Kent JSNA Cohort Model
Key summary and update

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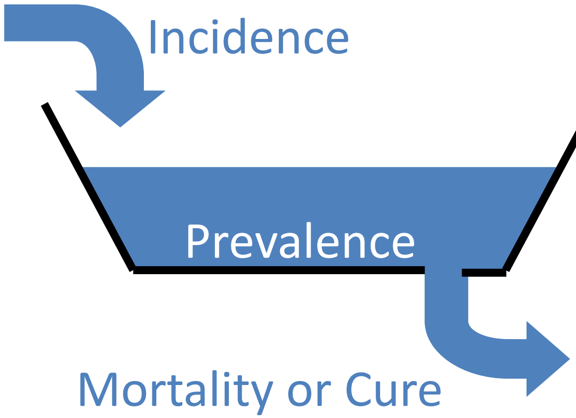
Background and Rationale

- Developed by Whole Systems Partnership in collaboration with KCC Public Health, upon special request by the Kent Health & Wellbeing Board in 2017
- To provide a local evidence base to support Kent Joint Health & Wellbeing Strategy development as well as health care commissioning and planning decisions
- To satisfy local ambition to enhance local JSNA capability with prospective modelling capability to simulate **'what if?'** scenarios describing **complex** strategies that <u>**combine**</u> different interventions and reducing risk factors and understanding their effect on population health improvement over time

What is the JSNA Cohort Model?

- Stock and flow (Systems Dynamics or SD) modelling to estimate changes in population segments across gender, age and cohorts taking into consideration:
  - Underlying demographic differences
  - Changing underlying risk factors
  - Risk factors scenarios
- When do we use SD?
  - The scope of issues are strategic / population / cohort level not for ‘tracking’ individuals, within a system
  - Control over the system is exerted through rates
  - Timescales are relatively long
  - To inform policy making

How does it work?



Stocks (point counts)

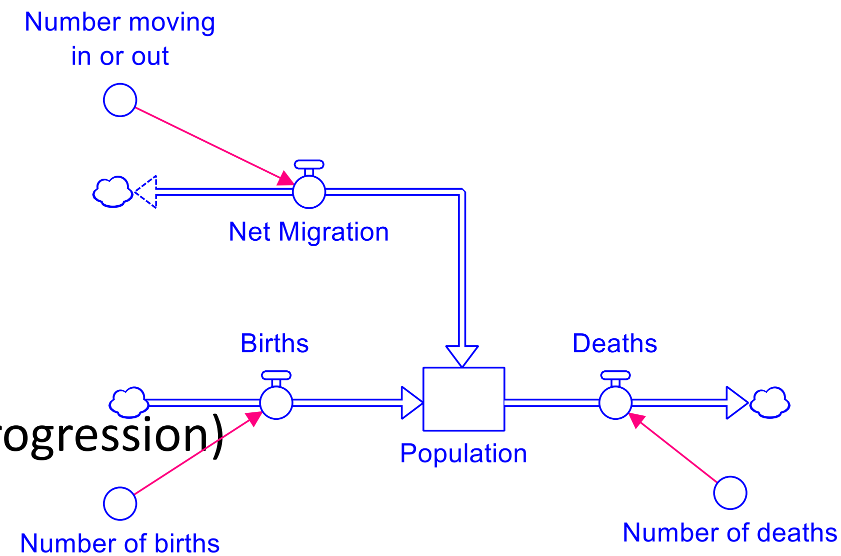
- Prevalence
- Patients needing treatment
- People at risk

Flow (counts per time)

- Incidence
- Cure/mortality rates
- Patients entering treatment

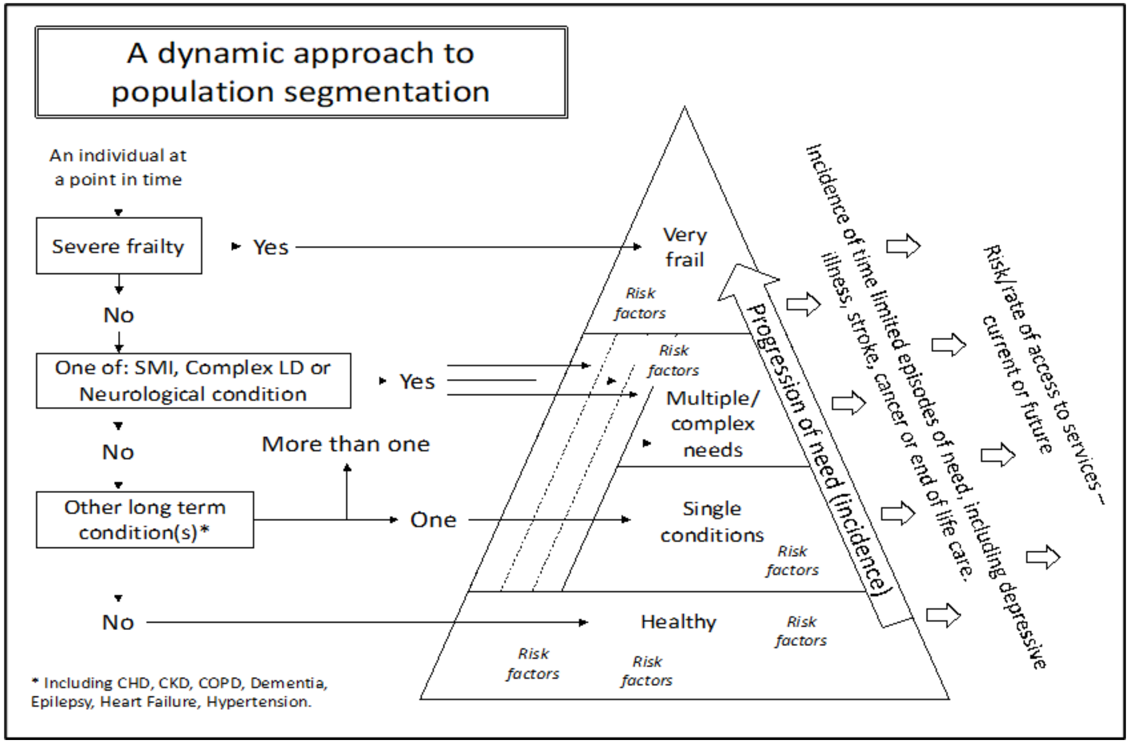
Dynamic events:

- Various factors changing incidence
- Changes in treatment
- System delays (treatment time, disease progression)



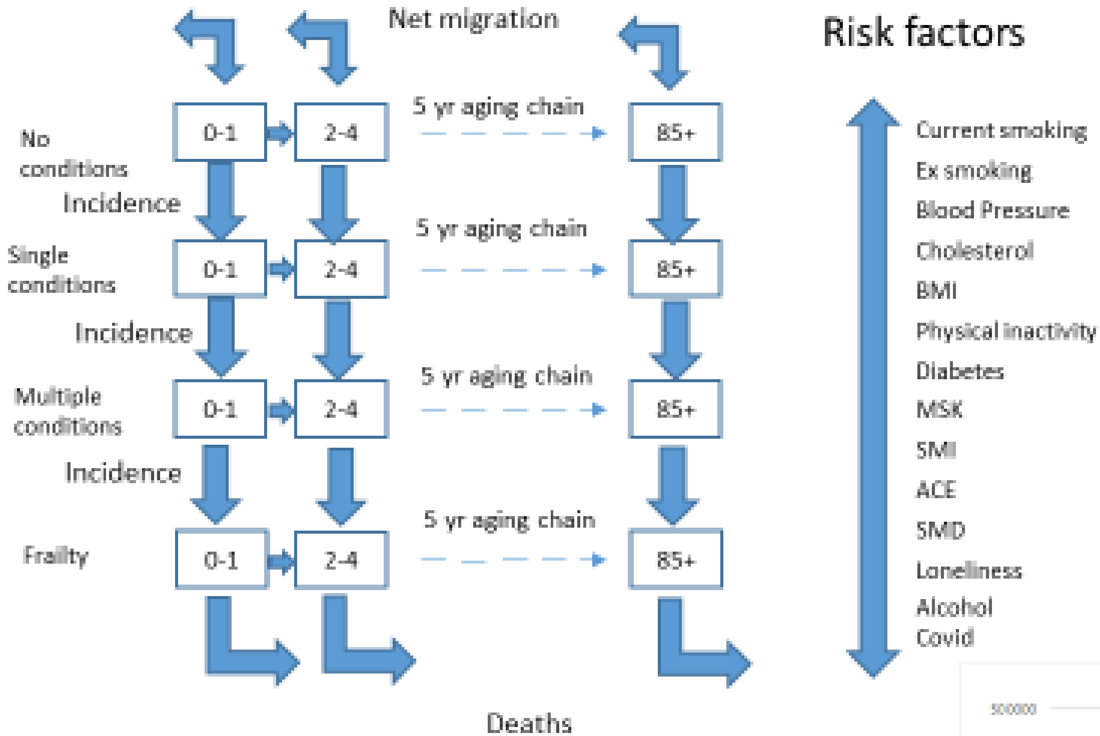
Cohort model design principles – segmentation

- Prevalence rates gender and age groups:
  - No conditions
  - Single conditions
  - Multiple conditions
  - Frailty

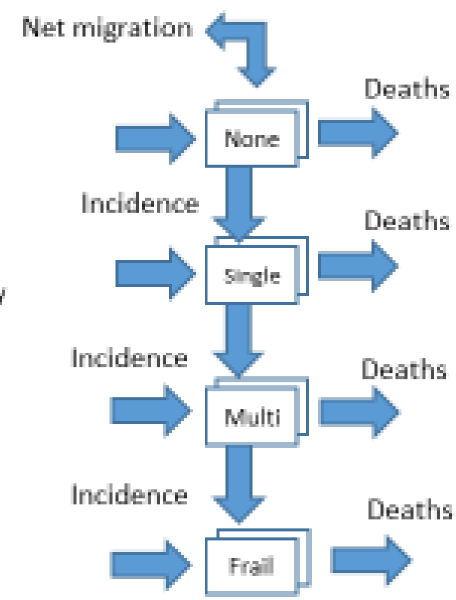


Cohort model design principles - flow

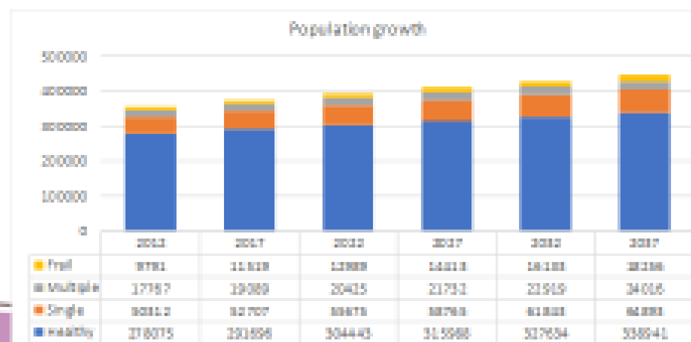
What’s happening



How it looks in stella



What is produced?



Cohort model characteristics

- The JSNA cohort model uses the same ***segmentation*** approach underpinning Population Health Management approaches but is designed to provide the prospective answer to a series of 'what-if' questions informed by local and national evidence of impact;
- The model has been developed with the potential to be calibrated and used at system, place and neighbourhood levels with recent applications focused on ***place and neighbourhood*** to ensure sensitivity to local socio-demographic characteristics;
- The model reflects ***health behaviours*** accounting for 30% of what affects our health and wellbeing, and explores the impact of modifying these;
- Is developing its approach to modelling ***the impact of socio-economic factors***, accounting for 40% of what affects our health and wellbeing;
- Uses the above to inform not only health outcomes but ***access rates*** to key health and care services.

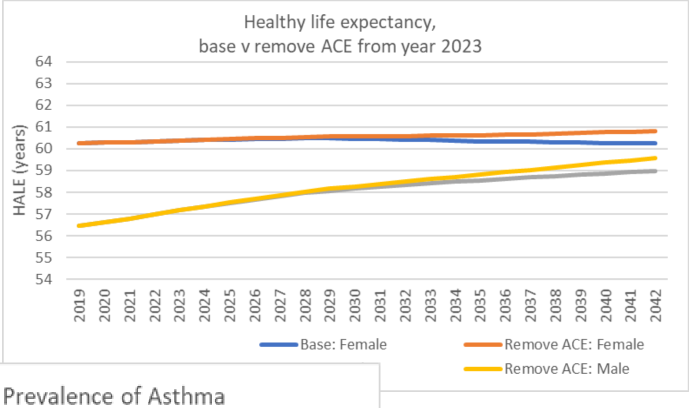
The best start in life

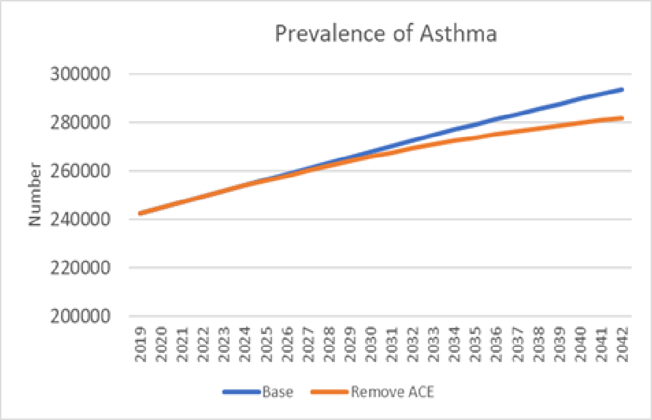
About 10% of children experience 4 or more adverse childhood experiences (ACEs). ACEs have a significant impact upon population health and mortality. For example, a child with 4 of more ACEs is:

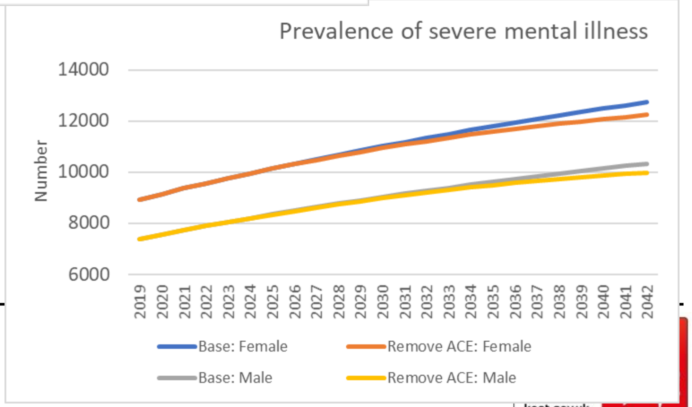
- 3 times more likely to have a respiratory condition as a child and adult;
- 2 times more likely to have a cardiovascular condition or stroke and 1.5 times more likely to have diabetes;
- Between 4 and 6 times more likely to have a severe mental illness as a child and adult.

Starting in 2023 to 2042, if aces are avoided for all newborn children this could:

- Add 0.6 and 0.1 years of average whole population healthy life expectancy and years of period life expectancy at birth respectively and;
- Reduce by 12,000 and 900 the number of people with asthma or a severe mental illness respectively across Kent.



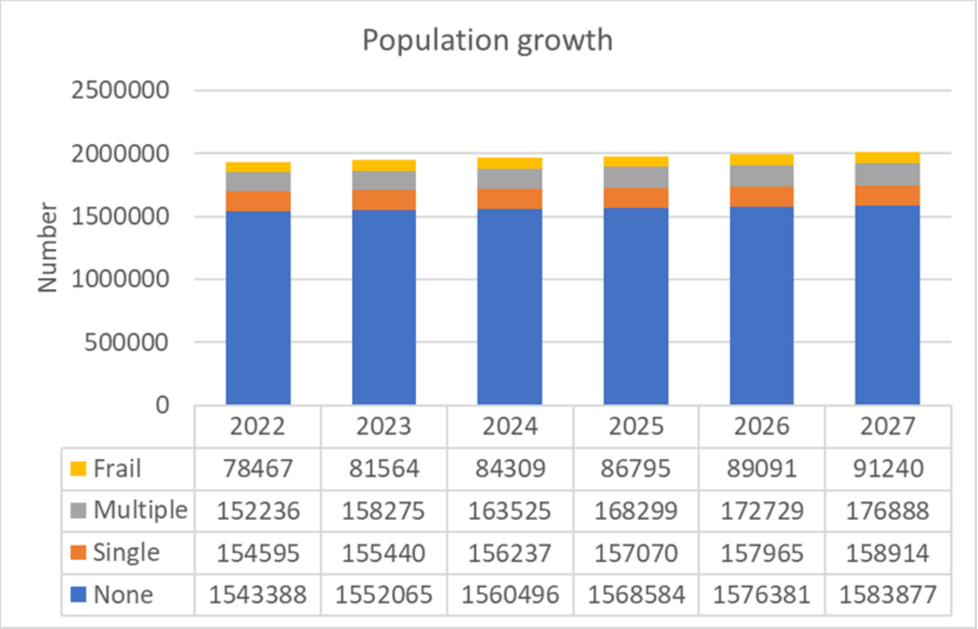




Prevention strategies – managing risk at all stages of need

Shorter term projections for different cohorts of need can help keep people healthy for longer as well as target different types of care needs. Base cohort projections estimate that between 2022 and 2027:

- The number with no long term conditions or frailty will increase by about 3%;
- Single long-term conditions will increase by about 3%;
- Multiple and complex conditions will increase by about 16.2% and;
- Frailty (severe) will increase by about 16.3%.



	2022	2023	2024	2025	2026	2027
Frail	78467	81564	84309	86795	89091	91240
Multiple	152236	158275	163525	168299	172729	176888
Single	154595	155440	156237	157070	157965	158914
None	1543388	1552065	1560496	1568584	1576381	1583877

- These projections illustrate the changing levels of health need as opposed to looking at flat population level changes.

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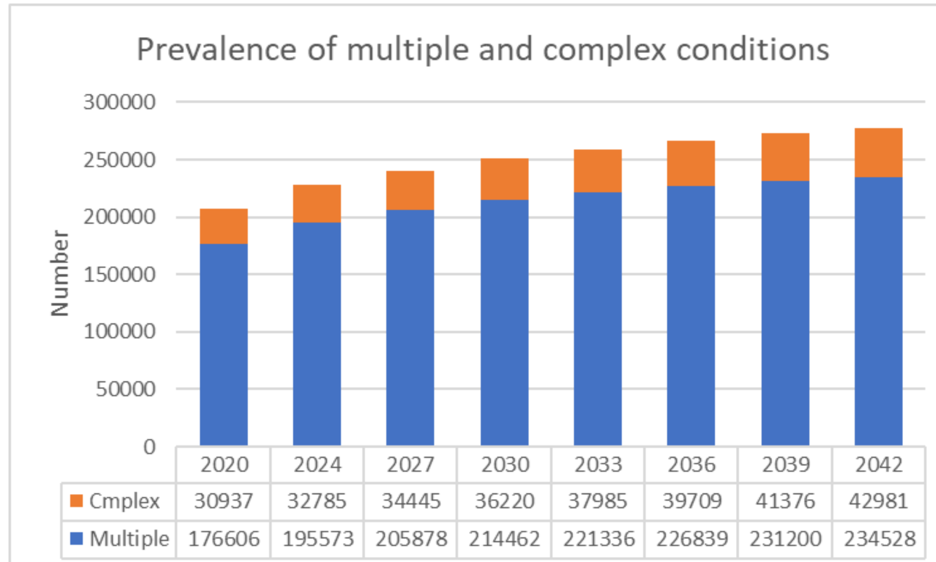
People with multiple or complex needs

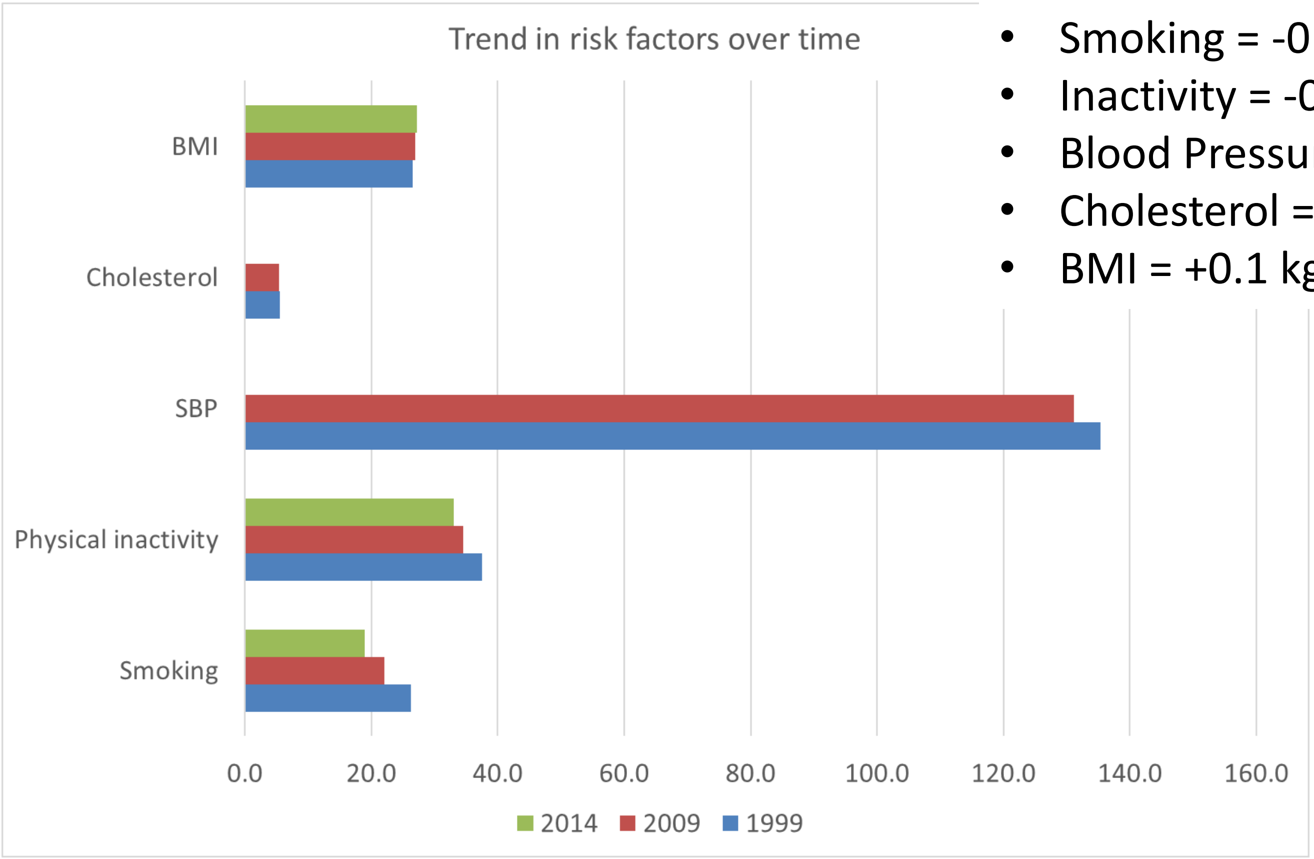
Even though the prevalence of some long-term conditions are decreasing the aging population means that the numbers of multiple and complex conditions is likely to continue increasing. Model estimates show a 34% increase in multiple and complex conditions over the next 20 years:

- 33% increase from multiple conditions and;
- 40% increase from complex conditions.



Multiple – 2 or more long term conditions
Complex – Dementia, SMI and neurological conditions and LD

The level of risk factors within the population is changing

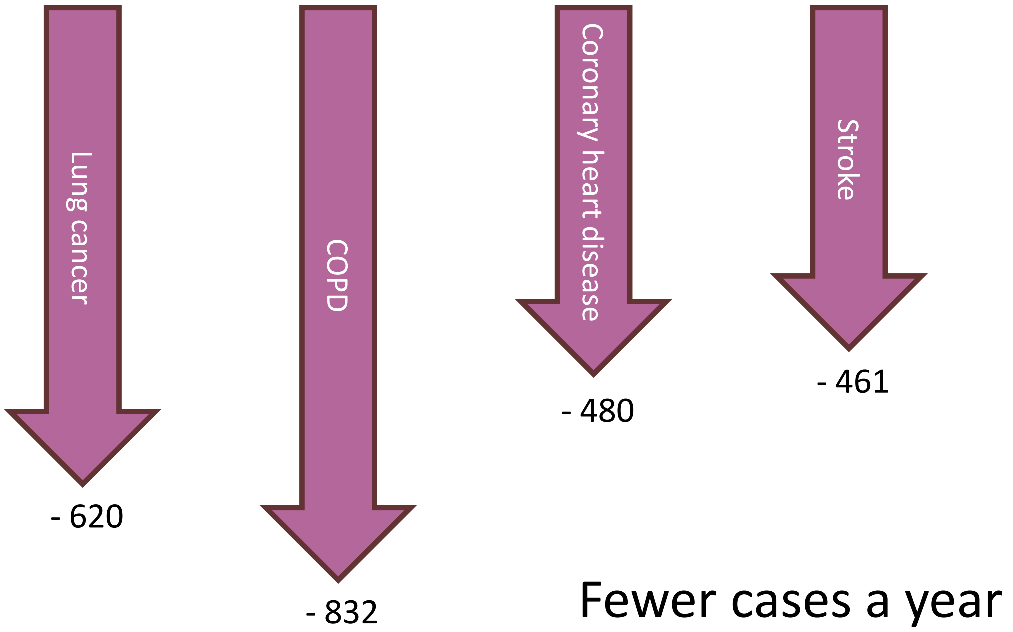


Annual risk factor change(s):

- Smoking = -0.4%
- Inactivity = -0.3%
- Blood Pressure = -0.2-0.4 mmHg
- Cholesterol = -0 – 0.01 mmol/l
- BMI = +0.1 kg/m

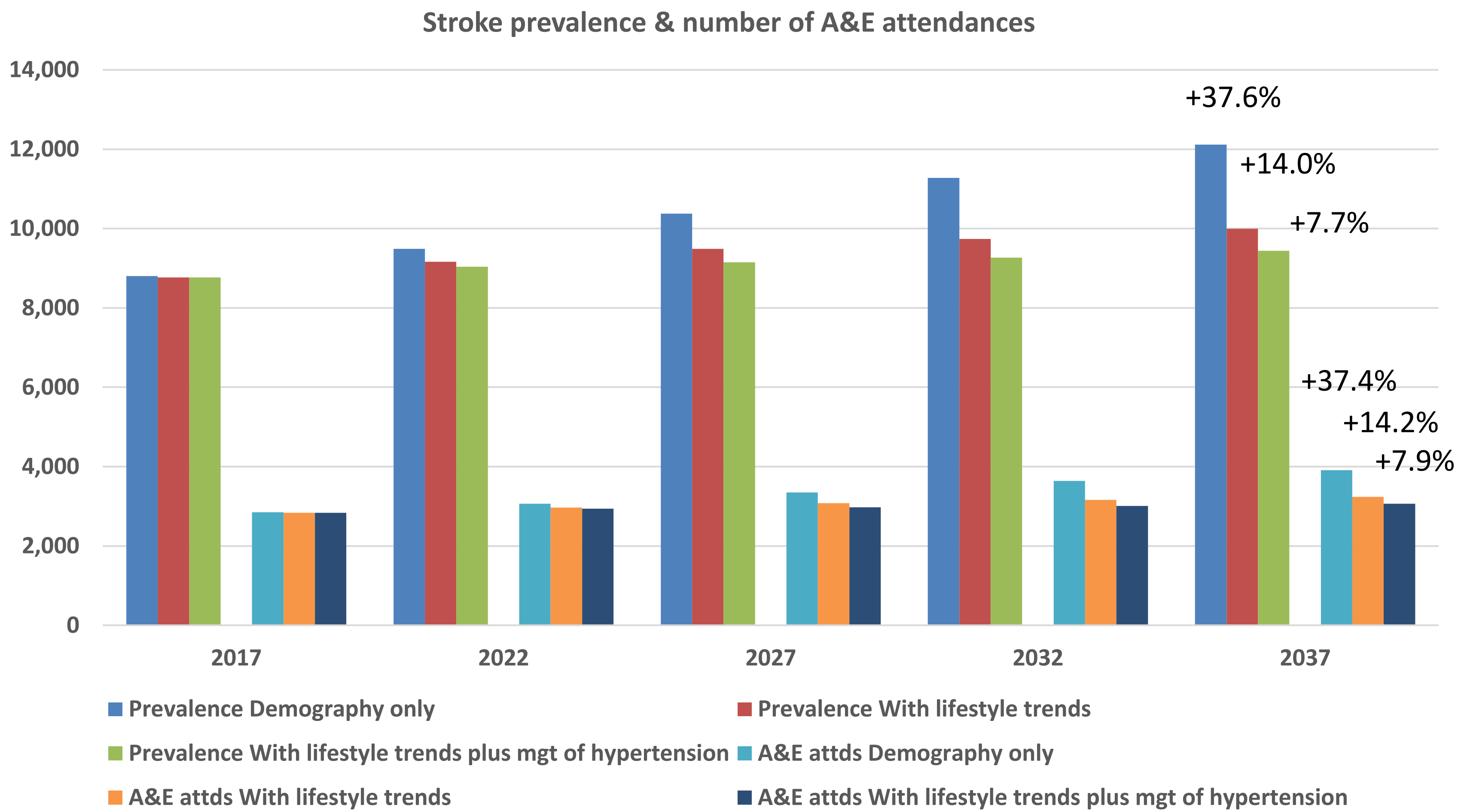
What if – we reduce levels of smoking to 12% across Kent...

The impact of changing one risk factor on a number of conditions:



What if – we address a range of lifestyle changes & manage hypertension...

The impact of changing a number of risk factors on one condition (Stroke):



How has the JSNA Cohort Model been used in the past?

- Pre COVID: The model helped inform Kent-wide, local system JSNA work, 5 year Long Term Plan including specific models for ‘local care’ capacity planning e.g. mental health, multimorbidity, frailty
- During COVID: JSNA Cohort model outputs inputted into a customized COVID model which helped toward local surveillance and emergency planning

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- During COVID: JSNA Cohort model outputs inputted into a customized COVID model which helped toward local surveillance and emergency planning

systems MDPI

Article

Use of System Dynamics Modelling for Evidence-Based Decision Making in Public Health Practice

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Abstract: In public health, the routine use of linear forecasting, which restricts our ability to understand the combined effects of different interventions, demographic changes and wider health determinants, and the lack of reliable estimates for intervention impacts have limited our ability to effectively model population needs. Hence, we adopted system dynamics modelling to forecast health and care needs, assuming no change in population behaviour or determinants, then generated a "Better Health" scenario to simulate the combined impact of thirteen intervention effects defined by age groups and diagnosable conditions, including "no conditions". Risk factors for the incidence of single conditions, progression toward complex needs and levels of morbidity including frailty were used to create the dynamics of the model. Incidence, prevalence and mortality for each cohort were projected over 25 years with "do nothing" and "Better Health" scenarios. The size of the "no conditions" cohort increased, and the other cohorts decreased in size. The impact of the interventions on life expectancy at birth and healthy life expectancy is significant, adding 5.1 and 5.0 years, respectively. We demonstrate the feasibility, applicability and utility of using system dynamics modelling to develop a robust case for change to invest in prevention that is acceptable to wider partners.

Keywords: system dynamics; public health; decision making; prevention; long-term conditions; resource allocation; complex systems

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1. Introduction

In any local health system, data and intelligence are essential for service planning and investment/disinvestment decision making for a defined population. This will invariably include forecasting demographics, health determinants, disease distribution and health status. At present, most attempts at forecasting the future health and care needs of local populations rely on linear extrapolations, which use a series of limited assumptions to estimate the likely burden of a specific health condition or demand for a service. These assumptions include trends in population change as well as in the condition or service under investigation [1]. This method of forecasting can be described as predictive analytics, where historical data are used to make predictions about future events [2]. Prevention is a key activity in public health, and this requires robust evidence to convince decision makers to invest in prevention where the gains may not be immediately apparent.

A variety of tools explaining the public health cost-effectiveness of individual interventions have been published, providing evidence for implementing them or not [3]. However, the use of such tools may not be feasible when it comes to extrapolating directly to local systems and contexts for financial and capacity planning, and decision making for

https://www.mdpi.com/2079-8954/11/5/247

Open access Original research

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Planning for healthcare services during the COVID-19 pandemic in the Southeast of England: a system dynamics modelling approach

Abraham George,[1] Peter Lacey,[2] Padmanabhan Badrinath,[1] Alex Gray,[2] Paul Turner,[2] Chris Harwood,[2] Mark Gregson[2]

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ABSTRACT

Objectives To develop, test, validate and implement a system dynamics model to simulate the pandemic progress and the impact of various interventions on viral spread, healthcare utilisation and demand in secondary care.

Design We adopted the system dynamics model incorporating susceptible, exposed, infection and recovery framework to simulate the progress of the pandemic and how the interventions for the COVID-19 response influence the outcomes with a focus on secondary care.

Setting This study was carried out covering all the local health systems in Southeast of England with a catchment population of six million with a specific focus on Kent and Medway system.

Participants Six local health systems in Southeast of England using Kent and Medway as a case study.

Interventions Short to medium 'what if' scenarios incorporating human behaviour, non-pharmaceutical interventions and medical interventions were tested using the model with regular and continuous feedback of the model results to the local health system leaders for monitoring, planning and rapid response as needed.

Main outcome measures Daily output from the model which included number infected in the population, hospital admissions needing COVID-19 care, occupied general beds, continuous positive airway pressure beds, intensive care beds, hospital discharge pathways and deaths.

Results We successfully implemented a regional series of models based on the local population needs which were used in healthcare planning as part of the pandemic response.

Conclusions In this study, we have demonstrated the utility of system dynamics modelling incorporating local intelligence and collaborative working during the pandemic to respond rapidly and take decisions to protect the population. This led to strengthened cooperation among

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ Use of local real time data and intelligence to develop local assumptions to reshape the model to make it more relevant and useful to our system as national assumptions were less applicable.
⇒ Use of system dynamics modelling enabled us not only to incorporate standard quantitative variables such as the reproductive number (R) but also include complex system factors for example, human behaviour.
⇒ We did not use the reproductive number over time (R(t)) as an input but rather estimated it over time as a model output. We did, of course, need an initial reproductive number (R(o)). This was a major strength in the modelling as alternatives available at the time ran 'what-if scenarios' based on different R(t) without reference to the progress of the pandemic, while our modelling kept a record of the balance of susceptible exposed infected recovered populations and therefore could estimate R(t) quite effectively given R(o).
⇒ The model is based on patients admitted for COVID-19 care and does not include those admitted with COVID-19 for other conditions and or those COVID-19 cases acquired in hospital.
⇒ Initially, there were inconsistencies in data submission by various health systems. However, the very act of modelling and then sense checking against actuals through iterative cycles led to a number of data improvements in local hospitals. So, the modelling approach led to improved accuracy and consistency in data sources over time.

analysis and modelling. Given the novelty of

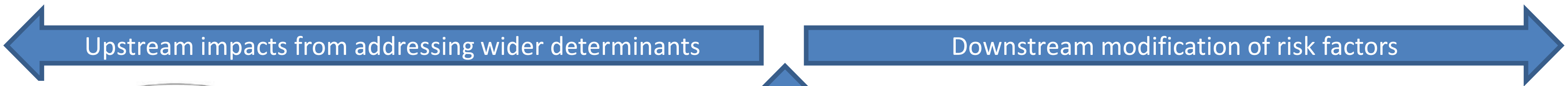
https://bmjopen.bmj.com/content/bmjopen/13/12/e072975.full.pdf

How is the JSNA Cohort Model being used now?

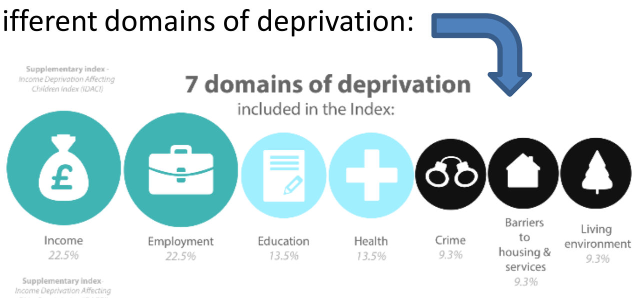
- We have explored the potential for accommodating wider determinants into the modelling approach – conceptualisation is considered valid with the potential to develop
- KCC is developing a transformation programme for commissioned services with a view to them being in place by March 2026 – the JSNA tool is being used to consider options for transformation at the very early stages of this process

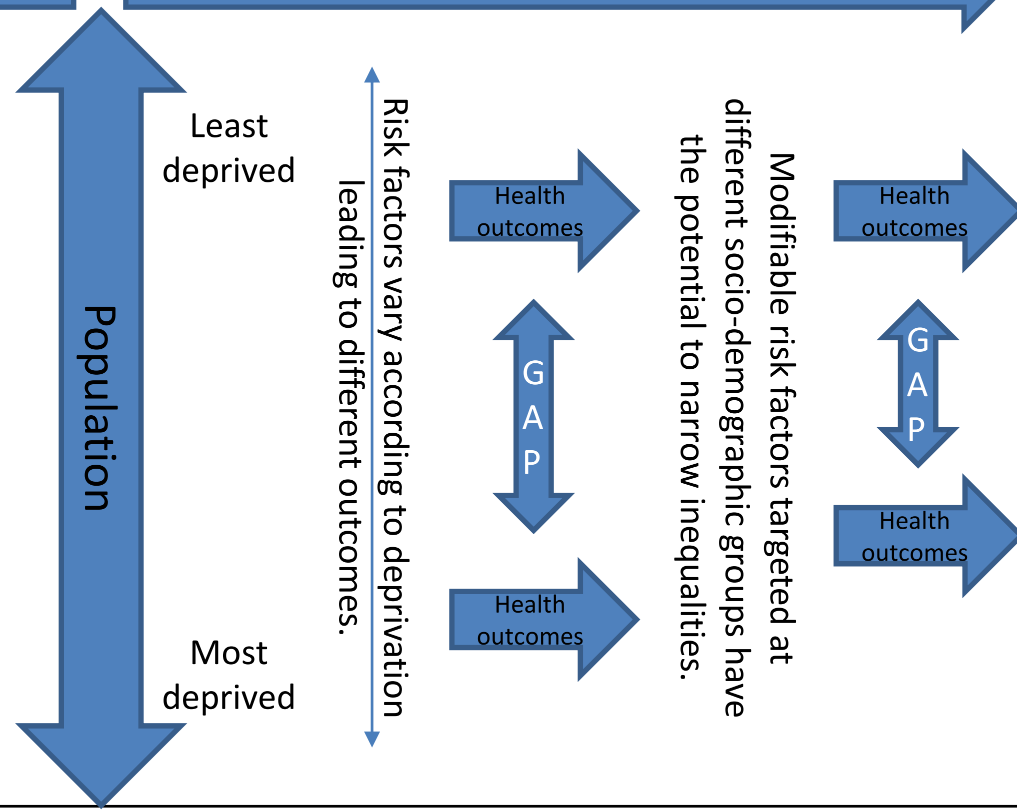
Understanding and reducing inequalities

The JSNA Cohort model is able to help us understand the risk factors and future health needs for different socio-economic groups in the population – upstream through impacting on the wider determinants and downstream by targeting modifiable risk factors in the population...



Changes in living and working conditions over time for a given population will impact on the different domains of deprivation:





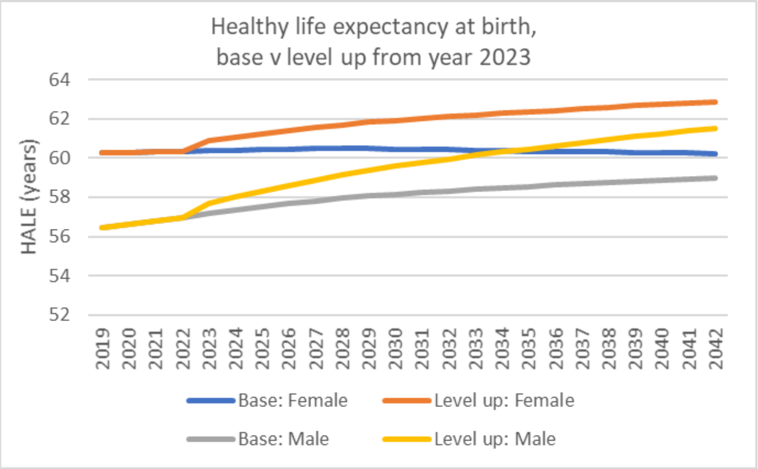
The impact of social inequalities

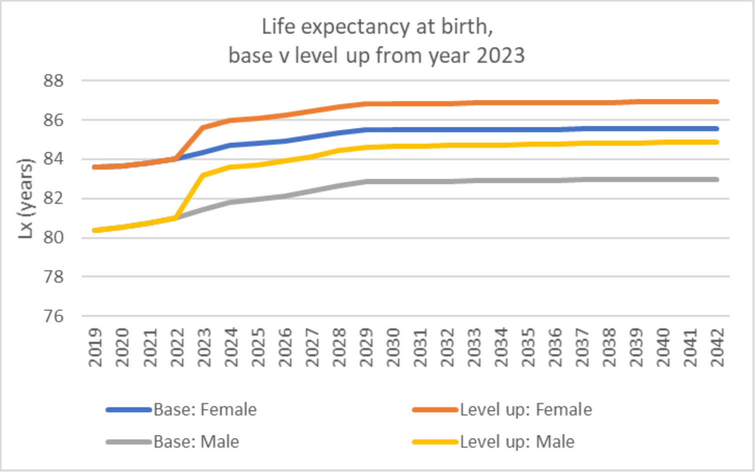
Social inequalities have a significant impact upon health and mortality for a population. For example, compared to average the most deprived fifth of the population is:

- 60% more likely to have cardiovascular disease or stroke;
- 40% more likely to have a severe mental illness and:
- 30% higher all cause mortality rates.

Starting in 2023 to 2042, if the whole population of Kent and Medway achieved the same health and mortality as the least deprived fifth of the population this could add:

- 2.6 and 2.5 years of healthy life expectancy for men and women respectively and;
- 1.4 and 1.9 years of period life expectancy at birth for men and women respectively.

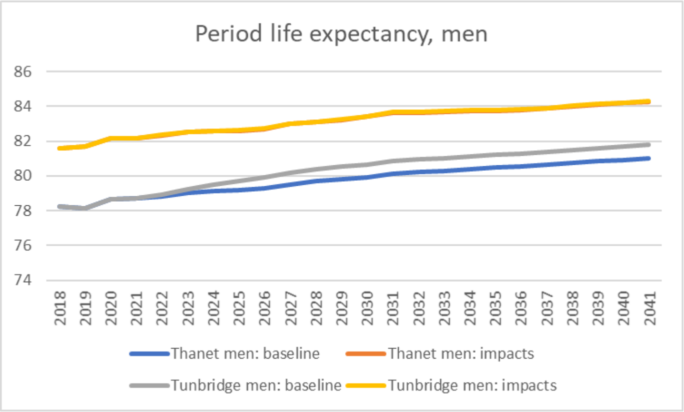




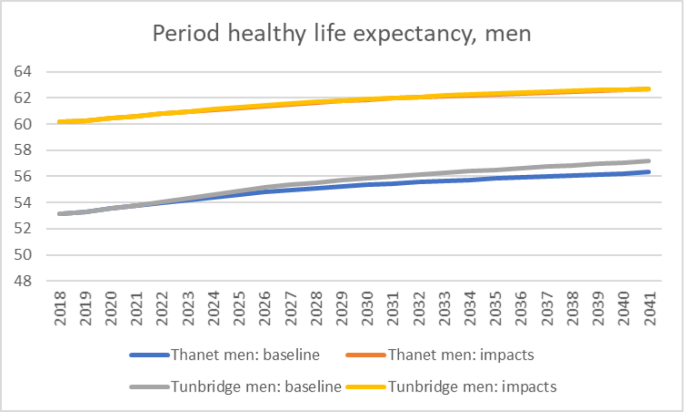
Impact of deprivation shift, Thanet v Tunbridge

LAD	Deprivation Quintile 1	2	3	4	5
Ashford	16309	18580	40032	30155	18971
Canterbury	19751	17137	38705	45925	38145
Dartford	10771	19040	36299	19476	17945
Dover	21299	24280	33379	26558	7930
Folkestone and Hythe	23480	31706	27869	21659	5124
Gravesham	21763	27145	18897	23012	14898
Maidstone	10843	27990	49948	32002	42569
Medway	63060	78676	44647	53843	34165
Sevenoaks	3017	7943	29562	38417	39226
Swale	34845	39415	35608	22654	8370
Thanet	51404	35623	27429	23944	1422
Tonbridge and Malling	4944	15044	24640	38133	43018
Tunbridge Wells	2053	7996	24111	32922	49528

LAD	Deprivation Quintile 1	2	3	4	5
Ashford	0	34889	40032	30155	18971
Canterbury	0	36888	38705	45925	38145
Dartford	0	29811	36299	19476	17945
Dover	0	45579	33379	26558	7930
Folkestone and Hythe	0	55186	27869	21659	5124
Gravesham	0	48908	18897	23012	14898
Maidstone	0	38833	49948	32002	42569
Medway	0	141736	44647	53843	34165
Sevenoaks	0	10960	29562	38417	39226
Swale	0	74260	35608	22654	8370
Thanet	0	87027	27429	23944	1422
Tonbridge and Malling	0	19988	24640	38133	43018
Tunbridge Wells	0	10049	24111	32922	49528



Thanet – 0.75 years
Tunbridge – 0.04 years
- 22 % reduced inequality



Thanet – 0.83 years
Tunbridge – 0.04 years
- 12 % reduced inequality

The transformation programme

- Five areas where the cohort model can assist in evaluating the potential medium to long term impact on population health:
  - Health checks – targeting, capacity, impact…?
  - Smoking – new intervention models & Govt. policy
  - C&YP – for example reducing the numbers experiencing adverse childhood experiences
  - Weight management – improving access
  - Frailty – reducing risks such has falls

Support to the programme

Process:

1. Area considered with input from service lead
2. Conceptualisation of proposed transformation and 'fit' with the existing cohort model
3. Data gathering and model development
4. Testing model outputs with service lead
5. Data extraction, interpretation and documentation

Options:

A. Using the existing model to extract useful intelligence in response to the proposed transformation

B. Additional outputs from the model created

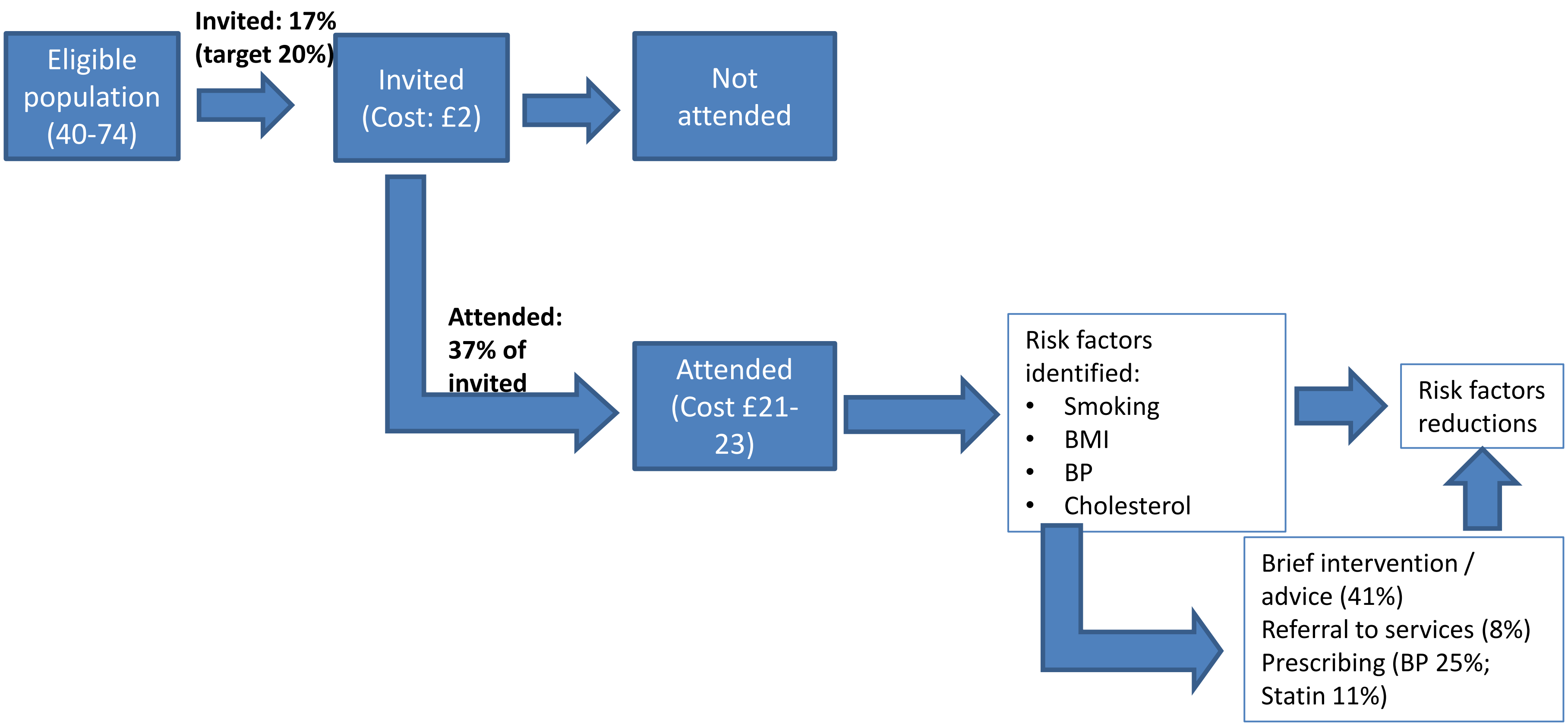
C. Minor model development to accommodate proposed transformation

D. Considered out of scope but potential for other modelling work

NHS Health Checks

- The aim of the NHS health check is to improve health outcomes and the quality of life our residents.
- Identifies people at early stages of vascular changes and provides opportunities to help reduce their future risk of cardiovascular disease ie. Stroke, dementia,heart disease ,diabetes and kidney disease

Current Health Checks implementation



Health checks

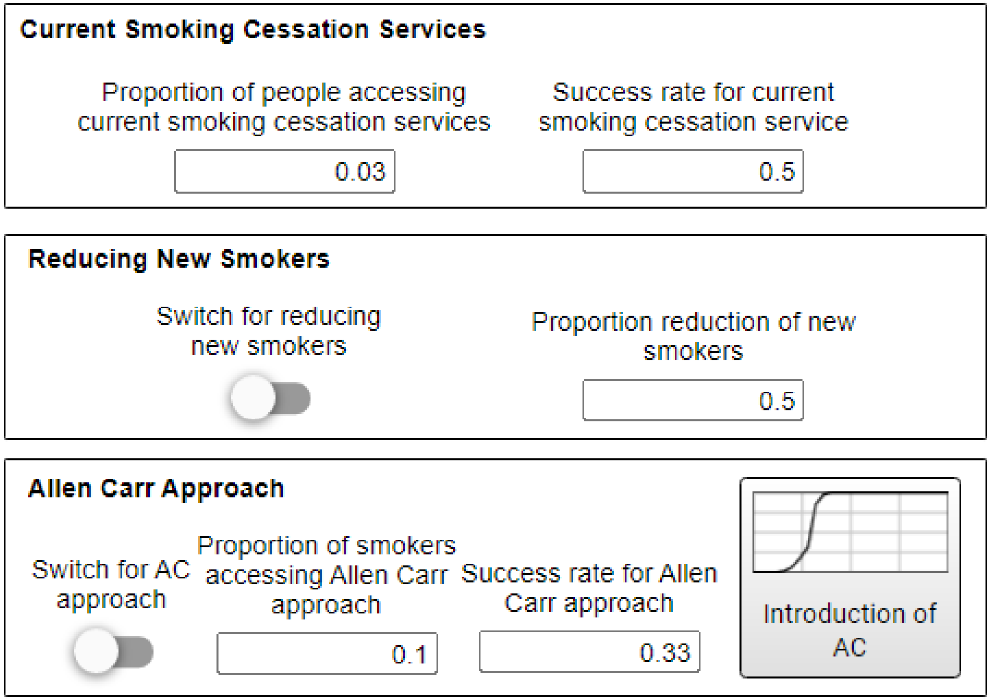
- Scenario A: continuing current implementation
- Scenario B:
  - for men continue the current implementation of NHS Health checks and;
  - for women targeting:
    1. the most deprived quintile and those from ethnic minorities and;
    2. current smokers and those who have a BMI > 30
- Scenario C: Scenario B but with improved uptake (50% most deprived) and increased treatment (increased prescribing by 30%)
- Scenario D: Scenario A but with improved uptake from deprived and ethnic minority populations and increased treatment

Health checks (2)

- Scenario D had the most impact upon disease incidence prevented or postponed
- Targeted approaches can have high impact condition related risks
- The model can also be used to estimate the impact upon inequalities
- Local intelligence / assumptions are needed to include interventions and generate different scenarios
- Other scenarios are possible adjusting age groups etc…

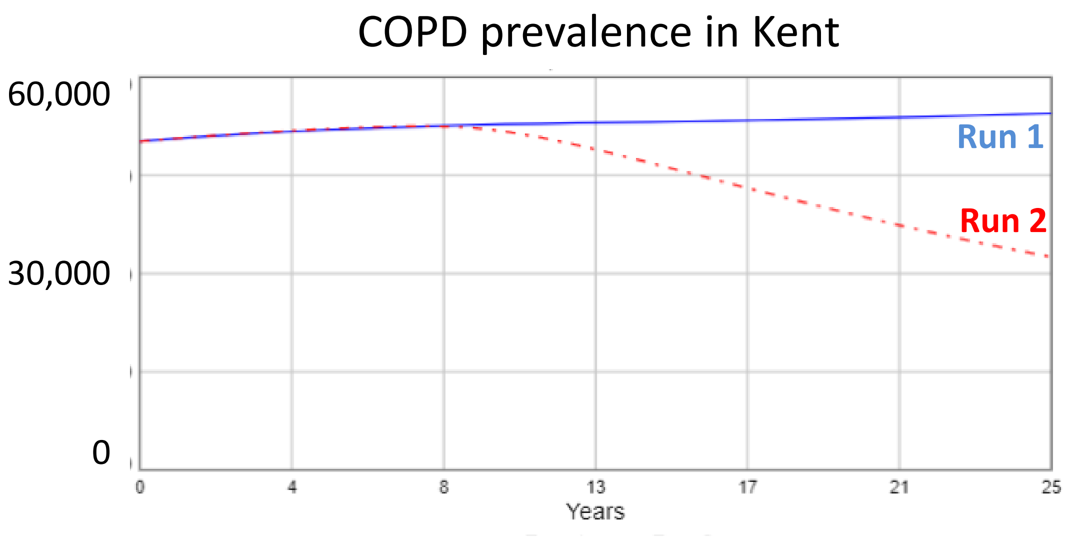
Smoking

- Baseline reduction for societal change
- Government policy to reduce new smokers
- 'Allen Carr' approach introduced between 3 and 9 years of the model



Smoking

- Primary effect: smoking prevalence
- Informs risk of all LTCs in the model



Example scenario

Run 1: current trends and existing smoking cessation services

Run 2: 'switched on' reducing new smokers and introduction of Allen Carr approach

Children & Young People

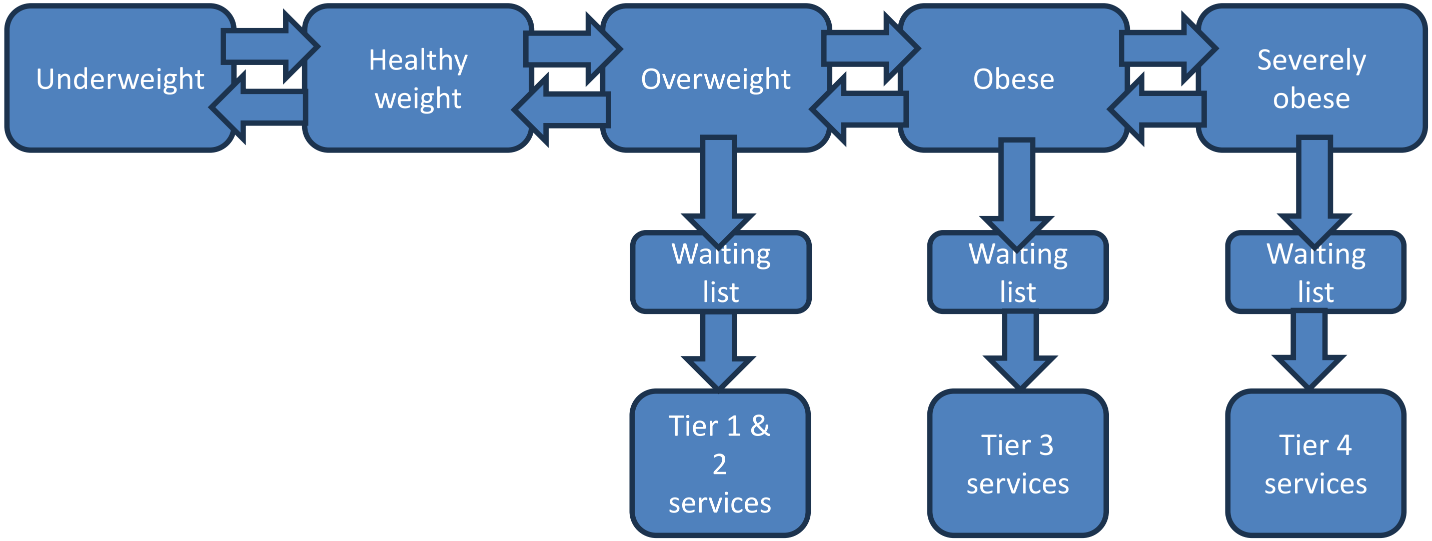
Adverse childhood experiences

- Switch off development from 2 to 3 ACEs
- Informs risk of: asthma, CHD, COPD, heart failure, stroke
  - Difficult to show
- To add: mental illness
- Alongside model: education attainment, crime

Other

- Smoking in pregnancy
- Infant feeding
- Fuel poverty

Weight Management



- We can use the cohort model with some additional data to identify cohorts of obesity in the population
- Expand the model to look at access to services from each of these cohorts
- Link the outputs back into the main population cohort to understand impacts
- Use this to test changes and improve understanding across the system

Weight Management

- Tier 1-4 services affect movement from right to left of the weight category chain
- Wider societal and behavioural factors will affect movement in either direction of the weight category chain
- An existing model created for the whole system approach to obesity can be used to modify the wider societal and behavioural factors that will affect the number of people in each of the weight categories
- Linking whole system approach to obesity model to cohort model via a weight management pathway will provide a holistic view of obesity and associated conditions

Frailty

- The model already tells us much about increasing levels of complex needs and frailty going forward (consistent with Chris Whitty's annual report last year), but what's the scale of that challenge in Kent and can it be moderated?
- Baseline cohort model projections for the number of people with severe frailty across Kent over a 5yr period suggested a c.16% increase compared with increases for the population with only one long term condition or none growing by c.3%;
- The questions that might be asked include the extent of the inevitable increases in the frailty population, whether slowing progression is possible but also whether the effort should be balance with enabling people to live and die well knowing that physical frailty is part of that journey.

Reflections from work on Health Checks

- The cohort model can be a useful ‘sobering’ tool to test impacts of interventions and run different scenarios
- Stakeholder engagement during model build is critical to ensure the right scenarios and outputs are generated
- Some of the scenario assumptions needed further scrutiny to check how realistic they were
- Robust local intelligence / assumptions are needed to include interventions and generate different scenarios – controlled evaluation of health checks programme using linked data is going to be essential to ensure assumptions are robust

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Conclusion

- Support to the Transformation Programme is part of a process of embedding the capacity and skills for using the Cohort model within the KCC PHO, with support from WSP;
- It is designed to assist in the early stages of designing the desired transformation before defining these in any specification or contracting arrangements;
- However, the Cohort model can still play a part in ongoing discussion and refinement of the desired future service – such a model is never final…