visits-based model, there is also a range of the number of daily visits a patient might receive over their length of stay.

The model also enables a series of different planning scenarios to be run and their outputs compared. For example, a 'baseline scenario' might be run to show the implications of current actual parameter values over the following six months. A second scenario might show the same projected estimate with new target pathway average lengths of stay; a third might build further on this and introduce new pathway capacity limits.

The IPACS model manages all of these scenarios and graphs their outcomes on a single plot for each location and pathway embedded in a report in Word (via R Markdown) so they can be easily compared with each other. The underlying data for all of these plots is separately maintained and available via the CSV output files.

IPACS model structure

The IPACS model is written in 'R' which is a programming language for statistical computing and graphics software package (Version 4.2.2) widely used in the NHS analyst community, but there is very little essential direct interaction required with the 'R' code. All user inputs – parameter values, data, and scenarios to be tested - are managed through a front-end Microsoft Excel user interface.



Data Input (MS Excel) *Simulation (R)* *Output (MS Word report; CSV files)*

Figure 4: The structure of the IPACS model

The model outputs are provided in Microsoft Word (using R Markdown) and comprise descriptive text, a summary of the scenarios being tested, and a series of plots illustrating all scenarios for each complex care pathway and locality.

In addition, there are two .csv files containing all of the underlying numerical values from the scenario modelling produced (one for P1/visits-based pathways; one for P2-3/bed-based pathways). These can then be used as a basis for further local analyses and presentations as required.

Interpreting model outputs

Apart from the CSV data tables, the model produces a series of plots which – for each locality, and for each care pathway within each separate locality – present the model outputs in graphical form which is designed to provide an overall summary of the model outputs and give users an initial feel for the implications of their scenario assumptions.

The IPACS model should only be taken as generally indicative; during the course of the planning horizon operational mitigations will come into play which will affect resource deployment and mean that the 'end point' of the scenario is very unlikely to be realised as shown. The confidence intervals surrounding any projections get greater the further forward in time the planning horizon. For reasons of space and clarity the plots only show the mean values for each output, but the numerical ranges of the confidence intervals are provided in accompanying .csv file outputs.

Figure 6 provides an illustrative example of the output automatically generated by the IPACS model for all pathway-locality pairings. For each individual pairing, four graphs are produced – one for each output parameter. In order, from the top of the figure, these are:

- The mean number of patients in the pathway

- The mean number of patients who are medical fit for discharge from acute care but are awaiting access to their designated P1-3 care pathway (ie a queue)
- The mean number of days patients are in the queue
- Total mean cost which is defined as the average cost per day for a patient queuing in an acute setting plus the average cost per day of their stay in the relevant pathway

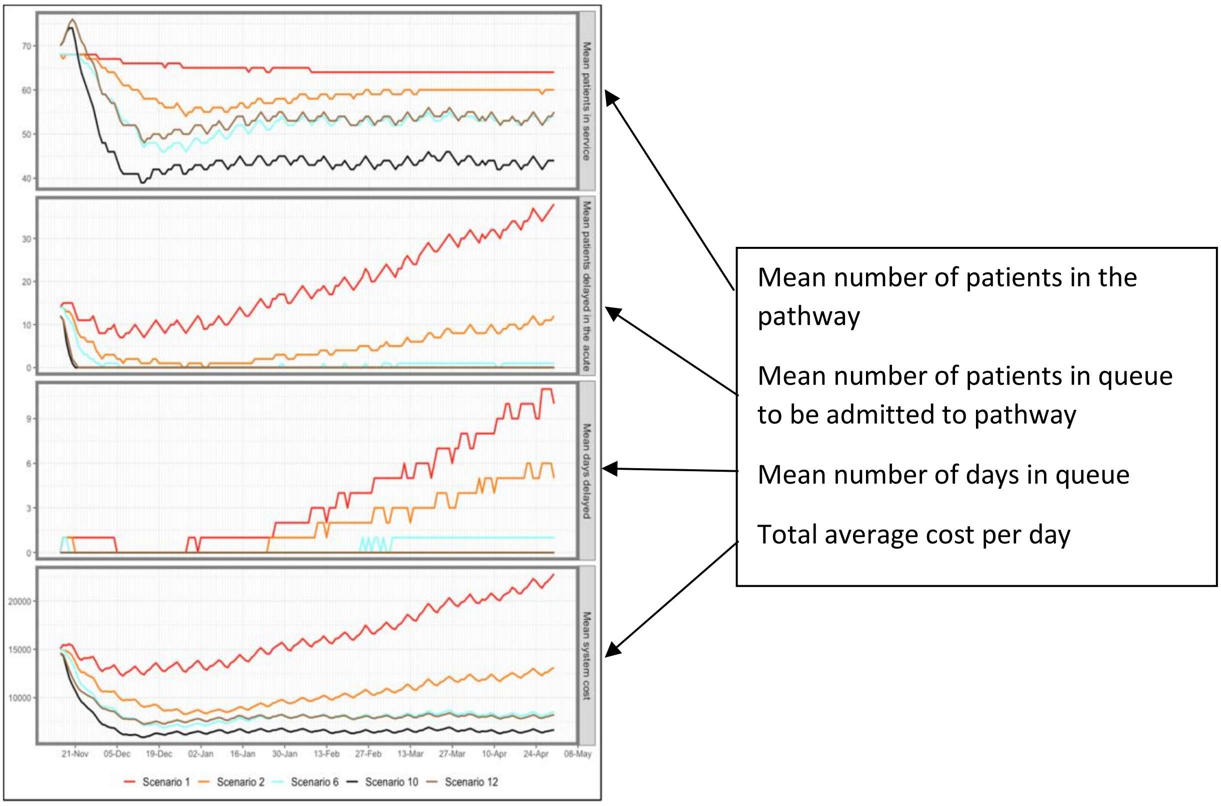


Figure 6: IPACS Model outputs for each pathway in each locality

The mean values of the scenarios selected for display are overlayed on top of each other to show the contrasting effects of the different parameter value combinations. In addition, there is a separate output file containing all of the underlying supporting numbers, and an output file which provides numerical values of the confidence intervals around each of the scenario plot lines (for each day, pathway, and locality).

The model automatically produces a plot as shown in Figure 6 for each pathway and each locality, but these can subsequently be incorporated into reports for planning and management purposes as required.

4. Applying the IPACS model

As an example, working with an ICB and its health and social care stakeholders involved in the D2A process, a set of input parameter values reflecting current baseline activity, and 6-month targets for length of stay and P1-3 capacity – by pathway for each of three localities - were described (see Figure 7).

Capacity and Length of Stay Scenario Parameters as of 21/11/2022					
Locality	Baseline Capacity	Target Capacity	Baseline LoS	Target LoS	Interim LoS
P1 Loc A	92	Unrestricted	18.1	10	14.0
P1 Loc B	71	Unrestricted	18.7	10	14.3
P1 Loc C	71	Unrestricted	12.1	10	11.0
P2 Loc A	102	Unrestricted	42.8	21	31.9
P2 Loc B	28	Unrestricted	38.3	21	29.6
P2 Loc C	61	Unrestricted	34.1	21	27.5
P3 Loc A	72	Unrestricted	59.1	28	43.6
P3 Loc B	39	Unrestricted	44.9	28	36.5
P3 Loc C	37	Unrestricted	32.2	28	30.1

Figure 7: Example capacity and length of stay parameters

The 'baseline capacity' column indicates caseload (P1) and bed capacity (P2, P3) A target capacity could be set but, in this case, leaving it 'unrestricted' leaves it to the model to estimate what capacity would be required if there were to be no queues of patients waiting in acute beds to enter the P1-3 pathways. The lengths of stay columns reflect baseline average lengths of stay and two sets of targets respectively.

Other baseline data on the initial queue of patients waiting in acute beds at the start of the planning horizon were also supplied. These are not shown here; see the Technical Manual for a description of the data input fields under the control of the user.

The next step was to develop a set of planning scenarios to be tested over the six-month forward planning horizon decided upon by the local stakeholders. Some 12 different scenarios were developed (see Figure 8) and modelled but, for illustrative purposes only the five highlighted are shown here.

These scenarios incorporated different combinations of baseline, target, and interim target lengths of stay, with baseline and target referral rates into the pathways from acute settings. 'Baseline' in this example was based on the daily average of referrals over the past six months for each day (so the referral rate for every Monday was the average of referrals for all Mondays in the previous six months. The target referral rates were based on a 40 % percent improvement with respect to referral targets to P1-3 pathways. These had been established through separate, external empirical analyses which indicated that proportions of current P2 and P3 referrals might have been referred instead to P1, and that there were also referrals in P1 that might not have required any complex care pathway referral at all.

It should be noted that referral rates could have been estimated/ forecast in many different ways. Another locality might have forward planning estimates derived from alternative analyses, for example. The IPACS model takes that information as an input; estimates are not generated internally by the model.

Scenario #	Capacity	LoS	Arrival
1	Baseline	Baseline	Baseline
2	Baseline	Baseline	Improvement Target (20% or 40%)
3	Baseline	Target (10:21:28)	Baseline
4	Baseline	Target (10:21:28)	Improvement Target (20% or 40%)
5	Baseline	Interim	Baseline
6	Baseline	Interim	Improvement Target (20% or 40%)
7	Unrestricted	Baseline	Baseline
8	Unrestricted	Baseline	Improvement Target (20% or 40%)
9	Unrestricted	Target (10:21:28)	Baseline
10*	Unrestricted	Target (10:21:28)	Improvement Target (20% or 40%)
11	Unrestricted	Interim	Baseline
12	Unrestricted	Interim	Improvement Target (20% or 40%)

Figure 8: Modelled scenarios.

Six scenarios used baseline (i.e. existing) capacity limits, and six had 'unrestricted' capacity (where the model, through generating the number of patients in service, effectively estimates the capacity that would be required if there were to be no queues). Scenario 10 represented the 'best case' scenario in which all targets (lengths of stay; ideal referral rates) were achieved.

The model automatically produces a single page of the four output plots for each specific pathway and locality but, as illustrated in Figure 9, these can be subsequently rearranged as required as local planners see fit. In this case, stakeholders wanted to be able to easily compare specific pathways across the three localities as a first step to understanding differences between them.

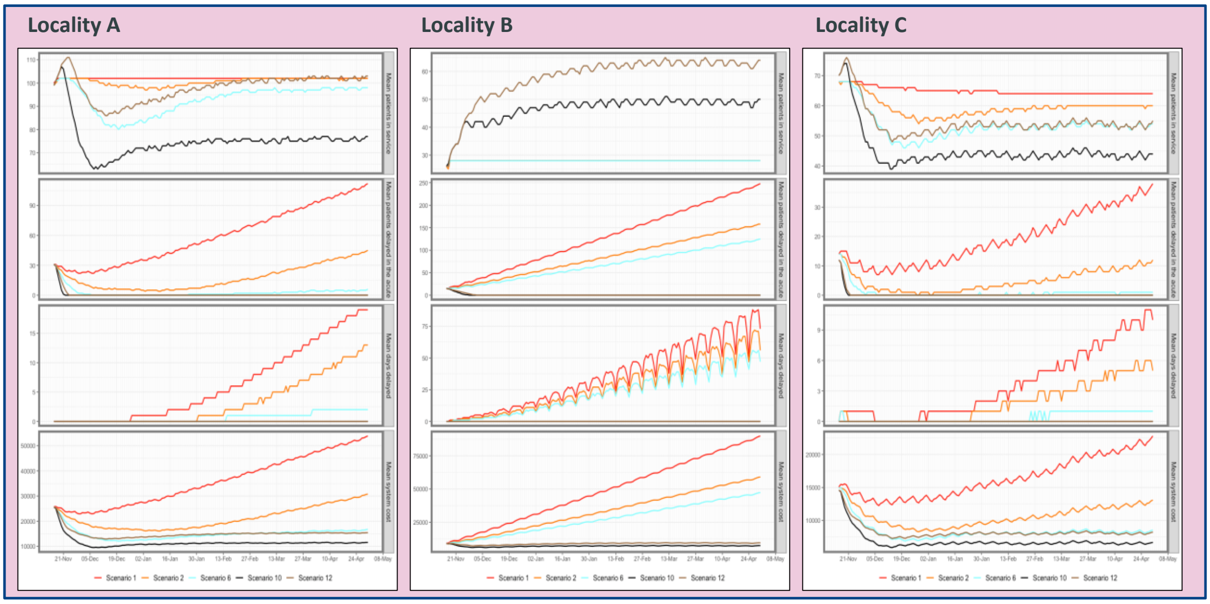


Figure 9: Comparing scenarios for an individual pathway across localities

Further comparisons using the numerical data produced by the IPACS model can also be made. Figure 10 shows a table constructed from raw data taken from the CSV output file.

The plots show the daily average (mean) for each scenario; confidence intervals are not shown on these plots for reasons of clarity. However, CSV output files with daily confidence limit values are produced and the values available as required.

This might be of interest when using model outputs in planning decisions as it may be more appropriate to be guided by the 95% confidence limit for, say, setting a capacity target rather than the mean; the implication being that capacity limits would be less likely to be breached.

RESULTS FOR SELECTED SCENARIOS (1,2,6,10,12)

	P1 Mean # patients in service; Mean # delayed patients; Mean # days per patient			P2 Mean # patients in service; Mean # delayed patients; Mean # days per patient			P3 Mean # patients in service; Mean # delayed patients; Mean # days per patient		
	A	B	C	A	B	C	A	B	C
Scenario 1	81	35	43	102	28	65	77	39	37
(Baseline Cap, Baseline LoS, Baseline Arr)	12	3	3	59	129	19	81	25	125
	1	0	0	6	36	4	12	10	34
Scenario 2	81	35	44	101	28	59	77	38	37
(Baseline Cap, Baseline LoS, 40% improvement towards LGA target)	11	3	3	17	84	5	44	10	76
	1	0	0	3	28	2	1	5	25
Scenario 6	66	28	41	93	28	53	72	37	37
(Baseline Cap, Interim LoS, 40% improvement towards LGA target)	5	2	3	3	67	1	12	4	70
	0	0	0	1	23	0	1	2	23
Scenario 10	51	22	38	75	47	45	76	33	63
(Unrestricted Cap, Target LoS, 40% improvement towards LGA target)	0	0	0	1	1	0	2	0	0
	0	0	0	0	0	0	0	0	0
Scenario 12	66	28	41	98	58	55	97	39	66
(Unrestricted Cap, Interim LoS, 40% improvement towards LGA target)	0	0	0	1	1	0	3	1	0
	0	0	0	0	0	0	0	0	0

Figure 10: Comparative numerical data for selected scenarios

In summary

- The IPACS model works at different levels. The numerical and graphical outputs provide an indication of potential levels of key D2A policy and planning outputs (patients accommodated on the pathways; queues in hospitals and length of waiting time; average costs) and this - in conjunction with other detailed data, local intelligence and analyses - can support the local decision making process when it comes to resource allocation or target populations.
- The IPACS model also acts as a process for supporting 'systems thinking' is also very important by enabling decision makers to consider a more integrated picture of the D2A whole system and consider which elements and what data are most important for its review and planning in strategic terms, rather than focused solely on constant operational level reaction to events.
- The model is open source and free to use, has minimal data requirements and is portable across different health and social care economies. The model and documentation are available free of charge on GitHub:

https://github.com/nhs-bnssg-analytics/ipacs-model

References

NHS England, 2020, Hospital Discharge Service: Policy and Operating Model.
HM Government.

Appendix I: The IPACS Research Team

RICHARD WOOD is Head of Modelling and Analytics at NHS Bristol, North Somerset and South Gloucestershire Integrated Care Board and is a Visiting Senior Research Fellow at University of Bath School of Management.

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MARTIN PITT is Director of The Peninsula Collaboration for Health Operational Research and Development, Exeter University: Medical School.

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ALISON HARPER is a research associate at the University of Exeter Medical School, in the Peninsula Collaboration for Health Operational Research and Development.

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For more information please contact Dr Richard Wood:

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Appendix II: IPACS Project Publications (April 2023)

- Harper, A., Pitt, M., De Prez, M., Dumlu, Z. Ö., Vasilakis, C., Forte, P., & Wood, R. (2021, December). A Demand and Capacity Model For Home-Based Intermediate Care: Optimizing The'Step Down'Pathway. In 2021 Winter Simulation Conference (WSC) (pp. 1-12). IEEE.
  Link: https://ieeexplore.ieee.org/document/9715468

- Önen-Dumlu, Z., Harper, A. L., Forte, P. G., Powell, A. L., Pitt, M., Vasilakis, C., & Wood, R. M. (2022). Optimising the balance of acute and intermediate care capacity for the complex discharge pathway: Computer modelling study during COVID-19 recovery in England. PLoS ONE, 17(6).
  Link: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0268837

- Wood, R. M., Harper, A. L., Önen-Dumlu, Z., Forte, P. G., Pitt, M., & Vasilakis, C. (2022). The False Economy of Seeking to Eliminate Delayed Transfers of Care: Some Lessons from Queueing Theory. Applied Health Economics and Health Policy, pp. 1-9.
  Link: https://link.springer.com/article/10.1007/s40258-022-00777-2

- Önen-Dumlu, Z., Forte, P., Harper, A., Pitt, M., Vasilakis, C., Wood, R. (2023).
  Improving Hospital Discharge Flow Through Scalable Use of Discrete Time Simulation and Scenario Analysis. In: Currie, C. and Rhodes-Leader, L. (eds) Proceedings of the Operational Research Society Simulation Workshop 2023 (SW23).
  Link: https://doi.org/10.36819/SW23.013