Modelling population health needs in the Barnsley Health and Social Care system

A System Dynamics contribution to understanding future population health needs – underpinning the Joint Strategic Needs Assessment & the Health & Wellbeing Strategy

Whole Systems Partnership

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Executive summary

This report explores the potential contribution that a 'stock and flow' modelling approach can make to understanding future population health needs. The project demonstrated that such an approach, enhanced by the application of intelligence derived from the national and other sources, has the potential to complement the tools available to refresh the local Joint Strategic Needs Assessment (JSNA), as well as forming the basis on which wider engagement of key stakeholders can be supported in making informed strategic decisions relating to both the Health and Wellbeing Strategy (HWB) and the local Strategic Transformation Plans (STP).

The modelling tool has been tested in other localities and this report provides outputs from a calibration of that tool to the Barnsley CCG registered population. It summarises an approach to understanding local adult health and care needs in terms of 'population cohorts'. In broad outline these cohorts are: the healthy population; those that are at heightened risk of developing a long-term condition due to factors such as obesity or smoking; those with a single condition; people with multiple conditions or complex needs; and people who are frail.

Importantly, for exploring alternative strategies for improving overall population health, the approach identifies the rates of progression of need using an evidence base rooted in the British Household Panel Survey and other sources. In addition, we have applied rates of access to key service types within the health and care system for each of the population cohorts. Together, these translate into a dynamic modelling environment that is able to respond to different 'what-if' questions regarding health and wellbeing interventions.

Understanding local population dynamics is complex given:

- Continued growth in the total Barnsley population to about 270,000 by 2037, from a current level of c. 240,000;

- The significant contribution that is made to this growth by net inward migration and increased life expectancy in older age;

- The changing nature of underlying risk factors that have the potential to lead to, or exacerbate, health and care needs – in this study we have focussed on levels of smoking, which are falling, levels of obesity, which are rising, diet which is improving and physical inactivity which is reducing;

- The natural ageing process at a population level as the 'baby boom' generation approach old age.

In this project, we have developed a 'best case' scenario based on continued reductions in levels of smoking, a reversal of the current trends in levels of obesity, improved diet and increased physical activity levels. These are all proven indicators for the incidence of conditions that lead to poor health and reduced life expectancy. We compare this 'best case' against a hypothetical position in which risk factor levels have not been decreasing and demonstrate the contribution to improved life expectancy and the overall burden of health needs that improvements in risk factor prevalence has and will continue to make.

Due to the underlying growth in the total population and using the modelling tool to explore possible future scenarios, it is reasonable to expect an increase in all major cohorts of need. However, when split into four simple groups of the healthy, those with a recognised single condition, those with multiple or complex conditions and those who are frail, and considered in percentage terms, we have arrived at a scenario in which the next 25 years will see:

- Continued, but slowing growth in the proportion of the population with a health condition;

- Small reductions in the proportion of the population who are healthy from the 2020's;

- Continued and significant rises in the proportion of the population who are frail.

In this picture 2020/21 appears to be a turning point for the moderation in growing health needs associated with diagnosed conditions, something that is attributable to the continued benefits into old age of reductions in smoking. The growth in the proportion of people who are frail, however, continues in its current trend almost irrespective of the scenarios run using the model. The proportion of the population we expect to be frail, on the definition used in the report, has already grown from about 3% in 2012, to nearly 3.5% today, and is expected to reach nearly 4% by 2037.

We have used the simulation model to explore one simple scenario relating to smoking cessation, representative of a public health intervention designed to improve overall population health. This has shown the moderate impact, particularly over the short to medium term, of this intervention when compared with reductions in the numbers of people who take up smoking in the first place. Whilst this does not argue against smoking cessation as a contribution to improved population health, it does provide the opportunity to compare the relative impact of different strategies.

The modelling tool has provided us with an initial appreciation of some of the medium to longer term challenges of improving population health and wellbeing. We have noted already the increasing proportion of the population who we expect to be frail. In addition, the model throws light on the following:

- *Life expectancy:* this continues to increase, but the modelling has suggested that any further increases could plateau during 30's unless significant health improvement measures are taken;

- *Healthy life expectancy:* current indications are that the years spent in poor health, including being frail, are increasing at a greater rate than total life expectancy, meaning reduced healthy life expectancy – our modelling suggests that this will have been particularly the case during the early 2020's but will moderate during the later 2020's and 30's, although any reversal of this is not within scope of the combined prevention measures included in the model at the moment;

- *The number of deaths:* these will continue to rise, currently estimated at c.2,400 a year, rising to c.2,700 a month by the end of the 2030's, with the percentage of deaths from those who are frail increasing from c.41% at present to c.47%;

- *Service utilisation:* the modelling has demonstrated the impact of changing population health needs on different health and care services, although our assumptions have not been 'normalised' to Barnsley – increases above the growth in total population are evident across all service types included, but particular increases are noted in services relating to the increase in the frailty population, for example social care home support.

This report demonstrates progress in developing an improved understanding of changing population health needs, and what can be done to address them, using 'stock and flow' modelling.

1 Introduction

1.1 Context

The Whole Systems Partnership (WSP) were asked to work with the Barnsley Council to develop a System Dynamics model that could demonstrate the impact of prevention and other 'whole population' interventions on overall health needs over the medium to longer term

The goal of the project is to demonstrate the potential contribution this approach can make to the development of the Strategic Needs Assessment for Population Health Management (PHM). The output from the work is a simulation model based on aggregate 'stock and flow' information relating to the health status of the whole adult population segmented into broad cohorts of need (application to children's health and care needs is possible but was considered out of scope for this initial exercise).

This report summarises the approach, the key assumptions, outputs and learning from the project. It is not the finished product, but an example of the potential uses of the system dynamics modelling approach to aid other approaches to population health intelligence.

1.2 Purpose for the project

The objectives for this modelling were:

1. To create a System Dynamics model that will provide population level projections of adult health needs with a view to identifying overall population health and wellbeing, and demands placed upon health and care services;
2. To identify, and project forward, the impact of key public health interventions and/or strategies on health and care outcomes and utilisation, including:
   a. The impact of smoking prevalence reductions and smoking cessation interventions;
   b. The impacts of interventions to reduce obesity;
   c. The impact of increasing primary prevention of hypertension.

The approach to modelling the health need and demands for adults included:

- A population approach to cohort groupings;
- The British Household Panel Survey to provide epidemiological analysis of the incidence, mortality and recovery of cohort groups;
- A system dynamics approach to model the health need and demand for adults aged 18 years and over from 2012 to 2037;
- Validation using local data sources, including population projections and local death statistics.

The preliminary results of this work show that it has been possible to create a model that produces reliable estimates for adult health needs for the Barnsley population, and is repeatable for other regions, and potentially at lower geographical levels. The demand for health care identified in the analysis is likely to be less reliable and requires local triangulation to validate due to the different models of care in different regions, but never the less still provides a very useful starting point for debate, further analysis and a basis for exploring local transformation programmes.

The main deliverable, described below, is a dynamic model of the relationship between population cohort needs and demand for services. The model outputs a monthly forecast of the overall shape of population health needs and demand for services over

a 25-year period from 2012. The approach that this report describes contributes to a potentially wider application that combines three complementary approaches, namely:

1. The use of the cohort study to provide the underlying epidemiology about incidence, prevalence and recovery of adult disease and illness, as well as inputs about demand for services such as hospital admissions and GP attendances.

2. A spreadsheet based template containing detailed analysis of demographic projections, epidemiology, hospital utilisation rates and assumptions. This analysis provides the assumptions that are fed into the third element of the tool…..

3. A System Dynamics modelling tool that combines this data in a simulation environment where future 'what if' scenarios can be explored.

Together these provide the context for more local application and operational planning for the future need and demand for health and care services and the impacts of population health risk factor changes. The model requires a range of input data, described in more detail below. Current values for various parameters in the model were chosen using a combination of available evidence and / or the knowledge and experience of the local stakeholders. Model validation and calibration work has also explored the sensitivity of the model to changes in input parameters. These are described later in the report.

2   Developing the model assumptions

2.1   Cohorts of health needs for adults

There is a lack of specialised studies that focus both on adult health problems and the link with health care demands. The *British Household Panel Survey* (BHPS) is an on-going survey of circa 15,000 population aged 15 years and over of people living in households, undertaken since 1990. The English Longitudinal Study of Ageing (ELSA) is a similar longitudinal survey undertaken since 2002, and reports on the health and wellbeing of adults aged 50 years and over. The data from both sources includes information on socio-demographic characteristics, health behaviours, health needs and demands including health and social care contacts. The modelling work has used the following data from the Cohort Study:

- Social classification;
- Condition linked to cohort;
- Disability (to create a frailty score for people aged 65 years and over);
- Number of health and care contacts by cohort.

Previous engagement work and experience has developed a method to help identify the types of conditions that enable adults with different health needs to be grouped relative to their current and future demands for services (Figure 1).
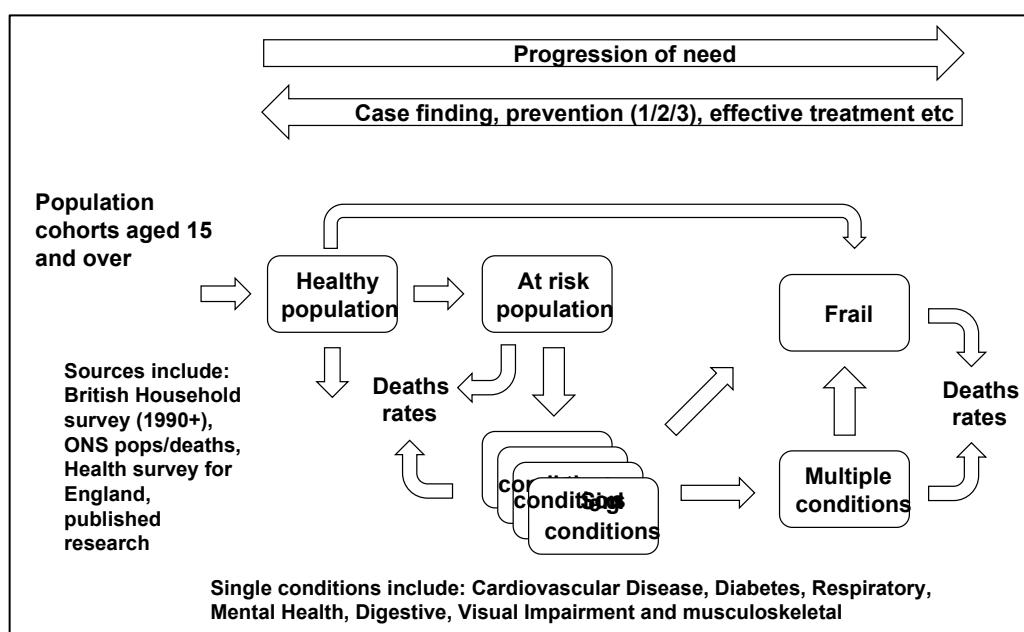
Figure 1   Conceptualisation of population cohorts underpinning the modelling tool

Our initial modelling has been guided by engagement work about cohorts and the use of a whole system approach. In this case we have used 14 cohorts that can be readily identified from the BHPS and ELSA, each with differing needs and demands for health and care services. The cohorts are distinct from each other so that an individual can only be in one cohort at a time but can change cohorts from one time step to the next. They are also grouped as a hierarchy so that people who are frail have, on average, the highest health and care needs, followed by multiple conditions, coronary heart disease etc…

	Age groups (years)					
Cohorts	18-49	50-59	60-64	65-74	75-84	85+
Healthy	89.6	76.8	70.2	58.8	43.2	31.8
Asthma	7.0	8.5	7.0	6.3	4.1	2.9
CHD	0.2	1.6	3.0	5.2	8.3	5.6
COPD	0.2	1.1	2.3	1.7	1.4	1.0
Diabetes type 2	1.0	3.9	5.7	5.5	5.3	4.6
Heart Failure[1]	0.0	0.0	0.0	0.0	0.0	0.0
Stroke	0.1	0.5	1.0	1.7	2.9	2.1
Moderately Frail	0.0	1.8	2.2	2.6	5.2	6.0
Multiple LTC	0.9	4.3	6.6	8.7	12.7	11.8
Severe mental health	0.6	0.8	0.5	0.2	0.0	0.0
Neuro	0.0	0.1	0.7	0.4	0.9	0.2
Dementia	0.0	0.3	0.5	0.4	1.7	1.9
LD	0.3	0.3	0.3	0.2	0.1	0.0
Severe Frail	0.0	0.0	0.0	8.5	14.2	32.2

Table 1   Baseline cohort prevalent rates (BHPS and ELSA)

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[1] Prevalence of heart failure appears as 0 because it always appears with another condition such as CHD and is therefore contained within the multiple condition cohort

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To create the cohorts of health need, annual incidence, prevalence and mortality rates were calculated using the BHPS and ELSA. Baseline incidence, prevalence and mortality were used to calculate the ongoing prevalence of each cohort. Prevalence rates were combined with population estimates for the same age groups to produce the baseline position. The data is aggregated further into cohort and social class, which enables the number of adults by area to be calculated. This approach is used with the aim of adjusting health needs for deprivation when considering different geographical areas.

Cohort	Healthy to cohort	Single to multiple	to severe Frailty	Death rate
Healthy	0.0	0.5	2.0	4.0
Asthma	1.5	10.7	2.4	3.7
CHD	1.6	25.3	8.0	24.0
COPD	1.1	43.6	25.8	36.9
Diabetes type 2	2.2	33.6	10.3	14.5
Heart Failure	0.0	0.0	0.0	0.0
Stroke	1.0	58.3	22.9	23.0
Moderately Frail	2.1	8.5	54.2	50.7
Multiple LTC	4.1		38.9	37.3
Severe mental health	0.1		10.5	8.0
Neuro	0.3		47.6	64.3
Dementia	0.6		65.6	73.8
LD	from CYP model		8.0	
Severe Frail				140.1

Table 2   Annual incidence per 1,000 population (BHPS)

Figure 2 shows how, using the British Household Survey, and adjusting for Barnsley socio-demographics, we arrived at an initial breakdown of needs for the purpose of this part of the project. The picture that emerges does not capture all comorbidities and is therefore an underestimate of this area of need, with corresponding increases in the estimate of numbers with single conditions.

In addition to the baseline demographics and need groupings, each cohort has a demand rating for health and care services, which includes GP appointments, outpatient attendances, hospital admissions, seen by a nurse, received social care support (home care, meals on wheels, social worker) etc…. When changes in the balance of cohort needs occur, influenced by risk factors which impact on the incidence of certain conditions, we can model potential impacts on service utilisation. The prevalence of risk factors for smoking, bodyweight and hypertension are calculated from the cohort study and the health survey for England, and impact on the healthy cohort within the model.
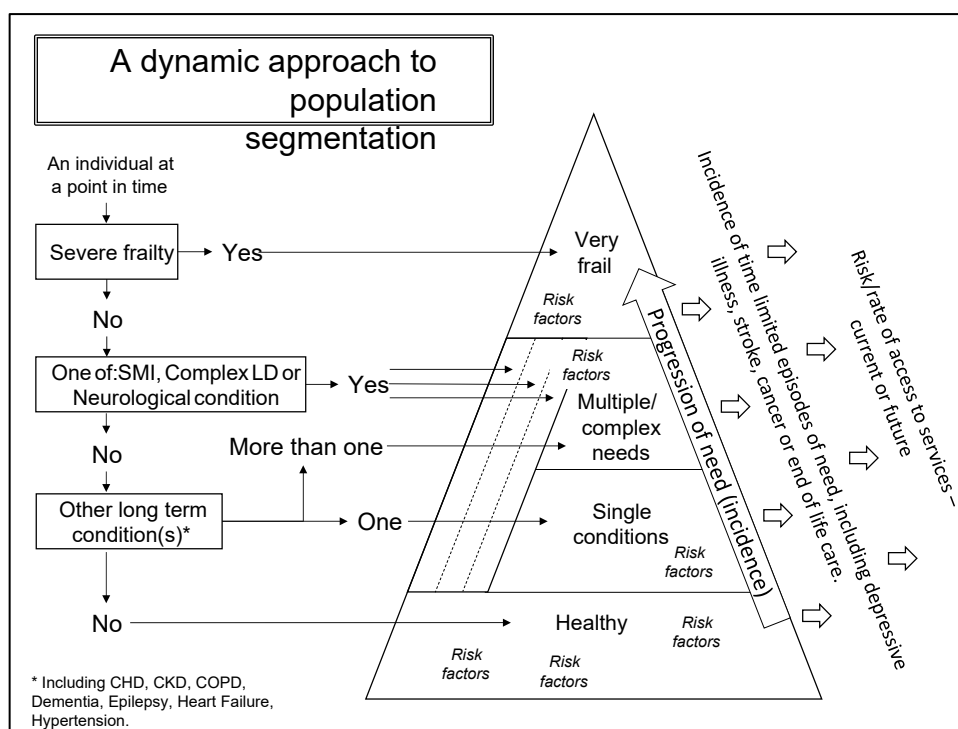
Figure 2   Adult health needs: cohort hierarchy

2.2   The impact of risk factors on the population

The rate of incidence and mortality for different cohorts is moderated by the impact of changing risk factors using the calculated population attributable fraction (PAF) for each risk factor. As previously mentioned the three initial risk factors in this model were smoking prevalence (and cessation), pre-diabetes (and bodyweight) and untreated or treated hypertension. The PAF calculates the proportion of the incidence and/or mortality of a cohort that is related to individual risk factors. When the risk factor profile changes e.g. the number of people taking up or quitting smoking changes, the population attributable fraction is adjusted, which either increases or decreases the cohort incidence and mortality rate.

The transition from the healthy cohort has been the focus of this work, but risk factors influencing the rate of death within each cohort, particularly in relation to secondary prevention for hypertension treatment have also been included.

Trends in risk factors from 2000 to 2009 are used as the basis for future changes up to 2037 (Table 3). This shows that the percentage of people smoking is decreasing by approximately 0.4% per year; for Body Mass index (BMI) it is increasing 0.2 kg/m2; for Blood Pressure (BP) it is reducing by 0.2 per mmHg; for cholesterol it is reducing by 0.01 mmol/l per year and untreated hypertension is decreasing by 0.2% per year.

	Change (+/-)
Smoking	-0.3
BMI	0.2
BP	-0.4
Cholesterol	-0.01
Physical inactivity	-0.5

Table 3   Annual risk factor changes

2.3 Calibration and comparison with Barnsley data

As mentioned previously the model has been calibrated to the Barnsley population in a number of ways. These include using the demographic profile, migration, age, deprivation and risk factors so that the model replicates as close as possible the changing shape of the Barnsley population over time, as currently reflected in ONS population projections.

Comparing the cohort prevalence and the local population projections illustrates that the model provides a reliable projection of total population (Figure 4). Table 4 summarises the respective demographic and local assumptions to which the model has been calibrated.

Assumptions	
Health areas	Barnsley CCG
Baseline population (over 18)	184,535 (mid-2012), c.191,188 (2017) and 214,188 (mid-2037) – a growth of 19% over the 23 years between 2017 and 2037
Number of people migrating in per year	c.1,500 people aged 18 and over net-migration into Barnsley per year
Deprivation	Barnsley is a less affluent profile of social class as England as a whole

Table 4   Local baseline demographic and deprivation data
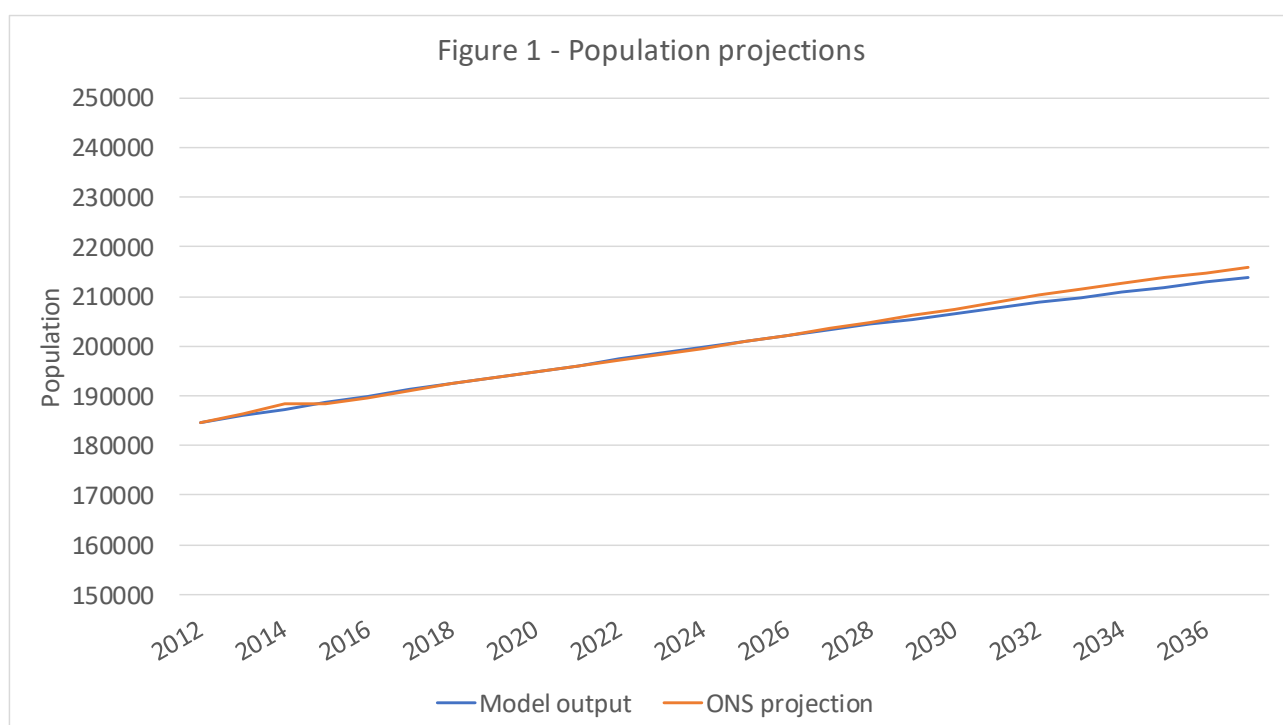

Figure 4   ONS Population projections v Model projection

3 Using the Model to Explore Scenarios

3.1 Factors contributing to changing health needs in Barnsley

It is very difficult from the data and cohort studies available to obtain an accurate estimate of future prevalence on a whole population basis, largely due to a focus in the evidence on single condition studies. However, our analysis of the BHPS has ensured that there is no double counting of people who might have more than one condition. The factors contributing to demographic change, and therefore to the shape of future health needs, include:

- Natural demographic growth, which will contribute an ageing process reflecting the national picture and will lead to increases in the very old who are likely to be frail;
- Net-migration, which in Barnsley is fairly significant, and in the short term adds relatively young and therefore overall healthy people;
- The prevalence of risk factors that impact on the incidence of specific health conditions, leading to an increase in people with specific or multiple conditions.

We have described how these are addressed in terms of the modelling in the previous section. This section combines the different population dynamics described above into a single model, with the ability to explore the impact of reducing key risk factors.

3.2 Scenarios for overall 'burden of health' calculations

The 'best case' scenario described in this section relies on the following assumptions regarding risk factors:

- That levels of smoking, reducing since 2000, continue to do so;
- That rising levels of obesity are reversed from 2017 due to a range of public health and related healthy eating initiatives at national and local level;
- That diet continues to improve leading to reduced blood pressure and cholesterol;
- That physical inactivity continues to reduce.

Each of these risk factors impacts on the incidence of certain conditions, which the modelling tool deals with individually, but which we have combined in this section to provide an overall sense of the changing health needs of the population.

Figure 5 shows the growth in the overall adult population of Barnsley, which increases in all three broad categories, based on the 'best case' scenario.
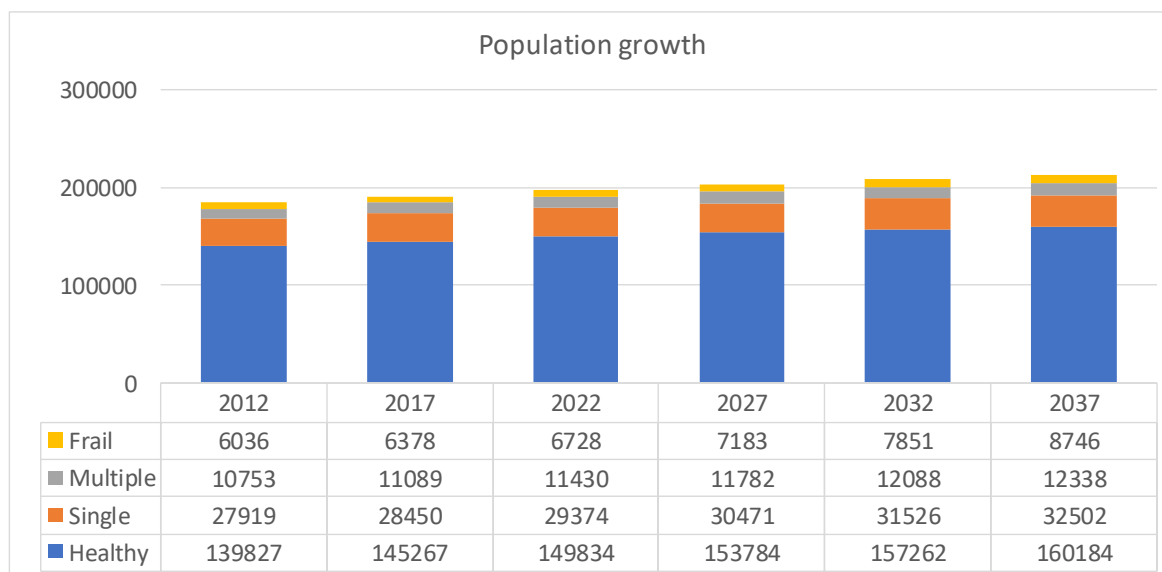
Population growth	2012	2017	2022	2027	2032	2037
Frail	6036	6378	6728	7183	7851	8746
Multiple	10753	11089	11430	11782	12088	12338
Single	27919	28450	29374	30471	31526	32502
Healthy	139827	145267	149834	153784	157262	160184

Figure 4   Barnsley population growth – healthy, with a health condition, with multiple and complex condition and frail (based on the 'best case' scenario described above)

The relative contribution of the different assumptions underlying this scenario can be seen in Figure 6. In summary, this suggests that:

- The benefits of reduced levels of smoking are noticeable, but continue to increase over the next 25 years, partly in response to continued reductions, but also because the benefits of having given up, or preferably never having started to smoke, are often only fully realised in later life;

- However, even with reduced smoking levels the prevalence of health conditions in the population continues to rise as a proportion of the whole population;

- The addition of reduced levels of obesity, diet and physical activity improvements further reduce the levels of, at a population level;

- There is approximately a 1% reduction in frailty when assessing the impact of all four underlying risk factors. However, frailty will continue to increase significantly, increasing by 30% between 2017 and 2037. The 'best case' in the longer term will still to see the numbers who are healthy and those with single or multiple conditions and frail population grow.

8

With a health condition
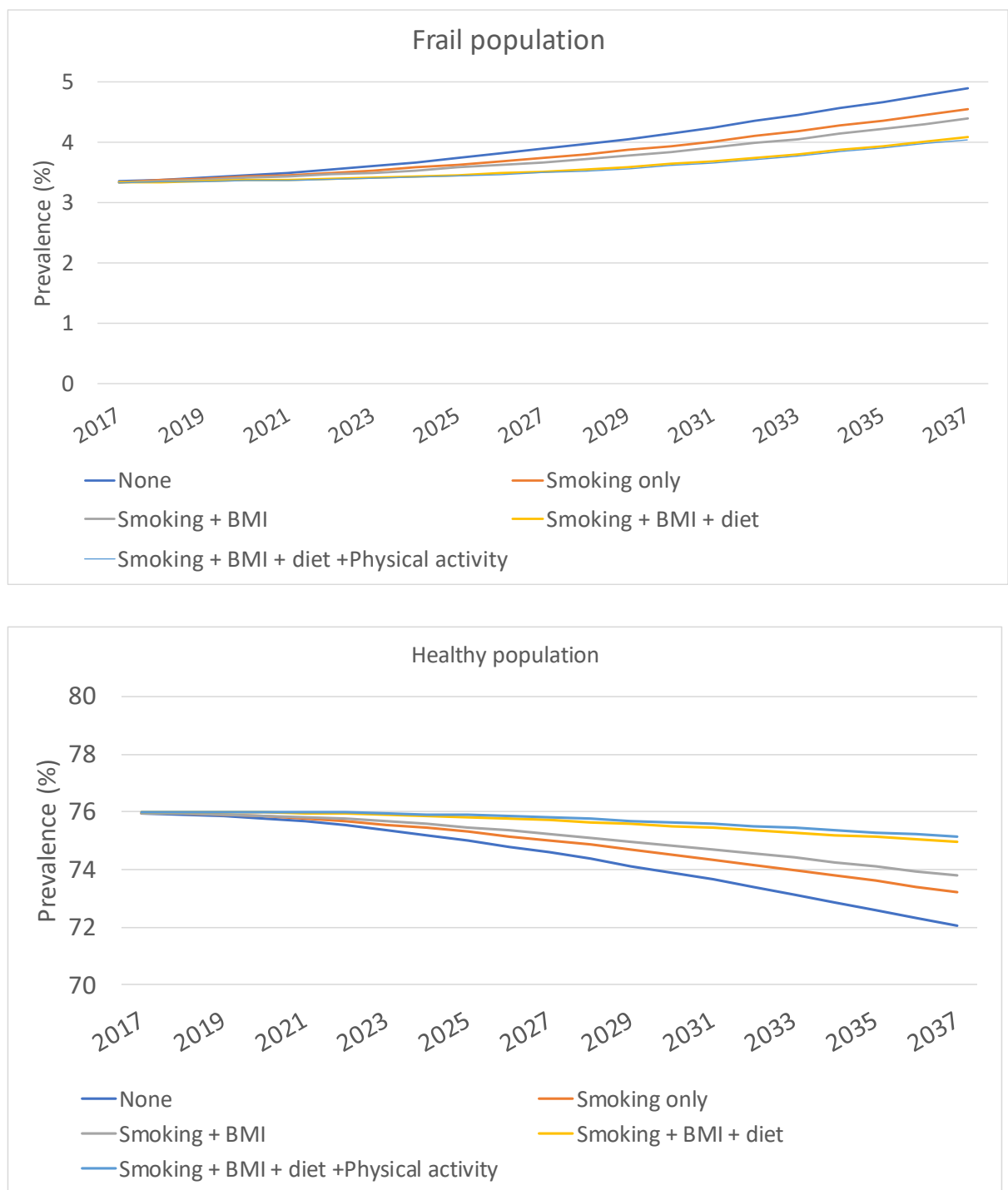

Multiple and complex population
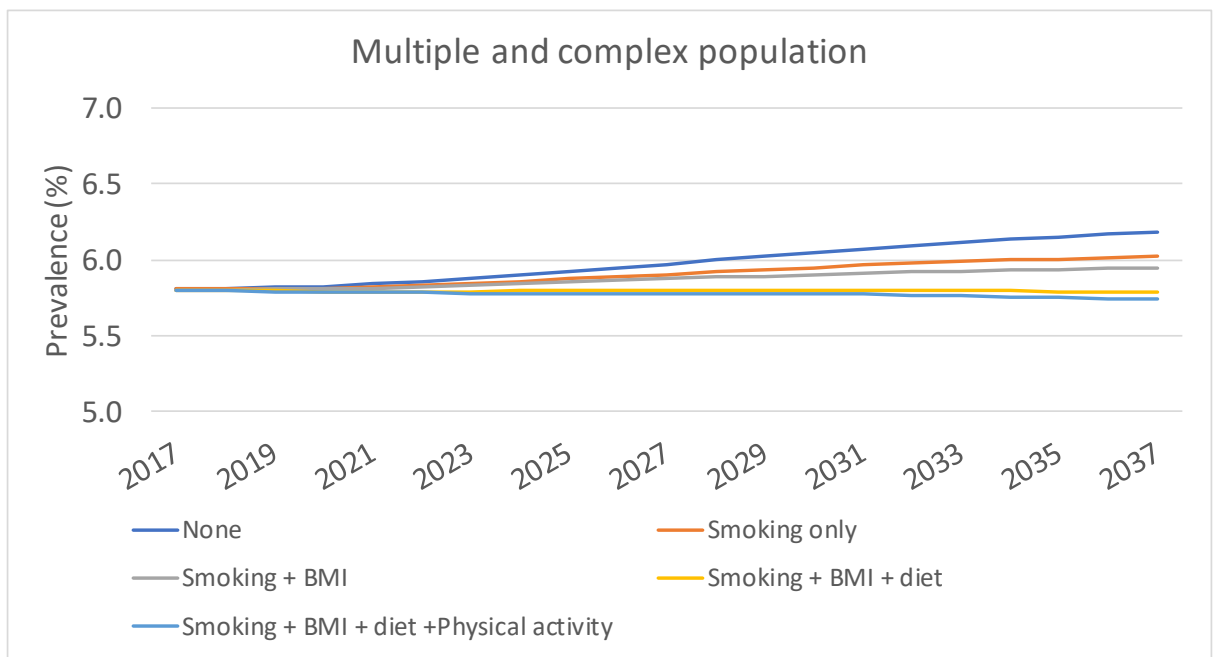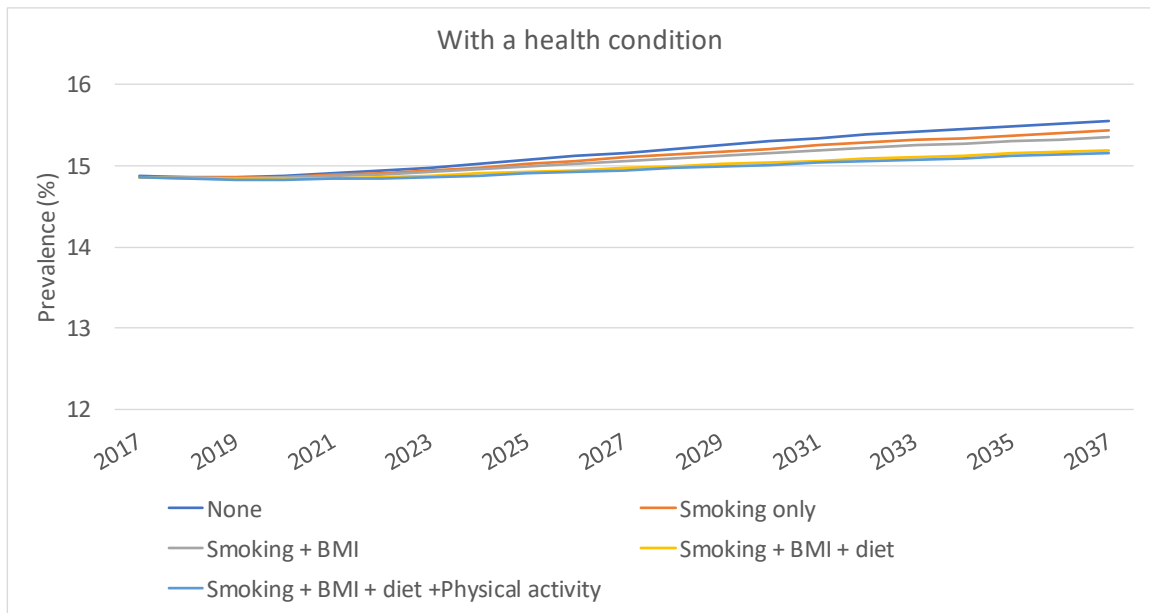
Figure 5   The percentage of people with a health condition, healthy, multiple and complex or frail under five different scenarios

The model results illustrate a continued increase in the absolute growth in most conditions / cohorts mainly as a result or the continued growth in the older population. Table 4 presents the change in prevalence across conditions illustrating the:
- reductions expected in cardiovascular and respiratory conditions, due to reductions in smoking, diet and physical activity;
- the increase expected in diabetes, due to continued increases in obesity and;
- the increase in dementia, neurological and frailty.

Condition	2012	2017	2022	2027	2032	2037	Change (2017 to 2037)
Asthma	9.5	9.4	9.2	9.0	8.9	8.8	-6.1
CHD	4.5	4.4	4.1	3.9	3.8	3.8	-13.9
COPD	2.9	2.8	2.7	2.6	2.5	2.5	-10.3
Diabetes2	5.5	5.7	6.3	6.7	7.3	7.8	38.1
HF	0.3	0.3	0.3	0.3	0.4	0.4	5.7
Stroke	2.5	2.4	2.3	2.2	2.1	2.1	-10.8
Frail moderate	3.1	3.1	3.1	3.2	3.2	3.2	3.9
Multiple LTC	5.2	5.3	5.2	5.3	5.3	5.3	1.8
SEMI	0.6	0.6	0.6	0.6	0.5	0.5	-13.8
Neuro	0.3	0.3	0.3	0.4	0.4	0.4	13.9
Dementia	0.7	0.7	0.7	0.8	0.8	0.9	19.7
LD	0.3	0.3	0.3	0.3	0.4	0.4	32.7
Frail severe	3.3	3.3	3.4	3.5	3.8	4.1	23.1

Table 4   Modelled prevalence of individual conditions (including overlap of conditions with multiple and frail cohorts)

3.3   Further scenario development – the smoking cessation example

The section above has described a basic set of assumptions to inform broad future scenarios. In addition, the modelling tool can explore the scale of impact that different prevention measures could have going forward.   As an example of that, we can illustrate the impact on the model from improved rates of smoking cessation, i.e. stopping people who already smoke.

Figure 7 shows the output from the model from 2012 to 2037 for the prevalence of respiratory conditions across Barnsley:

- Run 1 shows the growth in respiratory conditions had smoking prevalence remained at levels in 2012;

- Run 2 shows the impact of reduced levels of smoking, largely through people not starting to smoke;

- Run 3 shoes the additional benefit of an enhanced reduction in smoking cessation from 2018 by 5% for people who already smoke.

The significant observation is the additional benefit in terms of respiratory condition prevalence from the latter intervention. The actual difference at the end of the model run is a reduction of c. 100 on a population of about 5,000 people with COPD. This is in part because giving up smoking is not as beneficial as never taking it up, and also because the effect only starts in 2016. This is mirrored in Figure 8, which shows the same three scenarios for levels of smoking and smoking cessation, on this occasion with its impact on emergency inpatients admissions for COPD.
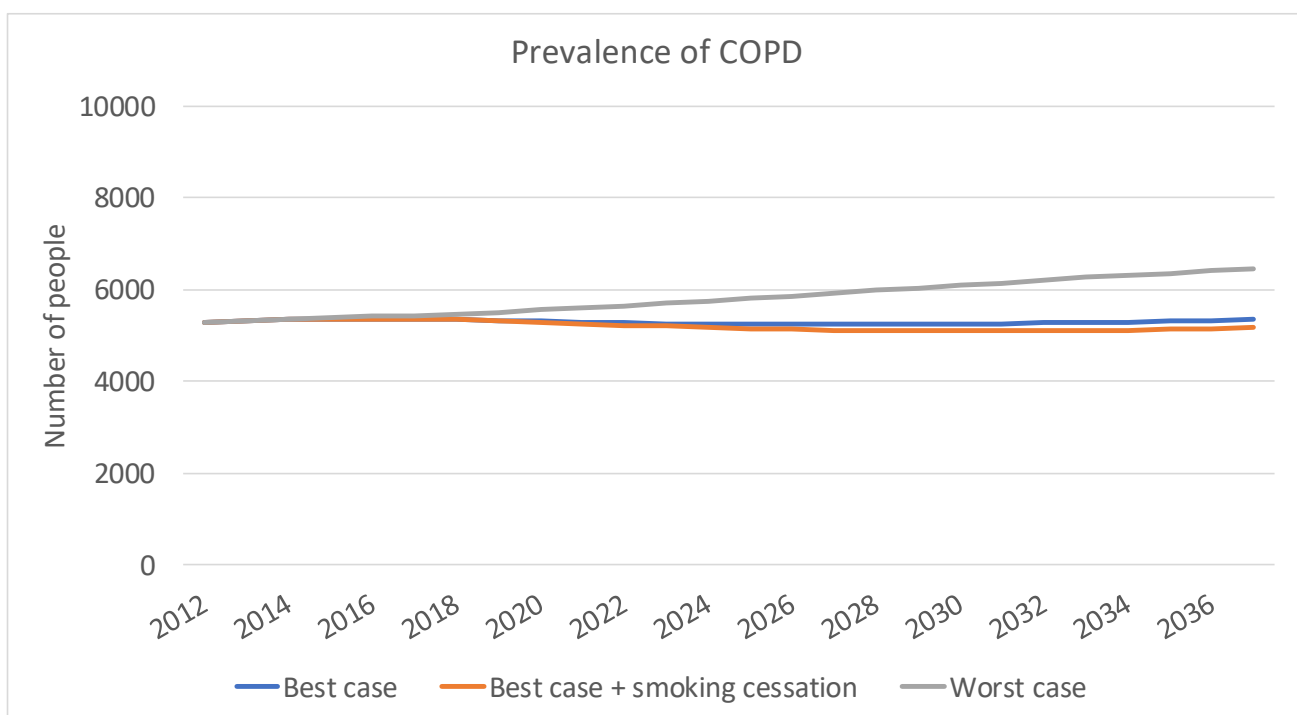
Figure 6 **The impact of reduced rates of smoking (Run 2) and smoking cessation (Run3) on the prevalence of respiratory conditions**
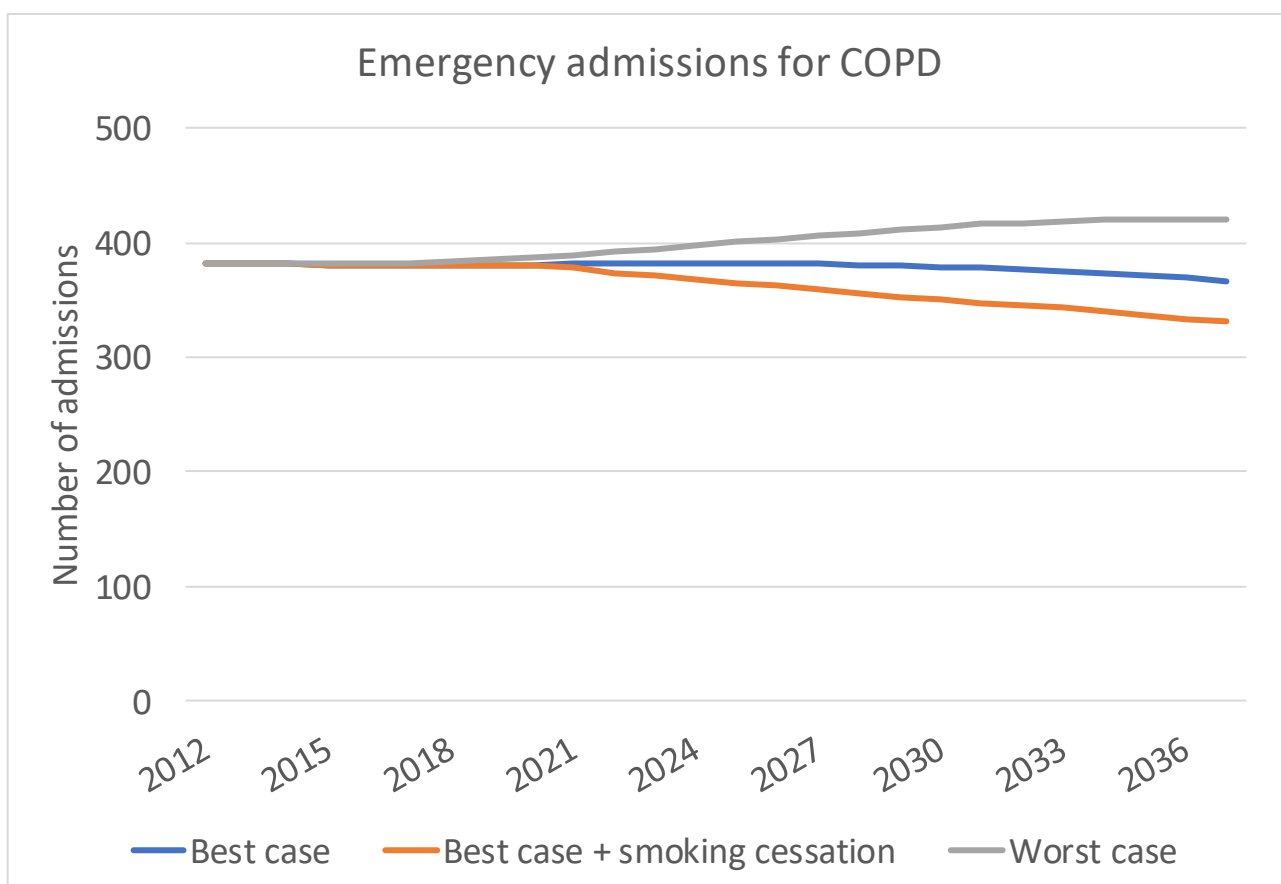

Figure 7 **The impact of reduced rates of smoking (Run 2) and smoking cessation (Run 3) on inpatient admissions for COPD.**

3.4 Further scenario development – the social deprivation example

It is well researched that many of the causes of ill health and disease causation are beyond the control of the individual or health and care system (ref.). In comparison, to the England average, Barnsley has a higher proportion of the adult population that are from lower social class / grade based on the 2011 Census (Table 5). This section provides an illustration of the impacts of reversing deprivation (or in this case lower social class).

Social Grade	Description	% HRP population (Barnsley)	% HRP population (England)
AB	Higher & intermediate managerial, administrative, professional occupations	13.9%	22.9%
C1	Supervisory, clerical & junior managerial, administrative, professional occupations	26.5%	30.9%
C2	Skilled manual occupations	25.5%	20.7%
DE	Semi-skilled & unskilled manual occupations, Unemployed and lowest grade occupations	34.1%	25.5%

Table 5   Approximated social grade

Figures 9, 10 and 11 show the impact upon the prevalence of single health conditions, multiple and complex conditions and severe frailty by reversing the percent in each social class grouping to be equivalent to the England average in Table 5 (SC reversal).

- Single health conditions show a 3,500 reduction by 2037;
- Multiple and complex health conditions show a 1,100 reduction by 2037;
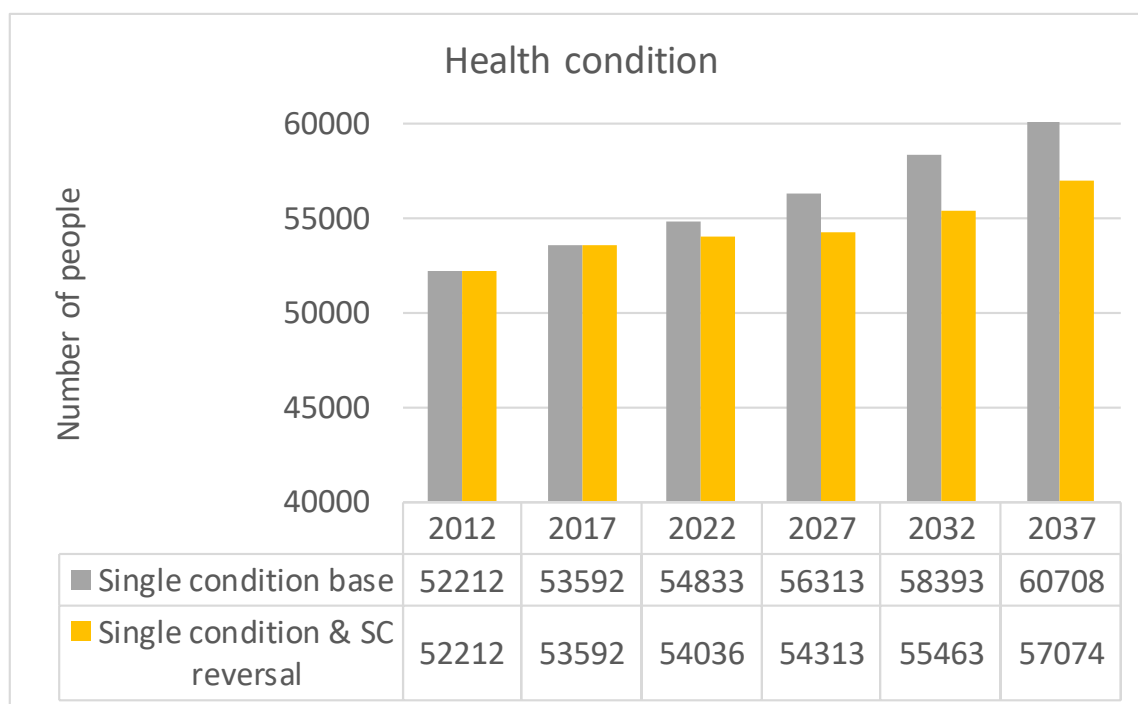- The impact for severe frailty shows about a 1,000 reduction by 2037;

Health condition

	2012	2017	2022	2027	2032	2037
Single condition base	52212	53592	54833	56313	58393	60708
Single condition & SC reversal	52212	53592	54036	54313	55463	57074

Figure 9   The impact of social class reversal upon the prevalence of single health conditions.

	2012	2017	2022	2027	2032	2037
■ Multiple & complex base	13315	13790	14252	14769	15346	15975
■ Multiple / complex & SC reversal	13315	13790	14028	14177	14444	14822
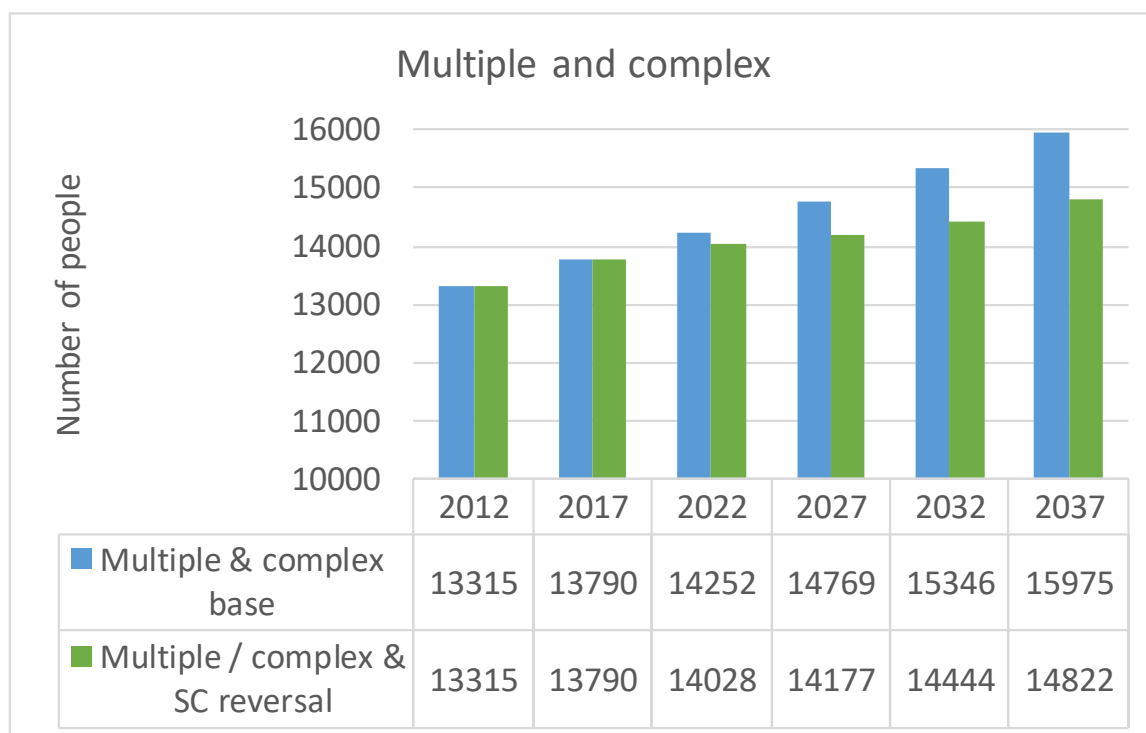
Figure 10   The impact of social class reversal upon the prevalence of multiple and complex health conditions.

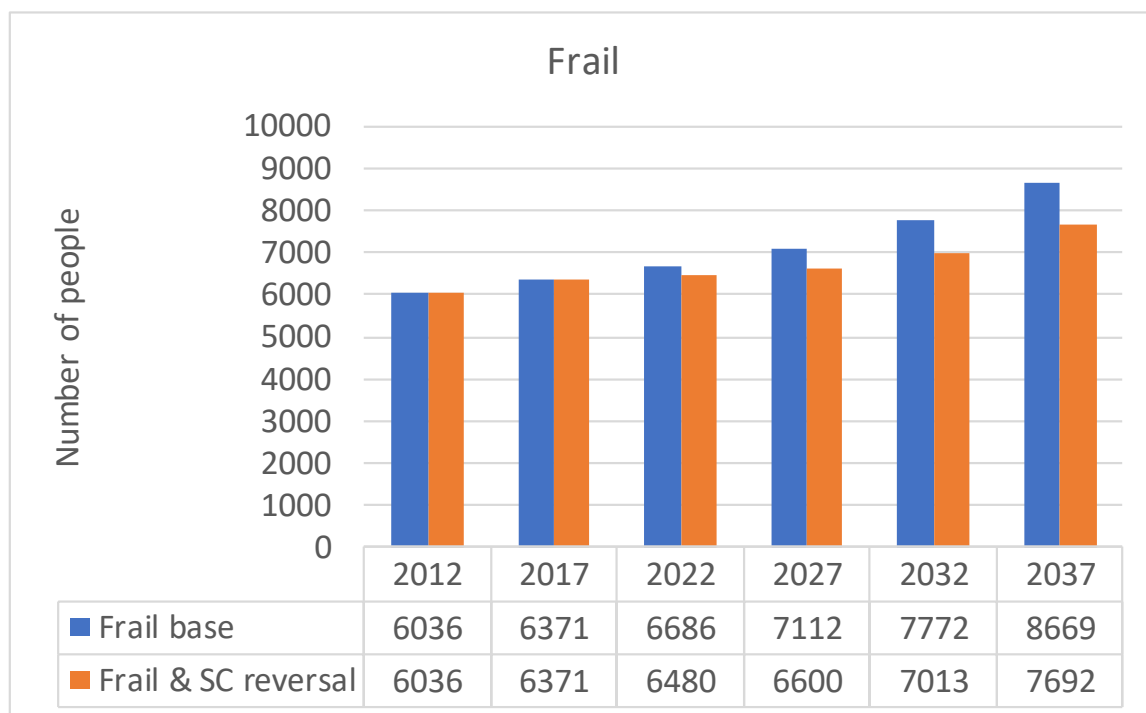|	2012	2017	2022	2027	2032	2037
■ Frail base	6036	6371	6686	7112	7772	8669
■ Frail & SC reversal	6036	6371	6480	6600	7013	7692

Figure 11   The impact of social class reversal upon the prevalence of severe frailty.

3.5 Life expectancy and healthy life expectancy at 18

The model currently develops outcomes for individual cohorts and health and care utilisation under different scenarios, but an approximation for health and life expectancy at age 18 is used as a summary measure of health improvement. This is illustrated in Figure 12 which represents the impact of risk factors upon life expectancy at 18 years. Figure 13 shows the equivalent outputs with the latter interventions included for healthy life expectancy.

Figure 12 illustrates the impact of the four underlying risk factors on reducing life expectancy at age 18 up to 2037. The impacts are as follows:

- 3.8 years for smoking;

- 1.9 years for BMI reversal;

- 3.9 years for improved diet and;

- 0.5 years for physical inactivity;

Figure 13 illustrates the impact of the four underlying risk factors upon healthy life expectancy at age 18 up to 2037. The impacts are as follows:

- 3.1 years for smoking;

- 1.6 years for BMI reversal;

- 3.3 years for improved diet and;

- 0.4 years for physical inactivity;

The charts show that improvements in life expectancy occur across the 20 years period, whereas for healthy life expectancy improvements plateaux at about 2027. This occurs because the ageing process increases the incidence from the healthy to single, multiple and frail cohorts.
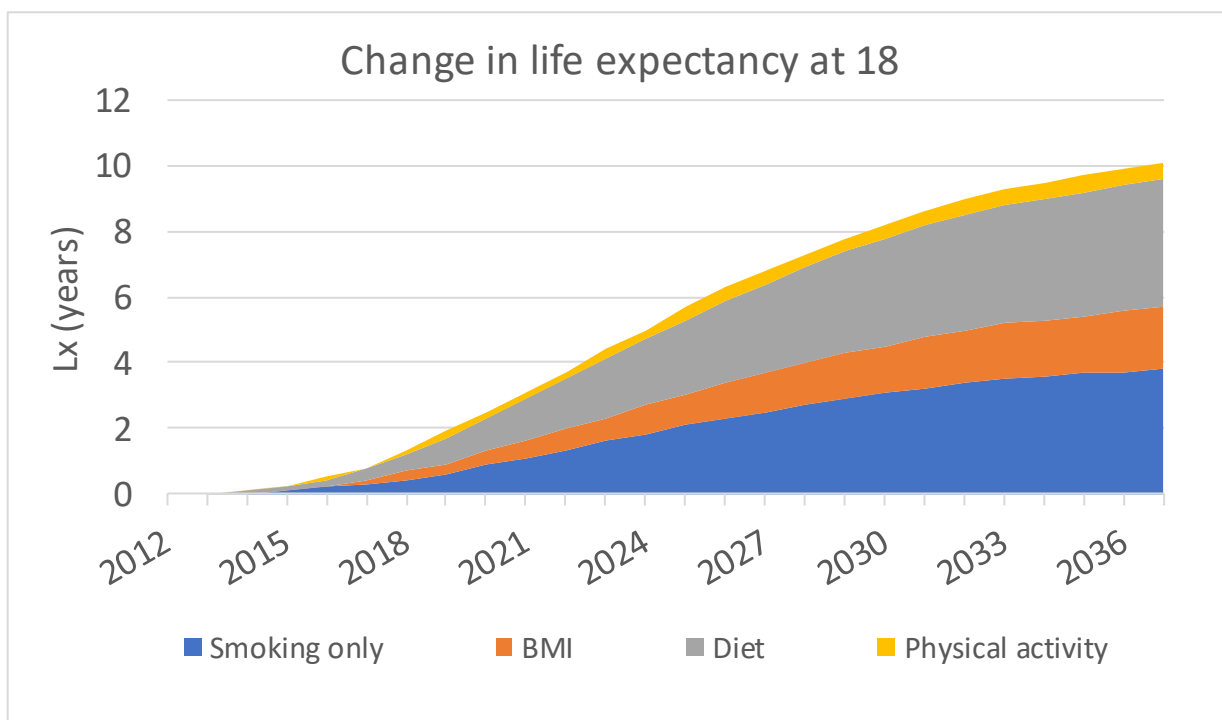
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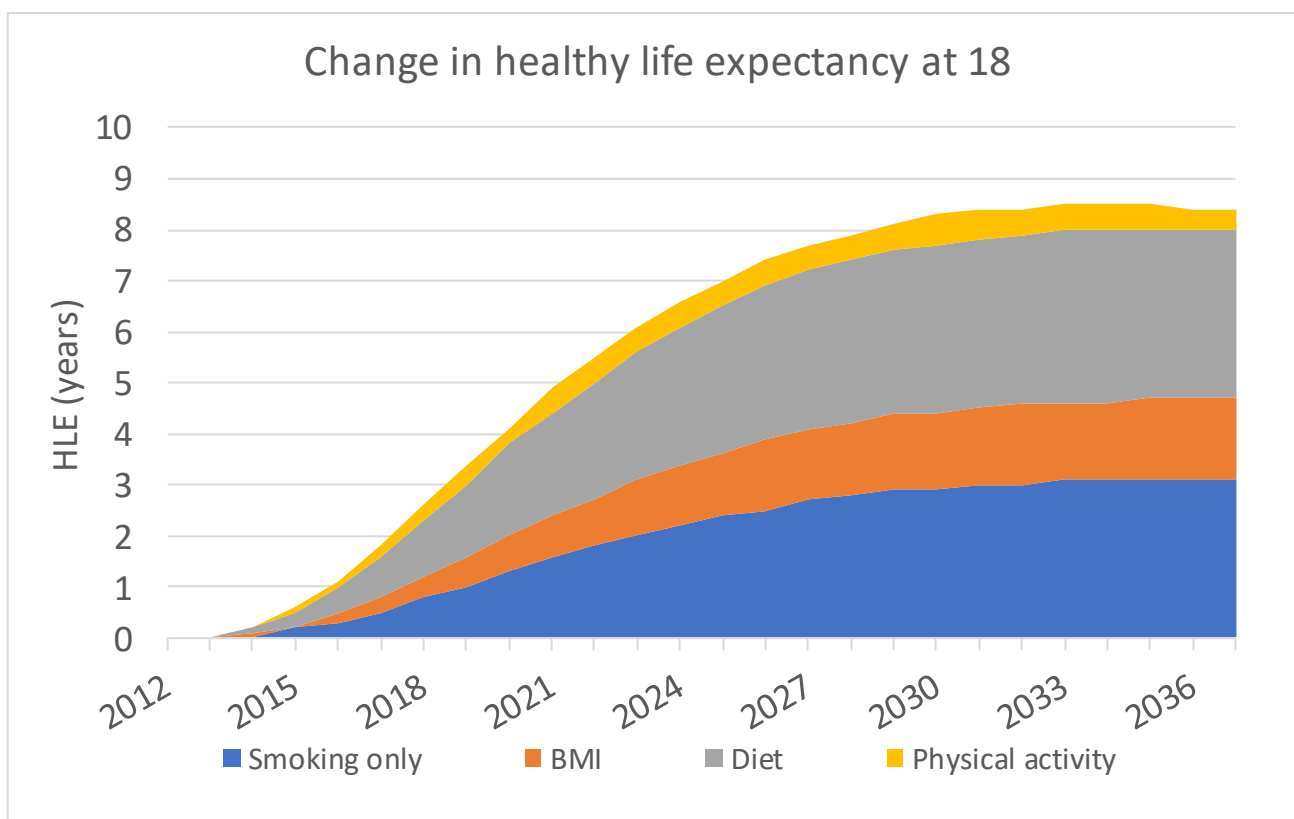**Figure 12   Life expectancy at 18 years and risk factor impacts**

Figure 13   Healthy life expectation at 18 and risk factor impacts

3.6 Deaths

The model reflects the total population at any point in time, which on the baseline run is closely calibrated to ONS population projections. We have also ensured that the model reflects the total 'inflows' (people passing 18 and net inward migration). The consequence of this is that the balancing figure is deaths. Table 2 showed the mortality rates from the different population cohorts in the model, which means that we can get a good understanding of the future projection for the number of deaths, and from which cohort they would come from.

Figure 14 shows the overall numbers of deaths per month simulated by the model. Across the whole of England the number of deaths was still falling up to 2014 due to the overall effects of increased life expectancy.

What is also of significance, however, is the changing balance of the cohorts form which the deaths are coming, with increasing numbers of people who are frail. In summary, regarding deaths, we see

- The total number of deaths reduces compared to the baseline scenario over the next 25 years when levels of smoking, BMI, diet and physical activity change in the ways described in this report, by c.400 per year by 2027 and c.800 per year by 2037 – this contributes to the modelled outputs of a higher population as a result of improved health over the same period;

- The number of deaths for people who are frail increasing from c.1,700 per year to 2,600 per year over the 20-year period;

- The percentage of deaths from the frailty cohort is currently fairly stable at c.40%, rising to 48% over the next 20-25 years under the 'best case' scenario.
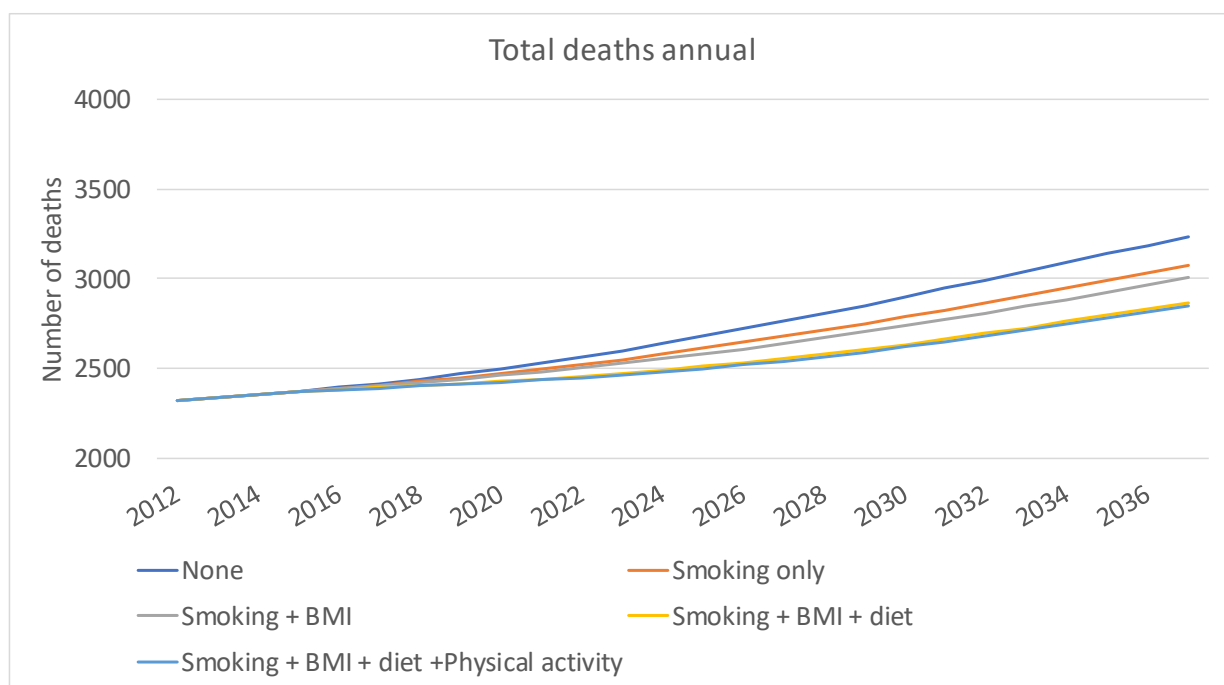

Figure 14   Total deaths per month under the different scenarios from 2012 to 2037
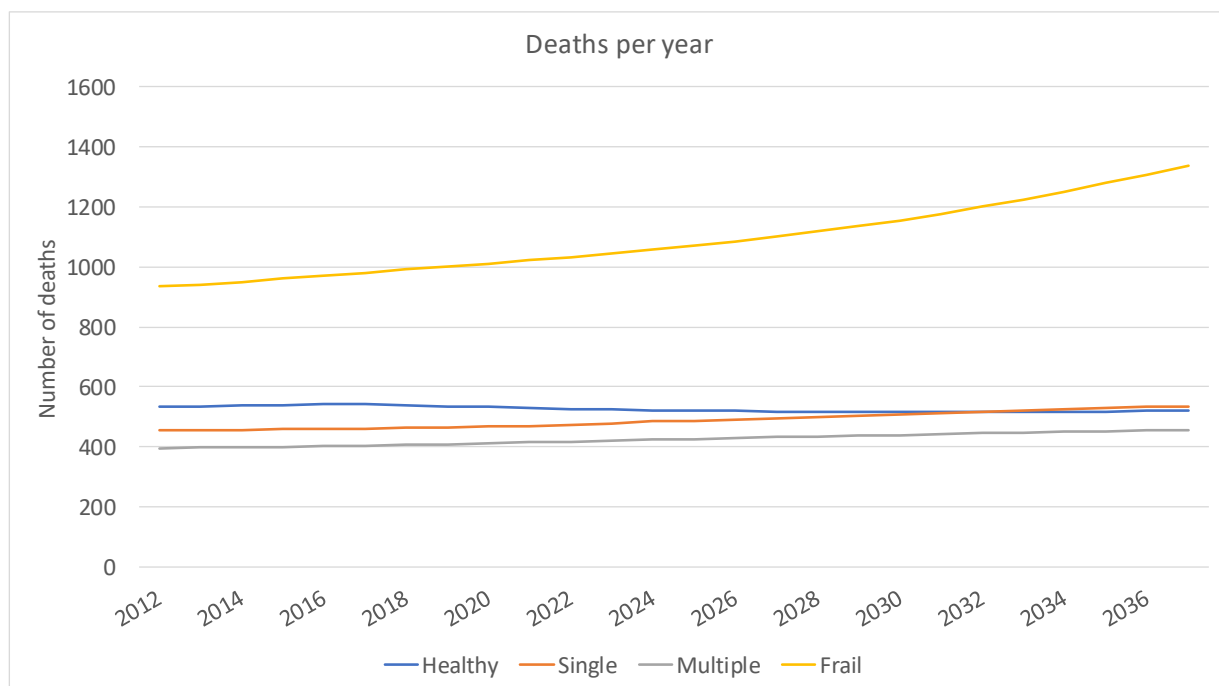
Figure 15   Share of deaths from the three main groups within the population from 2012 to 2037

3.7   Children and Young People

The majority, of this report has focused upon model inputs and outputs for the adult population (aged 18 years and over). This section provides a look at some of the model outputs that can be generated from the cohort model for children and young people. In this case we are going to present a sample of model results related to children with Adverse Childhood Experiences (ACE).

ACEs are, as the name implies, experiences that adversely affect children. The evidence cites issues commonly categorised as ACEs. This is not necessarily an exclusive list and is in part based on the Centers for Disease Control and Prevention ACE questions - refer to the respondent's first 18 years of life.

Five Direct impacts:
- Sexual abuse by parent / caregiver.
- Emotional abuse by parent / caregiver.
- Physical abuse by parent / caregiver.
- Emotional neglect by parent / caregiver.
- Physical neglect by parent / caregiver.

Five Indirect impacts:
- Parent / Caregiver addicted to alcohol / other drugs.
- Witnessed abuse in the household
- Family member in prison
- Family member with a mental illness.

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- Parent / Caregiver disappeared through abandoning family / divorce.

The impacts of a 20% decrease in ACE for Barnsley CCG would result in a:
- 3% reduction in severe mental illness in adults by 2037;
- 2% reduction in diabetes for adults by 2037 and;
- 3% reduction in stroke for adults by 2037.

The result shows that improvements in ACE can impact upon adult health outcomes but delays in impact(s) exist.
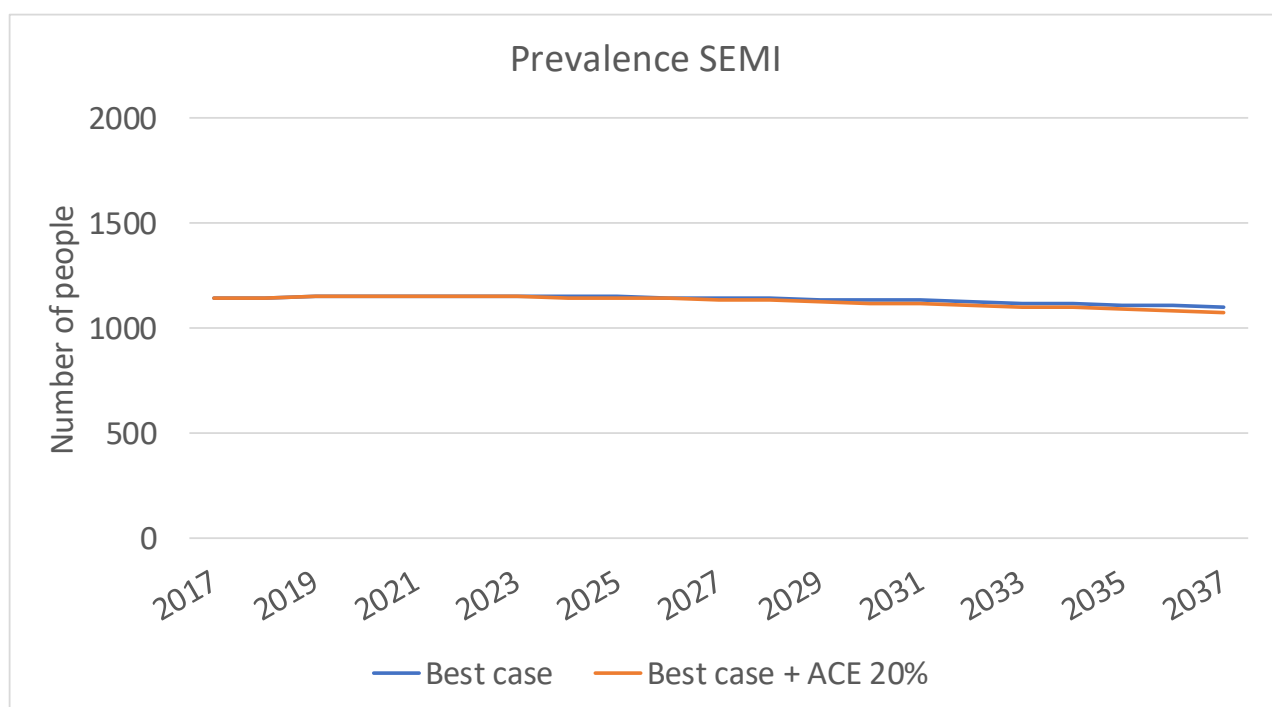

Figure 16   The impact of a 20% reduction In ACE upon the prevalence of severe mental illness, 18 years and over
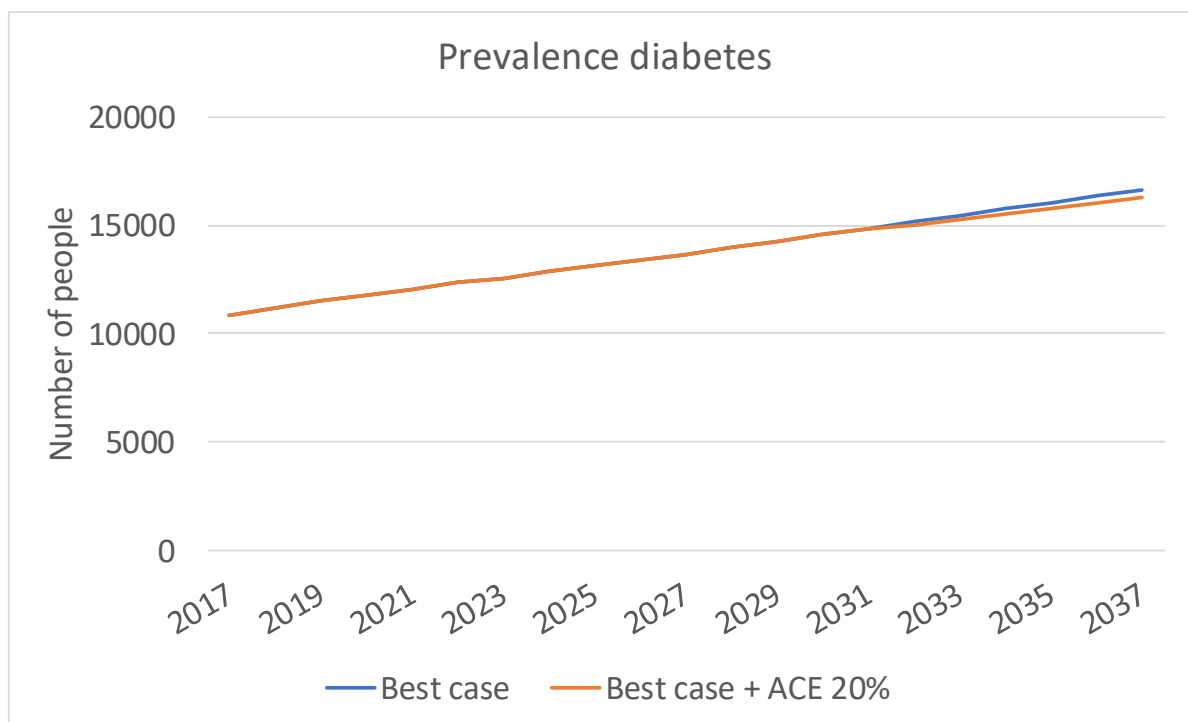
Figure 17 **The impact of a 20% reduction In ACE upon the prevalence of diabetes, 18 years and over**
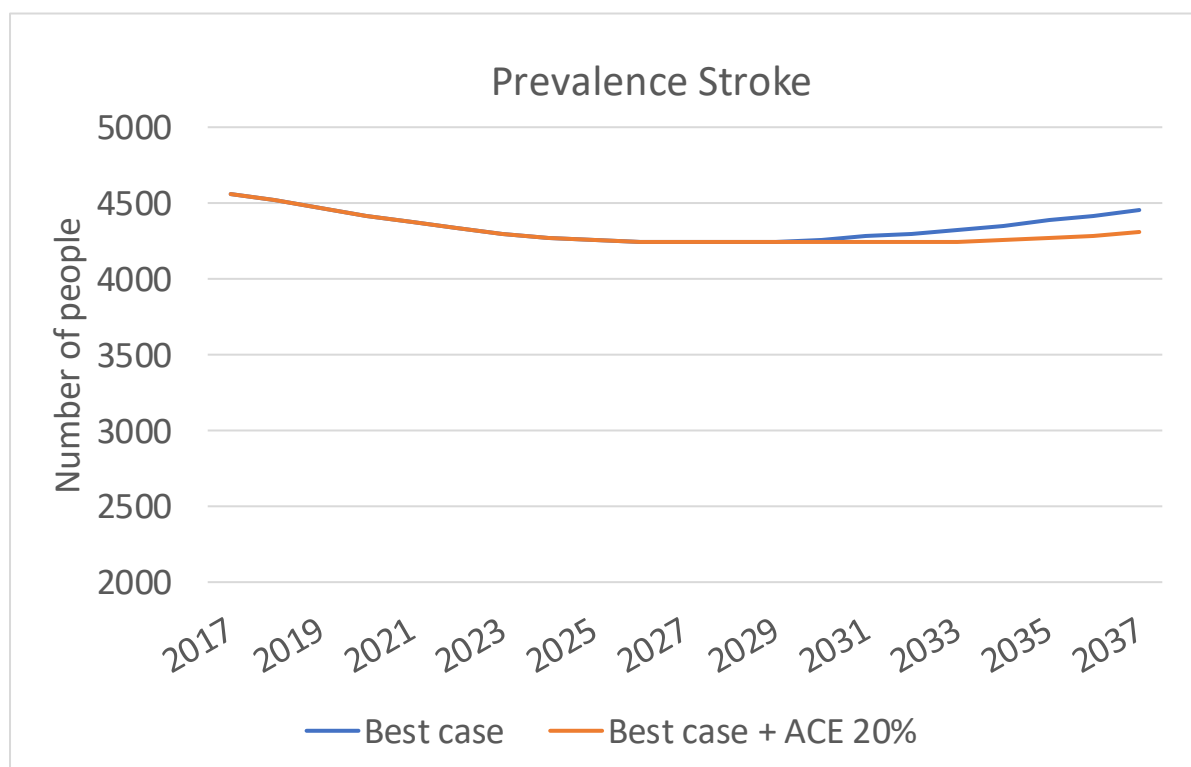

Figure 18 **The impact of a 20% reduction In ACE upon the prevalence of stroke, 18 years and over**

4 Simulating the use of health and care resources

4.1 Approach

In the context of a significantly growing population for Barnsley over the medium to long term great care needs to be taken to estimating actual demand on services, given a mix of considerations. An example of the impact on inpatient admissions is shown in the case of smoking cessation in section 3.3, to develop assumptions for resource utilisation for different population health cohorts provide significantly improved accuracy in the projections derived from the model.

An important caveat is that the modelling of the demand for health and care resources in this way does not take account of service transformation, for example in providing care in the community rather than in hospital. The outputs should only therefore be used as an indication of underlying demand, which may be addressed in different ways, rather than as projections of actual resource needs.

However, the scenarios above, and the way in which the underlying population health demand drivers inform the wider health and care resource planning, do provide a valuable starting point for this journey.

4.2 Health and care contacts

To help determine the demand for health and care services, data from the Kent Integrated Dataset (KiD) about whether an individual has been admitted to hospital or attended A&E in the last 12 months was analysed into cohorts, along with contacts with other services. This is shown in Table 5.

Cohort	GP attendances	A&E attendances	Emergency admission	Elective admissions	Outpatients attendances	Domiciliary Care	Residential Care	Nursing Care
Healthy	212.8	18.8	5	10.2	87.7	1	0.7	0.3
Asthma	393.9	27	6.4	12.4	118	0.9	0.2	0
CHD	610.6	35.1	16.1	27.3	209.1	3	1.3	0.7
COPD	706	41.9	20.1	29.3	224.6	4.5	1.1	0.4
Diabetes type 2	677.4	28	10.4	21.8	181.5	3.7	1.2	0.6
HF	838.9	50.4	27.4	30.4	272.5	13.5	4.1	0.6
Stroke	589.1	40.7	19.9	25.1	211.8	22.1	8.1	7.6
Frail moderate	718.5	38	17.8	37.3	259.7	8.9	4.6	2.3
Multiple LTC	605.4	39.7	19.8	28.1	247.4	8.8	2.6	1.3
Severe MH	678.1	52.3	17	12.5	170.1	10.4	20.8	1.4
Neuro	761.1	47.2	23.7	24.8	366.3	32.5	15.6	7.3
Dementia	631.5	62.8	35.6	11.5	144.2	51.7	80	28.4
LD	580.9	58.3	15	9.8	119.9	21	160.9	1
Severe Frail	1078.3	78.7	44.1	38.7	353.6	39.9	20.6	7.1

4.3 Table 5 Health and care utilisation rates per 1000 population (KiD)Demand ratios for services

Figure 19 shows the demand ratio for five key services using utilisation rates from the KiD and based on the 'best case' scenario described above. The first thing to recognise in interpreting this output is the underlying total population growth over the 25 years modelled, which is c.13%. The increases in service use for general practice, planned care, urgent and emergency care and social care contacts of between 18% and 27% are therefore in excess of the rise in total population.

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Demand ratios
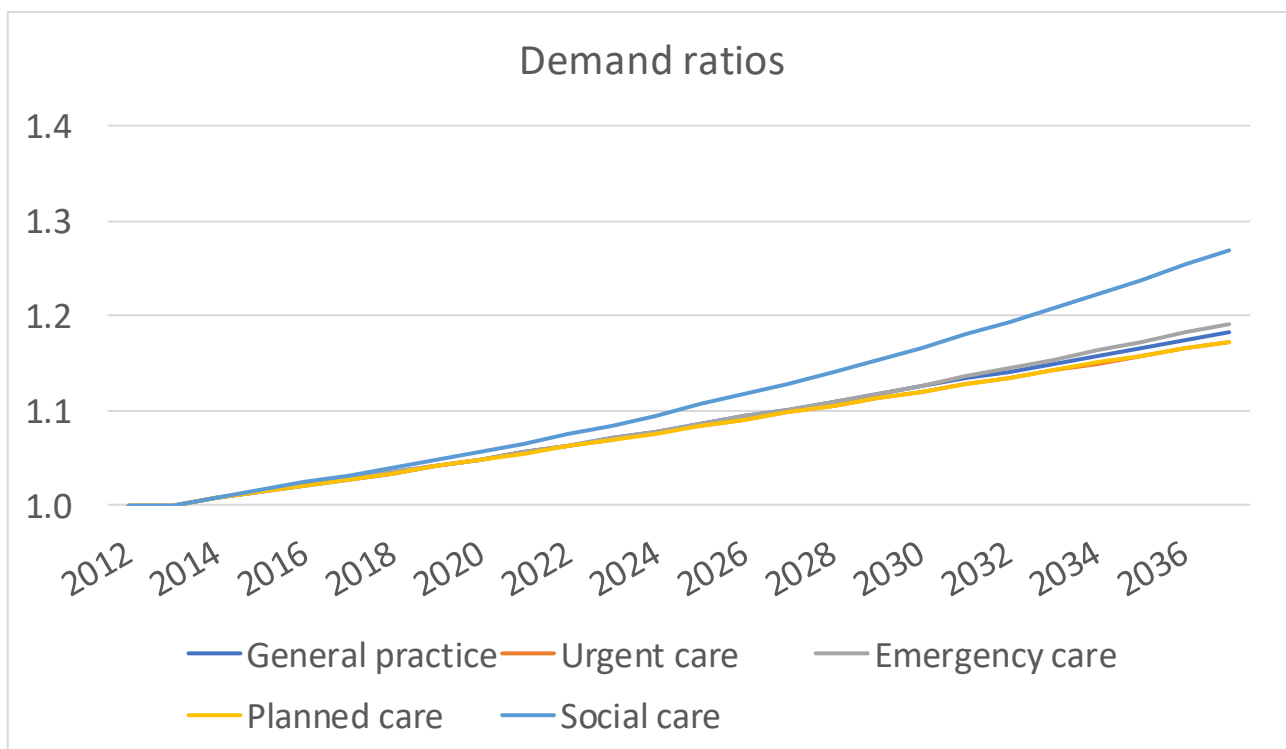
4.4 Figure 19   Modelled growth in demand for inpatient/urgent care needsHealth and care impacts

This s ection illustrates the impacts that trends in underlying risk factors can have upon health and care utilisation and costs. Figure 20 shows the change in the number of unscheduled admissions from 2012 to 2037 related to changes in underlying risk factors. This shows that improving risk factors has an impact upon admissions, but the trend is still one that is increasing.
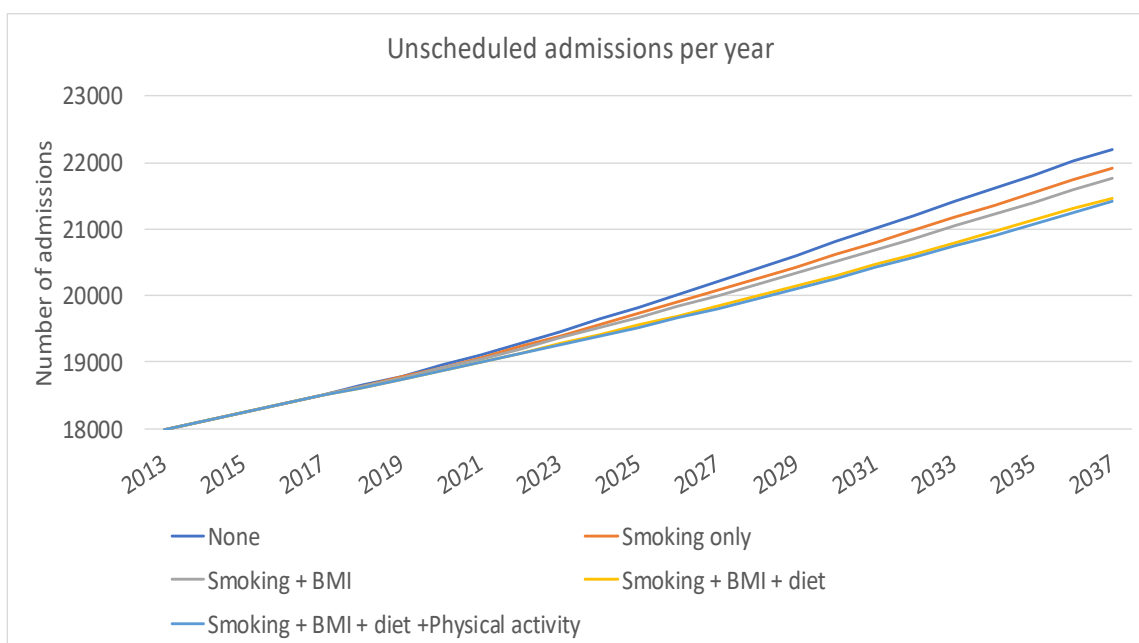

Unscheduled admissions per year

Figure 20   Modelled growth in demand for inpatient/urgent care needs

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Table 6 illustrates another facility of the model to project the impact of utilisation and costs of risk factor reductions and public health interventions. In this case the results illustrate the absolute change in emergency admissions resulting from the five modelled risk factor changes. (Cost of an emergency admission in this case is £2,000).

In summary, regarding emergency admissions we see:

- The cumulative impact of risk factor reduction is large but takes 10-15 years until that becomes significant, highlighting the delay between risk factor change and health and health care outcomes.

- Over the 25 years of the model the reductions in risk factors results in an average reduction in costs of £300,000-700,000.

	2012	2017	2022	2027	2032	2037
None	17982	18508	19280	20214	21211	22208
Smoking only	17982	18503	19230	20078	20986	21923
Smoking + BMI	17982	18500	19201	20003	20866	21769
Smoking + BMI + diet	17982	18493	19133	19841	20622	21473
Smoking + BMI + diet +Physical activity	17982	18490	19118	19807	20577	21423
Cumulative difference in admissions						
None	-	-	-	-	-	-
Smoking only	-	-7	-146	-646	-1599	-2920
Smoking + BMI	-	-12	-232	-1010	-2477	-4506
Smoking + BMI + diet	-	-23	-440	-1839	-4370	-7786
Smoking + BMI + diet +Physical activity	-	-28	-491	-2021	-4758	-8420
Cost savings, cumulative						
None	-	-	-	-	-	-
Smoking only	-	-£14,855	-£292,671	-£1,292,773	-£3,198,310	-£5,839,023
Smoking + BMI	-	-£23,798	-£463,285	-£2,019,966	-£4,954,561	-£9,012,576
Smoking + BMI + diet	-	-£46,987	-£879,639	-£3,678,529	-£8,740,521	-£15,571,867
Smoking + BMI + diet +Physical activity	-	-£55,801	-£981,584	-£4,042,227	-£9,516,236	-£16,839,573
Cost savings, annual						
None	-	-	-	-	-	-
Smoking only	-	-£2,971	-£29,267	-£86,185	-£159,915	-£233,561
Smoking + BMI	-	-£4,760	-£46,329	-£134,664	-£247,728	-£360,503
Smoking + BMI + diet	-	-£9,397	-£87,964	-£245,235	-£437,026	-£622,875
Smoking + BMI + diet +Physical activity	-	-£11,160	-£98,158	-£269,482	-£475,812	-£673,583

Table 6   Impact of risk factor reductions upon emergency admissions, 2012- 2037

5 Conclusion

5.1 Summary

This project has demonstrated a methodology using 'stock and flow' modelling and a cohort study to define and produce projections for health population needs using cohorts rather than individual diseases. It therefore presents an exciting opportunity to inform the development of the local Joint Strategic Needs Assessment, and therefore the Health and Wellbeing Strategy at a time when 'whole population', 'whole system' solutions are required. It also therefore provides an invaluable contribution to help understand the wider context and challenges of sustainability within the local CCG.

The distinctives of the approach are the combination of both a population and a cohort approach, coupled with simulation modelling, in an environment that allows for testing future 'what if' questions, particularly those associated with prevention and wellbeing. Local incidence of conditions may vary from the BHPS and ELSA – and other cohort studies include more detailed collection of data about cohorts. However, the BHPS and ELSA has the most complete collection of health care utilisation data and has

therefore provided a useful and comprehensive starting point that can now be supplemented by other evidence sources. For example, an area of limitation in the BHPS is a lack of a cohort data relating to memory / dementia and the relationship of these needs to frailty and old age but is included in more detail in the ELSA.

The results of this modelling approach illustrate that risk factor changes have an impact upon the future health of the population. It also shows that testing the implementation of public health interventions is useful and can illustrate the potential short and long-term impacts both for population health and for health care costs. Having said that the model also shows that the underlying demand for health and care services is still going to increase even though risk factors are generally improving. This is mainly due to the ageing population which has a significant influence upon the frail cohort but also because some risk factors such as BMI and obesity are going in the wrong direction.