



# **BNSSG Dynamic Population Model**

Midlands Analyst Network Huddle 2024-10-17 Iuke.shaw4@nhs.net



### Where is **BNSSG**

• About 1 million people

 Bristol North Somerset South Gloucestershire

Rough demographics not too dissimilar to England



### **Team Structure**

- 4 Data Scientists (led by Richard Wood)
- Build data science models within the ICB to solve problems and inform decisions
  - flows through the system (eg hospitals)
  - forecasting/projections
  - collaborating across NHS & academia
- → Modelling & Analytics Team (~4)
  - $\rightarrow$  Systems Intelligence team (~30)
  - →Transformation & Digital Directorate (~70)
  - $\rightarrow$  Integrated Care Board (~500)

### **Tech Stack**

- BNSSG-hosted SQL servers
- Model built in R
- Model run locally (have desktops for extra power)

### HACA 2024

No knowledge assumed

• More detail on model structure

Developments (v2 not v1)



HEALTH AND CARE ANALYTICS Conference 2024

Modelling long-term changes in population health state and associated healthcare resource requirements: applications in BNSSG ICS

Luke Shaw Modelling & Analytics BNSSG ICB





Bristol, North Somerset and South Gloucestershire Integrated Care Board

### **HACA Slides**





### Bristol, North Somerset and South Gloucestershire Integrated Care Board

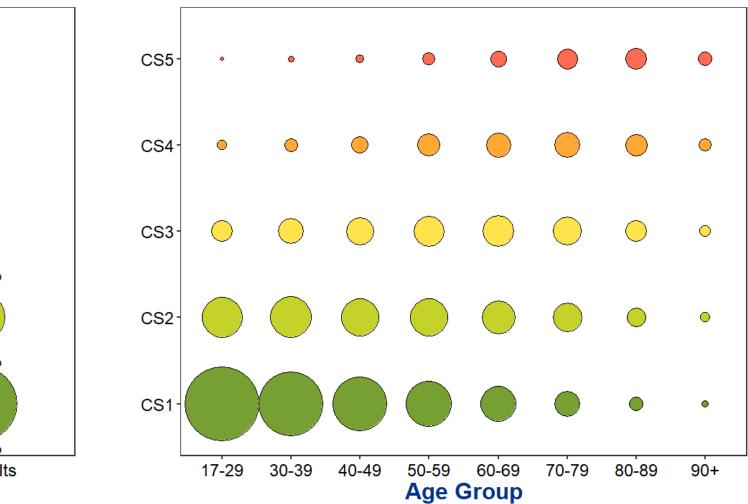


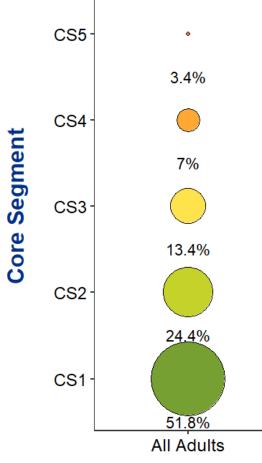
## Version 2

### DPM V1 -5 starting states

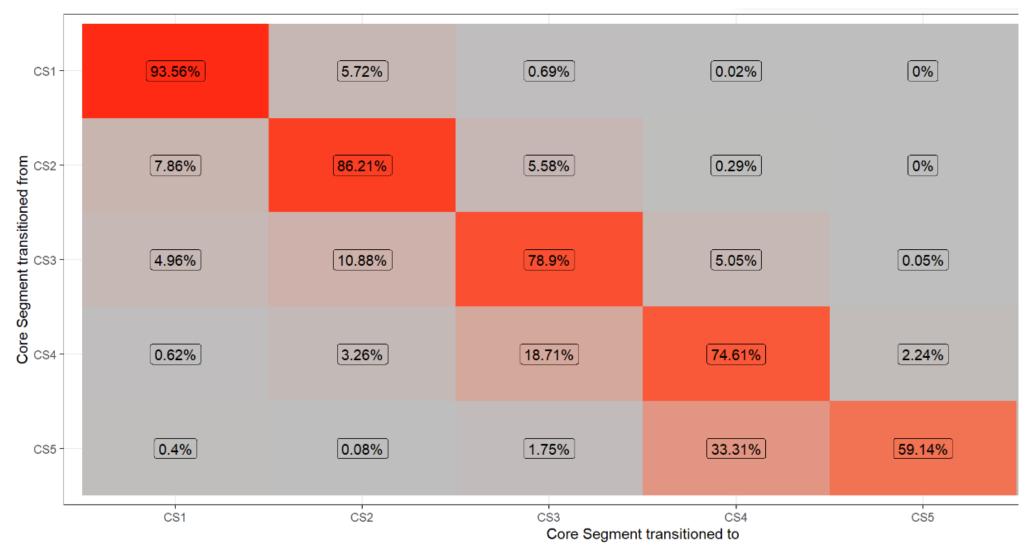
### DPM v2 40 starting states

Size determined by number of people in that state in BNSSG 17+ population





### **V1 Transition Matrix**

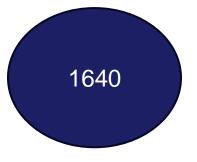


### **V2 Transition Matrix?**

### Number of people seen for each transition in one month

For the one month from Aug 2023 to Sep 2023

	0		50000			100	0000																												_							
17-29			767				932		-		0																														1	
	_CS2	379		218	4	0	3	_	5		0																															36k
	_CS3			7k	50	0		-			0																														1	8k
	_CS4	0		31	1k	3					0																														0	<b>1</b> k
	_CS5-	0	0	0	0	43	0	<u> </u>	0		0	_	_	_	_		_	_									_	_				_		_		_	_		_	_		43
	_CS1							405				770		2	0																										0	102k
	CS2						231				0	3		4		0																										39k
	_CS3							147			0		-	109	1	0																										12k
	_CS4						1				20	0	0	0	40	0																									3	2k
	_CS5			_			0	0	0	7		0	0	0	0	4				_							_	_									_				0	209
	_CS1											69k			4		469	2			0																				2	70k 32k
	_CS2											140			12	0		263	4		0																				1	32k
	CS3											73			134				145		0																					15k
	_CS4													81	4k		0	0			0																					4k
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50-59																			137			326			0 (																	49k
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50-59	_CS3															-[	70	156	19k	206			2	198) (	1	)																20k
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60-69	_CS2															- 1					[	42	23k	199 4	11	3 0	168	3 0	0	0					-							24k
60-69	_CS3															- 1					[	64	140	19k 2	50	3 1	1	150	1	0												20k
60-69	_CS4																					0	11	134 1	1k 1	10 0	0	2	99	1												[12k
60-69	_CS5																					0	0	1 5	57 4	k 0	0	0	0	53											19	4k
70-79	_CS1																									13	86	94	6	0	55	1	0	0	0						7	13k
70-79	_cs2															- 1										30	17	206	57	1	0	94	2	0	0						5	17k
70-79	_CS3-																									55	126	5 17k	264	20	0	0	90	1	0					-	22	17k
70-79	_CS4																									1	17	146	13k	182	0	0	1	115	0						37	13k
70-79	_CS5																									0	0	1	74	<b>7</b> k	0	0	0	1	87						45	[7k]
80-89	_CS1																														[2k]	[24]	35	4	3][1	10]	0	0	0	0	[12]	[3k]
80-89	_CS2																													_	3	6k	97	27	7	0	18	0	0	0	5	6k
	_CS3																														17	54	7k	178	33	0	0	28	1	1	23	8k
	_CS4																														1	10	91	8k [1	81	0	0	2	37	0	47	8k
80-89	_CS5																														0	0	4	84) [	8k	0	0	0	0	44	130	8k
	_CS1																				Т														2	63	2	5	1	0	1	272
	CS2																																		+10	1	900	18	12	3	7	941
	CS3																																			3	9	1k	40	7	12	1k
	_CS4																																		+1	1	2	30	1k	45	23	2k
	_CS5																																						21			3k
	Total-	133k	36k	8k	1k	46	102k	39k	12k)	2k	218	70k	32k	15k	4k)	705	49k	31k	20k	9k	2k	28k	24k)	20k   1	2k 4	k 13	( <b>17</b> )	( <b>17</b> k	13k	7k	3k	6k	8k	9k) [	8k 2	79	931		2k		564	780k
		<u>7</u>	32	CS3	CS4	CS5	CS1	CS2	CS3	CS4	CS5	50	CS2	CS3	2	CS5	50	CS2	33	7	35	50	32	8	CS4	CS5	5 5	C CS3	CS4	35	50	82	ŝ	7	22	50	22	33	74	35	p	
		17-29CS1	17-29CS2	17-29CS	17-29_C5	17-29_CS	30-390	30-39CS	30-39_CS	30-39_CS	30-39_CS	40-49CS1	40-49_C	40-49 CS	40-49CS4	40-49_CS	50-59CS1	50-59_CS	50-59 CS3	50-59_CS4	50-59C	60-69C(	.e0-69C	0160-69_CS3	69-69 69-09	60-69_CS	70-70 052	70-79_CS	70-79CS	70-79CS5	80-89CS1	80-89CS2	80-89CS3	80-89CS4	80-89CS5	90+CS1	90+CS2	90+ CS3	90+CS4	90+CS5	NA Died	



CS1\_17-29 CS1\_30-39 CS1\_40-49 CS1\_50-59 CS1\_60-69 CS1\_70-79 CS1\_80-89 CS1\_90+ CS2\_17-29 CS2\_30-39 CS2\_40-49 CS2\_50-59 CS2\_60-69 CS2\_60-69 CS2\_70-79 CS2\_80-89 CS2\_90+ CS3\_17-29 CS2\_90+-CS3\_17-29-CS3\_30-39-CS3\_40-49-CS3\_50-59-CS3\_60-69-CS3\_60-69-CS3\_70-79-CS3\_80-89-CS3\_80-89-CS3\_80-89 CS3\_90+-CS4\_17-29-CS4\_30-39 CS4\_40-49- $CS4_40-49 - CS4_50-59 - CS4_60-69 - CS4_70-79 - CS4_80-89 - CS5_17-29 - CS5_30-39 - CS5_40-49 - CS5_50-59 - CS5_60-69 - CS5_60-69 - CS5_70-79 - CS5_80-89 - CS5_90+ - CS6_90+ - CS6_90+$ S S Died CS\_ Ś හි **Ending State** 

Probability.00 0.25 0.50 0.75 1.00

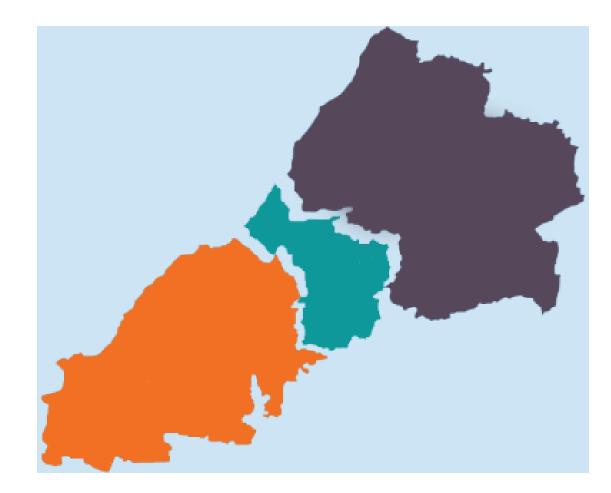
- v1: 25 transitions
- v2: 240 transitions

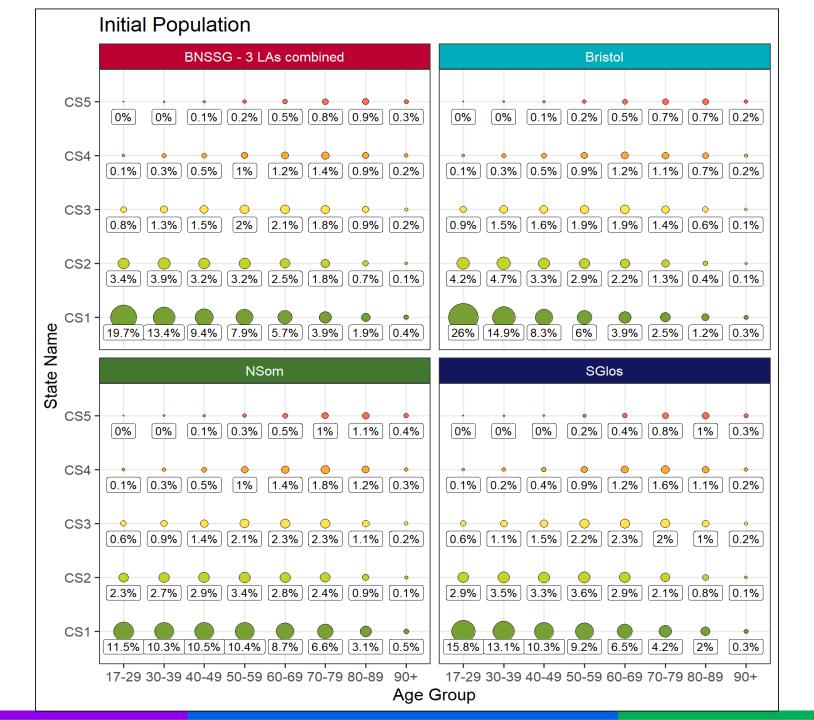
### **Local Authority Level**

User Feedback

• Expand Use Cases for the model

• More accurate estimates

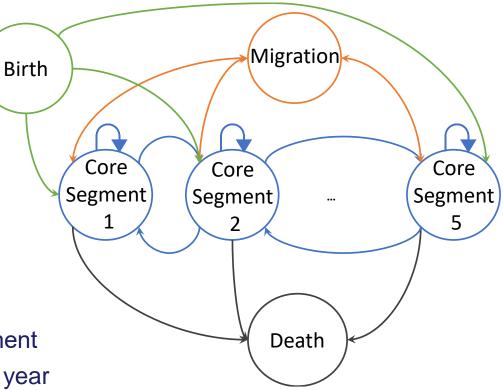




## Stochasticity

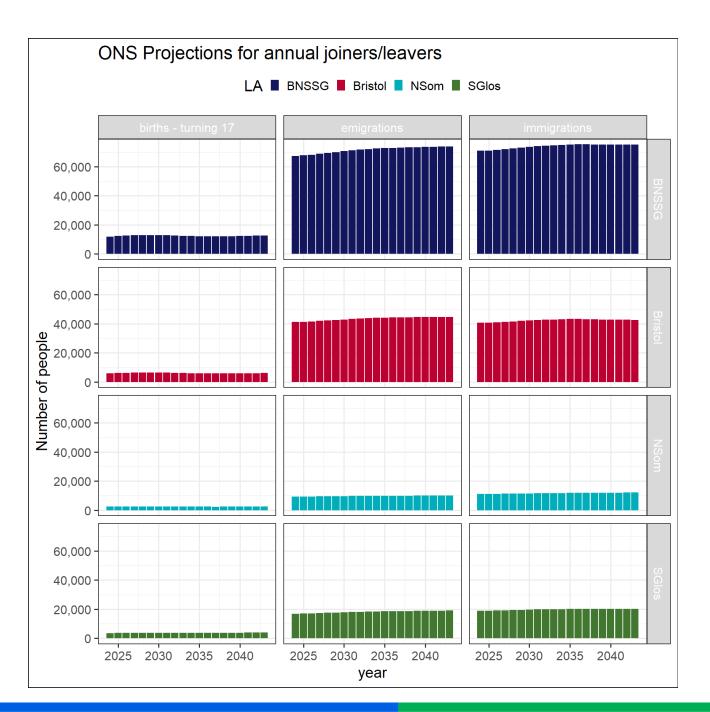
• V1 (and v2 can be) **deterministic** calculated on aggregate

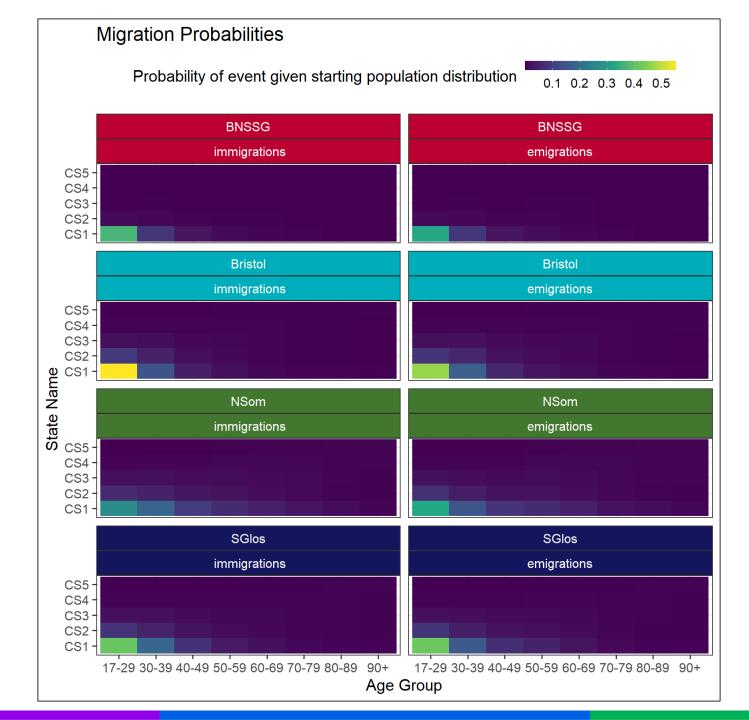
- V2 can run at individual-level
  - start with random population sample
  - at person-level have someone's age and Core Segment
  - probabilistically sample Core Segment change each year
  - aggregate up at the end



### Migration Profiles

- V1: net migration
- V2: immigration & emigration





### **Resident or Registered**

- ONS values are in terms of **RESIDENT** population (where people live)
- ICB values are in terms of **GP REGISTERED** population (who is registered to a GP)
- Differences:
  - Size
  - Cross-border healthcare utilisation
  - Who is missing (unregistered ~5%, registered but moved on ~10%)

For v2 we think of everything in terms of **RESIDENT** population as that's what ONS projections use

We have to make assumptions about the missing population from registered, assume CS1.

### **Other Changes**

- Deaths as an output, not input
- Stochasticity microsimulation model

### **Assumptions List**

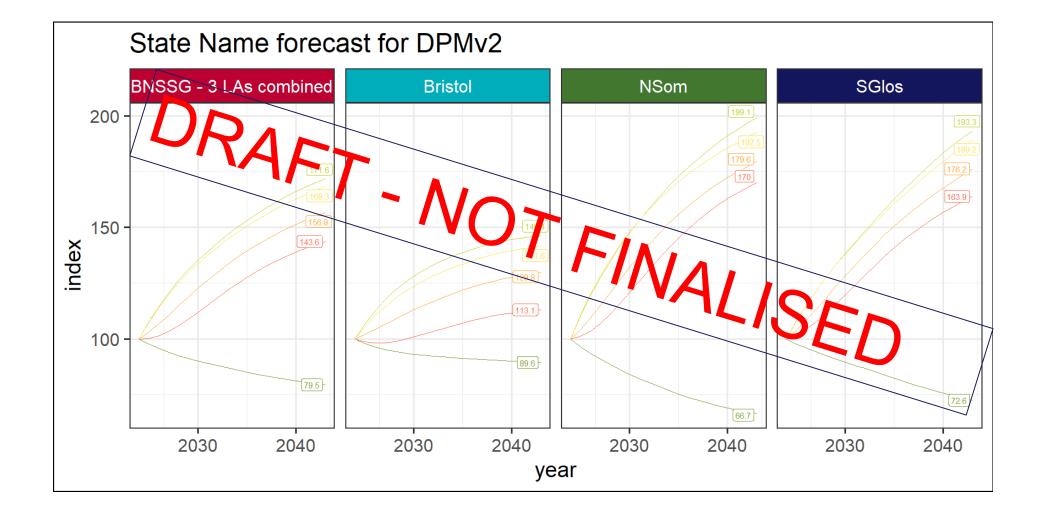
- a) 17+ population only
- b) Cost = tariff per unit. Cost per person assumed to stay the same through time
- c) Same level of delivery per person expected under current DPM model
- d) Source = SWD, any activity not in System Wide Dataset not included
- e) Data for forming current understanding only from May 2021 to Mar 2024
- f) Transition Probabilities between states (including death probabilities) are the average from SWD cleaned data (people in the data for past 12 months) between May 2021 and Mar 2024.
- g) Wherever population figures are used, we are using ONS Local Authority estimates and projections. These are the best guess for the resident population, which is slightly different to the BNSSG-registered patient population. For health states, we use the System Wide Dataset (SWD). The scaling of health states up to match ONS population figures is done assuming missing at random.
- h) Migration numbers and age distribution are from ONS, with health state distribution within age taken as random.
- i) Initial Population being adjusted to ONS populations assumes non-registration is from CS1 patients in that age group (down to 5-year levels) who are not registered due to not having symptoms.





## Outputs

### V2 – same trends







# Thank you

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