Institute and Faculty of Actuaries

Levelling up – The great health challenge

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What the Levelling Up white paper says

- Twelve wide-ranging missions for levelling up the UK were laid out
- The only health-related mission involved narrowing the gap in Healthy Life Expectancy (HLE) between local areas by 2030, and increasing HLE by five years by 2035
- The Government will tackle the core drivers of inequalities in health outcomes and are planning a White Paper on Health Disparities later in 2022
- There will be a strong focus on prevention and on health disparities by ethnicity, socioeconomic background and geographical region
- Communities with higher prevalence of health behavioural risk factors like smoking or poor diet, and where access to health services is more limited will receive special attention.

What do we observe?

- Since 2000, life expectancy (LE) has increased by more years than HLE, and therefore the number of years in ill health has been increasing
- The gap is in part being driven by an ageing population, differences in smoking rates, alcohol consumption and diet, and is affected by wider factors e.g. quality of housing and access to healthcare
- Physical health is also positively correlated with other measures of health such as wellbeing, satisfaction with life and mental health
- We also know that areas where people have the best health are economically more productive, as well as better off financially

What are the research challenges?

- Many health risk factors and socioeconomic outcomes are interconnected - smoking, mental illness, obesity, poor housing, deprivation
- Some risk factors are more closely related than others e.g. if they are aetiologically, socially or geographically proximal
- Untangling the chain of causation on the road to better health is complex – there is no silver bullet

If we had a magic wand, what would make the biggest difference in the shortest time and where to start?

We started with smoking cessation, where there is much work still to be done, which is likely to have a large impact on HLE, and where national statistics are available

Topic outline and research questions

- The smoking challenge
- Geographical patterns of smoking and its effects on health
- Economic impact of smoking (via HLE measures)
- How much would smoking cessation contribute towards the HLE targets, and over what period
- Smoking prevalence and smoking interventions over 1970-2022
- Interconnectedness with other behavioural risk factors
- What can we learn from other countries and disciplines

The smoking challenge

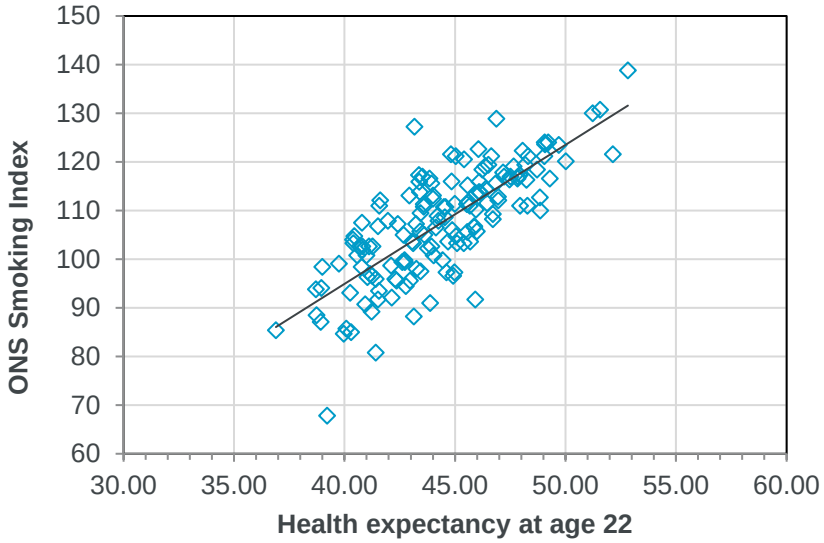
- Smoking reduces LE at birth by up to 10 years but less is known about its impact on HLE or the proportion of life spent healthy
- Although smoking prevalence has fallen to 14% (from 80% of men in the 1950s), it is still the largest cause of preventable mortality, and rates remain very high in some areas
- It is implicated in deaths from cancer, heart and respiratory disease, accounting for about 75k deaths a year and 0.5m hospital admissions in England (92k deaths UK-wide)
- If all smoking ceased what difference would its cessation make towards the Government's HLE+5 target and what are the wider benefits?
- Recent ILC research found that the economic cost of smoking is about £20bn a year in reduced economic output – this is indicative of wider economic and societal benefits of smoking cessation

Measures of health expectancy

- Numerous health expectancy measures are used across different contexts:
  - Healthy life expectancy (HLE) at a given age from official statistics is an estimate of the average number of years a person would continue to live in a state of ‘good’ general health
  - A less frequently used measure from official statistics is disability-free LE (DFLE): the average number of years an individual is expected to live free of disability
  - A health economics-focused measure is quality adjusted LE (QALE): the average number of high quality years an individual is expected to live, where years lived are multiplied by a fraction that relates to their quality of life
  - An economics-related measure is working LE (WLE): the average number of years a person would continue to be in the labour market
- We use data from the UK Annual Population Survey and other ONS publications to quantity differences in health between current and ex-smokers and never-smokers.
- Normally HLE is measured at birth or age 65, but here we assess HLE across all ages

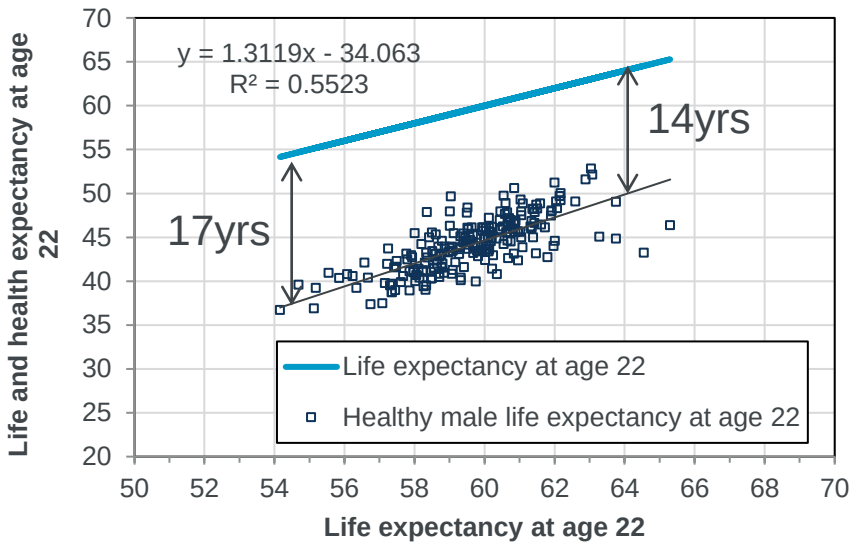
The geography of smoking and health

Smoking versus health expectancy at age 22 by local authority



The geography of smoking is strongly correlated with the geography of HLE (R^2=0.6). On the ONS smoking index, Richmond upon Thames ranks highest in England and the Blackpool and Kingston upon Hull rank lowest

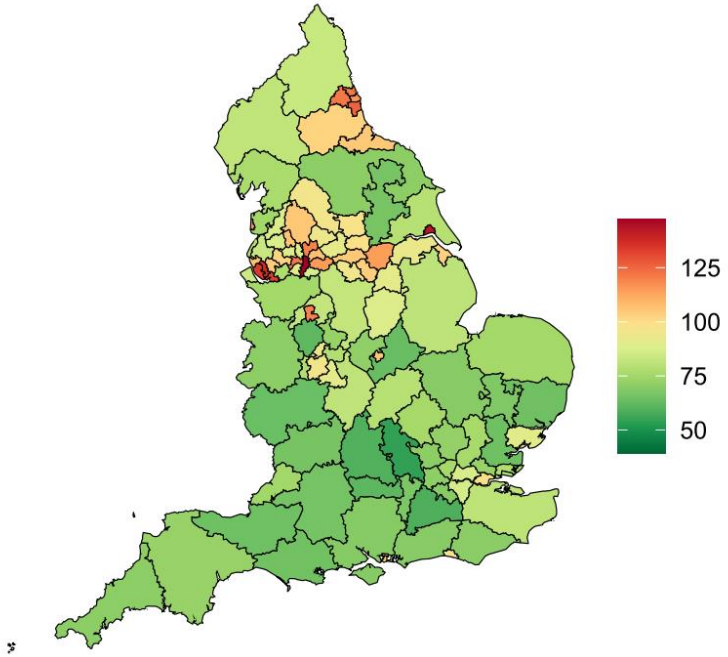
Health expectancy versus life expectancy by local authority



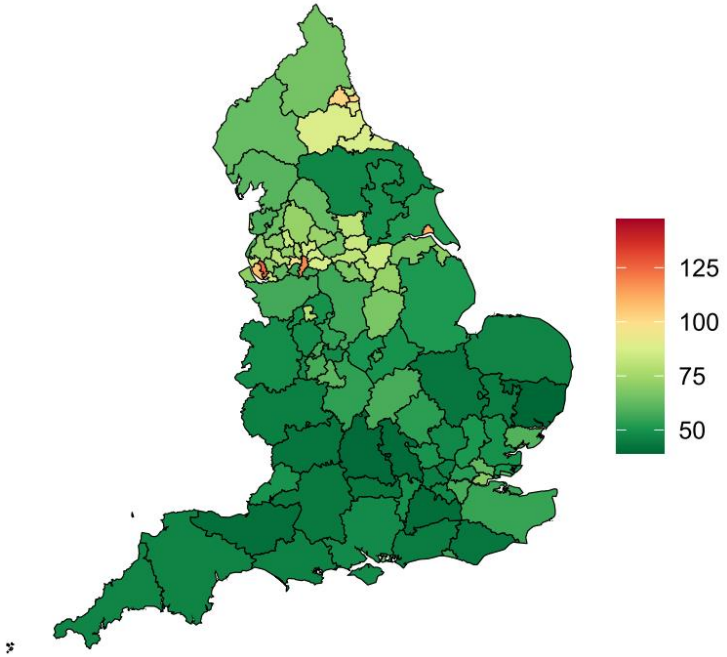
The gap between health and life expectancy remains consistently large across local authorities. Health and life expectancy are also strongly correlated (R^2=0.6). A one-year improvement in health expectancy extends life expectancy by 4-5 months – i.e. it reduces the time in ill health at the end of life.

The geography of deaths from lung cancer - ages 20 to 89

Males deaths per 100,000



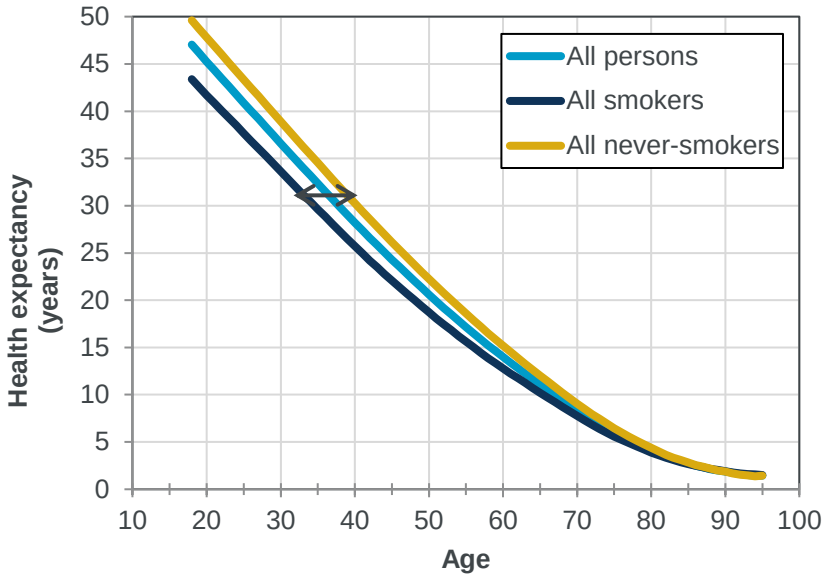
Female deaths per 100,000



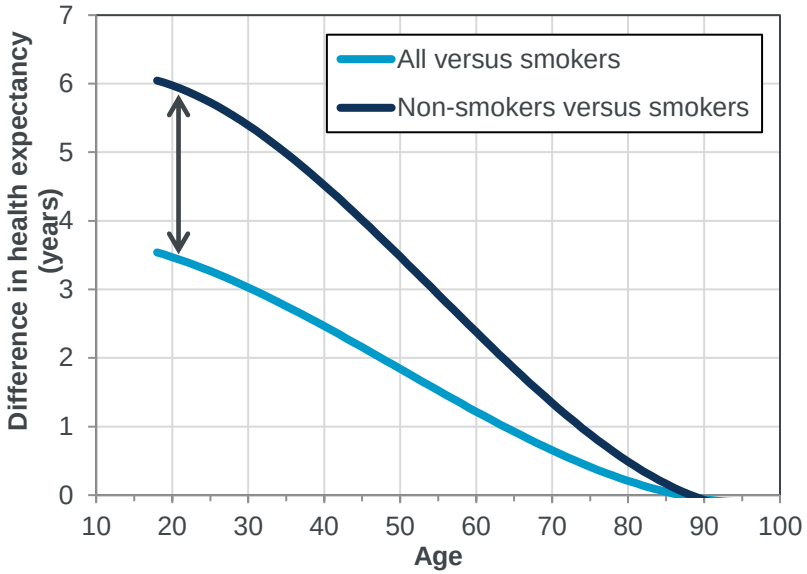
Smoking is attributed to deaths from many different causes across respiratory diseases, cardiovascular diseases and cancer – lung cancer being the most well known. Deaths from lung cancer were higher in northern, Midlands and coastal cities.
This pattern is similar to the pattern for deaths from heart disease. Whereas for deaths from other types of cancers, the geographical patterns are more dispersed.

Health expectancy over the life course – Smokers versus never-smokers

Health expectancy by age for smokers and never-smokers



Difference in health expectancy by age for smokers and never smokers

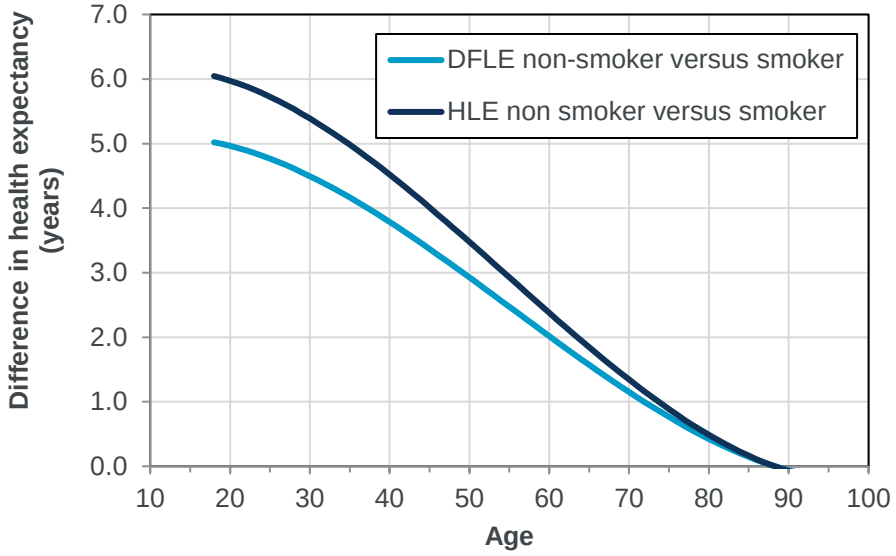


The arrow denotes the age difference of 6 years between a smoker and never-smoker having the same HLE, i.e. if never smokers had a biological age (BA) equal to their chronological age (CA) of 40 years, smokers with a CA of 34 years would have the same BA of 40 years.

The gap in health expectancy is greatest between non-smokers and never-smokers and is highest in young adults measuring about 6 years. The gap closes with age as remaining years of life decline.

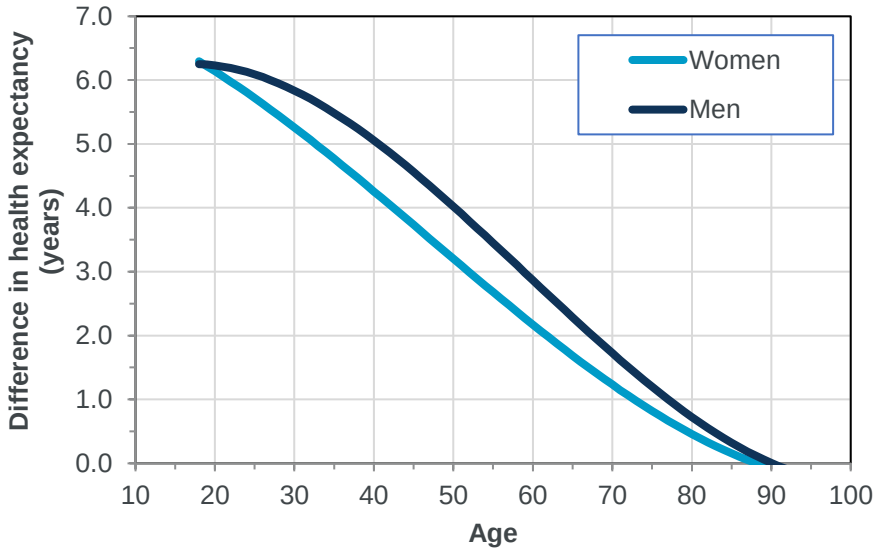
Health expectancy versus disability-free life expectancy from age 20 over the life course - Men versus women

Difference in health expectancies HLE and DFLE



The impact on DFLE from smoking is less than the impact on health – equating to about 1 year at age 20. This suggests that activities of daily living may be less affected by smoking than physical health

Health expectancy gaps between adult male and female smokers and never smokers



Never smoking females enjoy up to 6 extra years of health than female smokers, slightly less than for males. This is because they because they smoke less. Smoking is harmful in pregnancy and to young children.

The economic impact of smoking on male working life expectancy (WLE)

Age	DFLE (years)		Difference (years)	WLE (years)		Difference (years)	Activity rate %		Difference (%)
	Never smoked	Current/ex -smoker		Never smoked	Current/ex -smoker		Never smoked	Current/ex -smoker	
20	47.7	42.7	**5.0**	42.2	39.7	**2.5**	61.1	74.1	-13.0
30	39	34.3	4.7	33.9	31.0	2.8	94.8	91.2	3.6
40	30.3	26.1	4.3	24.3	21.9	2.4	95.2	89.7	5.5
50	22.1	18.7	**3.5**	14.9	13.1	**1.7**	94.1	86.9	**7.2**
60	14.8	12.3	2.5	6.1	5.1	1.0	72.5	67.8	4.7
70	8.8	7.2	1.6	1.6	1.0	0.6	19.9	12.3	7.7

Male never-smokers enjoy **5** more years of DFLE at the age of 20 than current/ex-smokers, and **2.5** more years of WLE. They are also more likely to be economically active at ages 30 and above, enjoy **3.5** more years of DFLE at the age of 50, and **1.7** more years of WLE. They are also **7.2%** more likely to be economically active than current/ex-smokers at ages 50-60. If all men were never smokers, GDP would be £11.5bn higher. (source: ILC)

A complementary approach to assess the impact of smoking cessation on *Life Expectancy*

- **Why LE rather than HLE? … better data; more objective**
- **What would happen if smoking prevalence had been 20% lower in all years in the past?**
- **Work in progress:**
  - How do we achieve this?
    - US data by sex, education level and 51 causes of death
    - Model mortality by cause using a CBD-type of model with individual cohort effects for each major controllable risk factor (smoking, alcohol, …)
    - Smoking cohort effect ⇔ impact of smoking cessation on each cause of death

What would happen if smoking prevalence had been 20% lower in all years in the past?

- Model + Scenario
  - **20% reduction in smoking prevalence** ⇔
  - **Reduce lung cancer mortality by 20%** (approximately)
  - Impact: death rates from other causes also fall
    - COPD mortality also falls by 18-22%
    - But a much smaller impact on most other causes

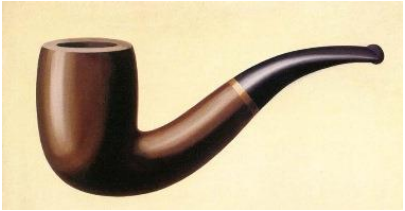
Scenario: what if smoking prevalence had been 20% lower

- At the all-cause level:
  - The amount of the reduction in all-cause mortality depends on
    - Sex, Education level, Age, Cohort (year of birth)
  - Key point: impact of a 20% *relative* reduction depends on **baseline smoking prevalence**
  - Low-educated US males: all-cause mortality falls by 8% to 12%
  - High-educated US females: all-cause mortality falls by 2% to 5%
- Caution #1: in reality this reduction in all-cause mortality would not be immediate
- Caution #2: methodology is experimental, but it gives a flavour of our thinking

Smoking reduction scenario: What impact on HLE?

- **Model + assumptions =>**
  - Impact on mortality and Life Expectancy (LE) is clear
  - Open questions:
    - What is the corresponding impact on HLE?
    - What impact on the number of years in poor health?
- **Next steps:**
  - Lower smoking prevalence + fewer deaths from lung cancer, COPD, …
  - So the “converts” will live longer and, on average, in better health
  - Background concept:
    - HLE ⇔ “How is your health in general?”
    - # Years in fair/bad/very-bad health is linked to the cause of death
    - E.g. Death from COPD => potentially 10 to 20 years in poor health
    - Death from ischaemic heart disease
      - Multiple controllable risk factors: smoking, diet, …
      - Years of poor health might depend on the risk factor

Is smoking cessation sufficient to meet HLE targets or just a pipe dream?



From analysis…

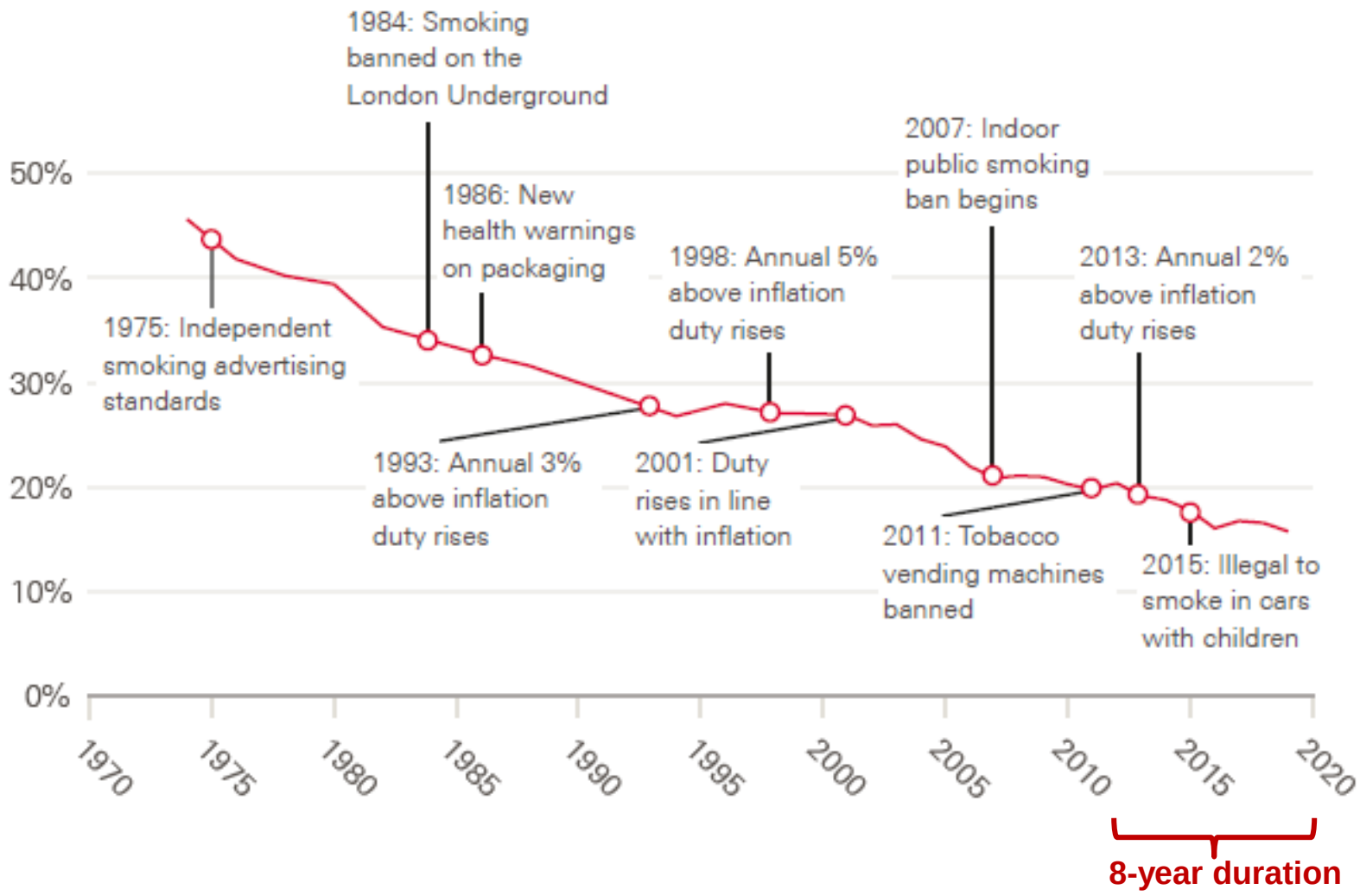
- This depends on the measure used: DFLE ↑5-5.8 years while WLE ↑1.8-2.5 years if people aged 20 who were smokers were non-smokers instead. This corresponds to all (DFLE) or half (WLE) of the HLE+5 target
- This depends on the ages at which cessation occurs: the smokers vs non-smokers gap narrows to 1.2-1.6 years (DFLE) or 0-0.6 years (WLE) at age 70. But this narrowing captures survival bias
- If smoking prevalence had been 20% lower, lung cancer mortality would reduce by 20% and COPD mortality by 18-22%. This is a large 1-to-1 impact on mortality, but still needs to be translated into HLE impacts

… to action

- Only a small fraction of these increases could materialise, as currently only 14% of the UK population are smokers, and smoking cessation interventions are not 100% effective
- Geographical distribution of smoking cessation efforts and their effectiveness has not yet been analysed
- HLE impact of exogenous factors such as switching to e-cigarettes are not well understood

Image source: www.renemagritte.org

Smoking prevalence, fiscal and public health interventions



Wider societal changes not shown here:

1950s: First research demonstrating that smoking causes lung cancer deaths (Doll and Hill)

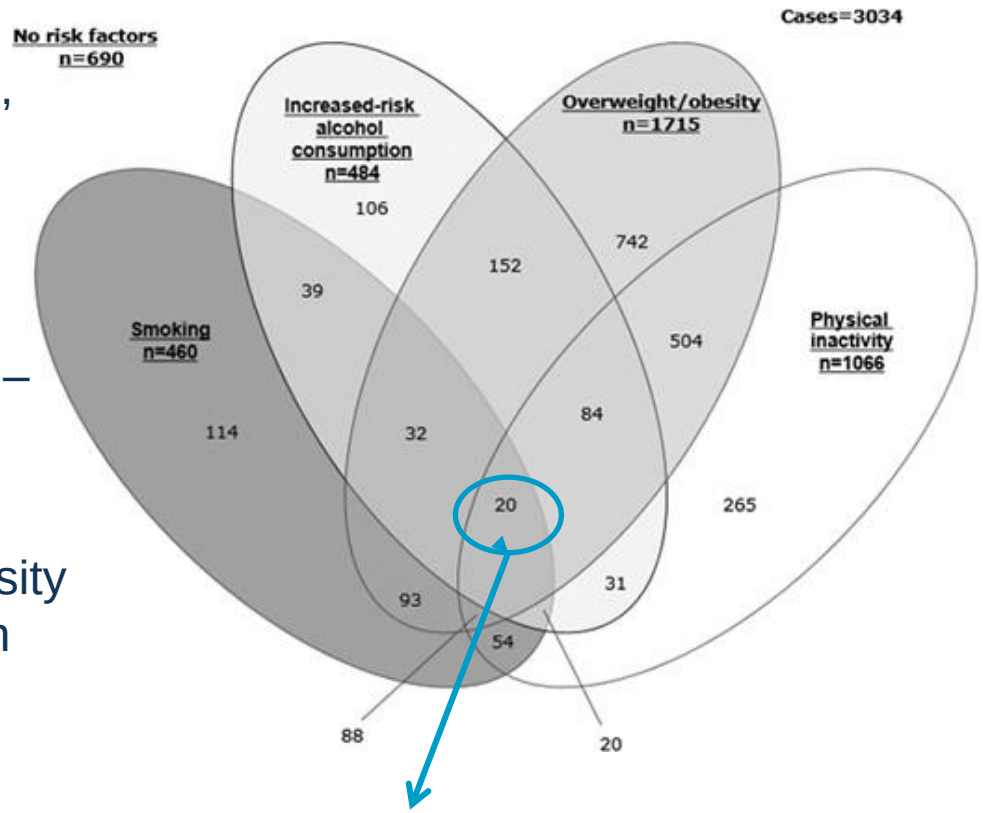
2000s: E-cigarettes widely used

2022: Government review ('Smoke free by 2030') recommends a multi-pronged set of interventions

Source: ONS, Health Foundation and ASH

Interconnectedness with other risk factors

- Smoking is one of 4 traditionally studied risk factors: Smoking, nutrition, alcohol consumption and physical activity ('SNAP')
- These risk factors tend to cluster together
- The clustering means that HLE differences due to other risk factors may already be accounted for by smoking differences – therefore harder to meet HLE targets
- After smoking, obesity may be the best risk factor to analyse, based on data availability and impact on HLE.* Acting on obesity also ties in with current public health policy priorities (although there was a recent policy U-turn in UK)

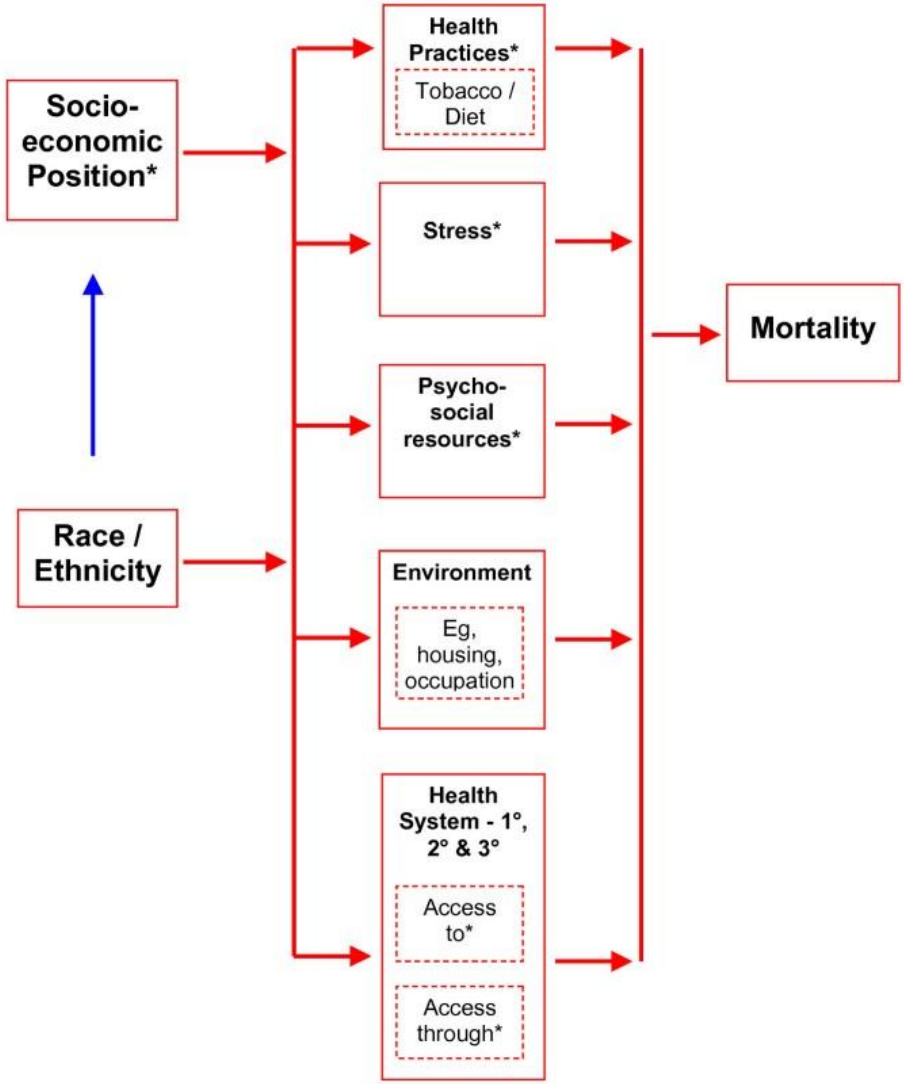


Group with highest risk profile
Constitutes 3% of those who smoke

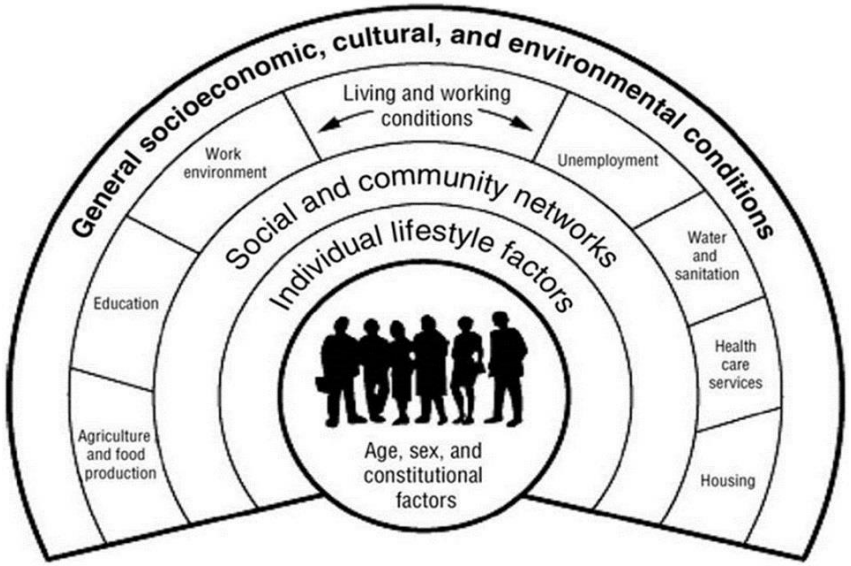
* Even if obesity is a consequence of health behaviours rather than a behaviour itself

Modified from: Birch et al 2019, J Publ Health

Interconnectedness with other risk factors



- Clustering and other data-driven analyses tend to be correlational, however web of causation is complex
- Mortality and single-disease impacts are well studied, but multimorbidity is difficult to analyse
- Effects of wider socioeconomic, cultural and environmental factors and their interactions with lifestyle factors often qualitatively discussed in public health reports



Source: Wilson et al 2006, Int J Equity Health

Source: Dahlgren and Whitehead (1991)

What can we learn from research and policies in other countries

Research

Simulation study of smoking cessation in US analysed impact of (1) increased quit attempts, (2) treatment use and (3) treatment effectiveness. Prevalence projected to reduce from 20% to 12% over 4 years assuming extreme scenario of 100% effectiveness for all 3 (Levy et al 2010). Still not a sufficient reduction for UK to be smoke free by 2030.

Policies

Smoking cessation interventions (from universal to localised):

- Taxation, which has mixed effects on widening/narrowing inequalities (Blakeley 2019)
- Strict cohort-specific ban, e.g. New Zealanders who turn 15 in 2027+ will be banned from smoking and Singapore is looking to emulate New Zealand
- Wide range of public health and therapeutic interventions - many were efficacious, effective and affordable globally (West et al 2015); all 67 in England were cost effective (Ford et al 2021)
- Bans on smoking in specific public areas, bans on sales through specific retailers (varies by country)

Combinations of interventions and localised implementation of interventions are generally more effective

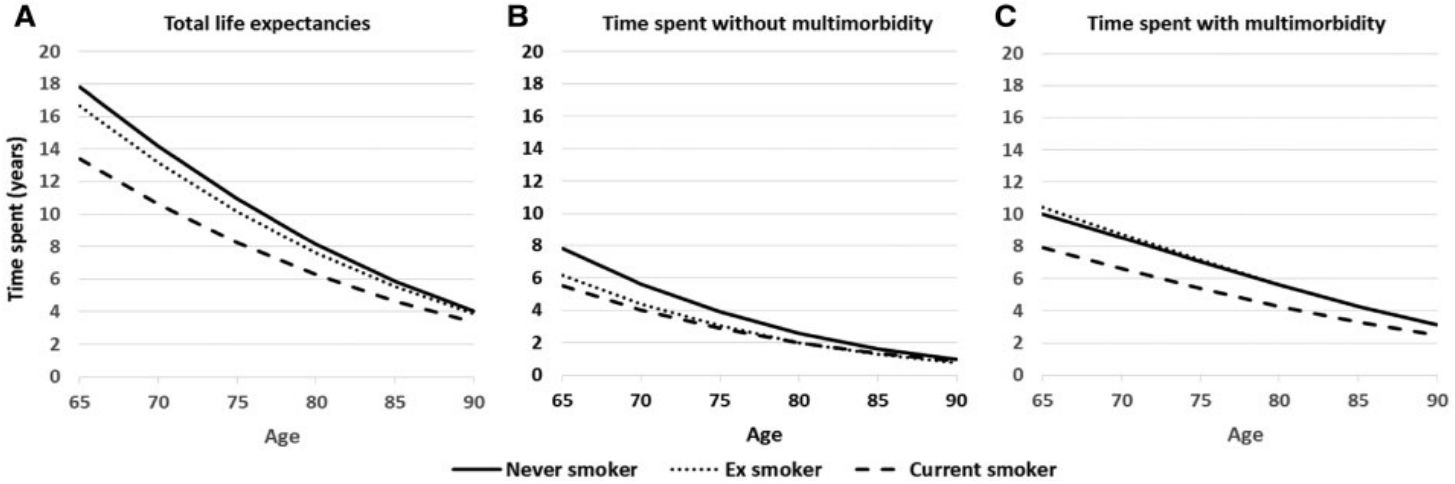
What can we learn from other disciplines

Health economics:

- More realistic decision analytic models - discrete choice experiments (Buckell et al 2020, Levy et al 2017) factor in and simulate individuals' behaviours in choosing between tobacco types and the resulting impact on mortality
- Decisions on whether treatments or medical technology should be implemented by national health providers are generally based on QALYs rather than HLEs, which additionally captures variation in quality of life while in ill health

Biostatistics and epidemiology:

- More advanced statistical methods (e.g. ELECT, IMaCh, SPACE) have been used to analyse HLE patterns by socio-economic status and by smoking status, using individual-level data



Source: Chan et al 2019, Intl J Epidemiol

- Predictors for quitting smoking can be ranked – strongest predictor: degree of dependence (Chandola et al 2004)

Conclusions

Background:

- Despite falls in smoking prevalence, we are not out of the woods and there is huge geographic and socio-economic variation

Analysis:

- Although never smokers stand to gain six years of health expectancy at age 20, the impact of smoking cessation will not be immediate due to the legacy problem
- As smoking prevalence has already been lowered, potential advancement is only around 2.5 years
- However we saw that in regions most at risk, the potential for improvement is much higher
- Even if all smoking ceased tomorrow, the whole process could take 40 years to work though, so other health improvement measures are also needed

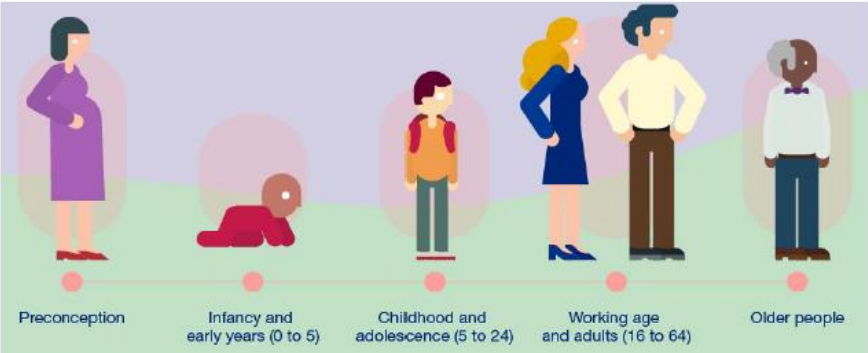
Action:

- Findings from other countries and modelling studies characterise this challenge better, but currently do not point towards a clear action plan for meeting the HLE targets via smoking cessation
- Other interconnected risk factors suggest the use of joined up approaches for both intervening and modelling

What happens next?

- In 2019, the UK Government set the ambition for England to be ‘Smoke free by 2030’
- The Khan review of smoke free 2030 policies was published this month. This review recommended an ambitious multi-pronged set of 15 public health, fiscal, and clinical interventions. None are particularly new except for the rapid rate of raising age of tobacco sale and offering vaping as a substitute to smoking.

This highlights the cumulative effect of smoking on poor health across the life course, and the importance of intervening at each stage
Source: Visual summary of the Khan review, 2022



- Our results suggest there are gaps in our understanding in terms of what is achievable over the timescale
- More research is needed on what works and who to focus interventions on - old or young smokers, socio-economic groups or at-risk areas, people with multiple health behavioural risk factors or multimorbidity; according to costs and benefits of interventions
- Are there wider lessons? Bear in mind that when a measure becomes a target it ceases to be a good target (Goodhart’s law)

Questions

Comments

Expressions of individual views by members of the Institute and Faculty of Actuaries and its staff are encouraged.

The views expressed in this presentation are those of the presenter.

Appendices

Discussion points

- Smoking cessation remains a prime candidate for tougher action, but where else does potential exist?
- What are the wider co-benefits from smoking cessation e.g. reductions in heart disease?
- Is smoking a red herring and are the better/quicker ways to improve health?
- Should measures to control smoking be universal, targeted or both?
- How feasible is it to ban smoking for everyone below a certain age as NZ is proposing?
- Could the same approach be used to measure the societal, impact of obesity, drug abuse, other health behaviours?
- If so what measures would you take specifically and would their effects be worse than the ‘cure’?
- To what extent is health one’s personal responsibility or a cost on the whole of society and the tax payer in particular
- Can the health message be communicated more effectively ?
- How could other sectors of society contribute such as business?

The economic impact of smoking on female working life expectancy

Age	DFLE (years)		Difference (years)	WLE (years)		Difference (years)	Activity rate %		Difference (%)
	Never smoked	Current/ex-smoker		Never smoked	Current/ex-smoker		Never smoked	Current/ex-smoker	
20	46.8	41	**5.8**	35.4	33.5	**1.8**	60.8	62.8	-2
30	38.1	33.2	4.8	27.7	26.4	1.3	79.9	76.2	3.7
40	29.5	25.6	3.9	19.7	18.7	1.0	79.3	77	2.4
50	21.6	18.6	3.0	11.4	10.9	0.6	84.9	79.4	**5.5**
60	14.5	12.4	2.0	3.7	3.6	0.1	57.8	58.1	-0.4
70	8.3	7.1	1.2	0.6	0.6	0.0	10.5	8.9	1.6

Female never-smokers enjoy 5.8 more years of DFLE at the age of 20 than current/ex-smokers, 0.8 years more than men They are also more likely to be economically active across ages 30-60, and experience 1.8 years of higher WLE. They are also 5.5% more likely to be economically active than current/ex-smokers at age 50. If all women were never-smokers then GDP would be £7.6bn a year higher (source: ILC).

Statistical methods for estimating health expectancy

Statistical method	Software	Max # states	Discrete/continuous time	Has covariates
Sullivan method (Sullivan 1966)	Any (including Excel)	3	Discrete	No
IMaCh (Lievre et al 2003)	Proprietary	No limit	Discrete	Yes
SPACE (Cai et al 2010)	SAS	No limit	Discrete	Yes
ELECT (van den Hout, **Chan**, Matthews 2019)	R	No limit	Continuous	Yes

- Analyses presented here have used the Sullivan method (unless otherwise stated)
- HLE estimated using the other methods can be split by multiple health thresholds, and can utilise more objective measures of ill health (e.g. disease diagnosis), but access to clinical records required for this

Decision theoretic model of impact of switching to vaporised nicotine products

Based on current use patterns and conservative assumptions, we project a reduction of 21% in smoking-attributable deaths and of 20% in life years lost as a result of VNP use by the 1997 US birth cohort compared to a scenario without VNPs. In sensitivity analysis, health gains from VNP use are especially sensitive to VNP risks and VNP use rates among those likely to smoke cigarettes.

Source: Levy et al 2017

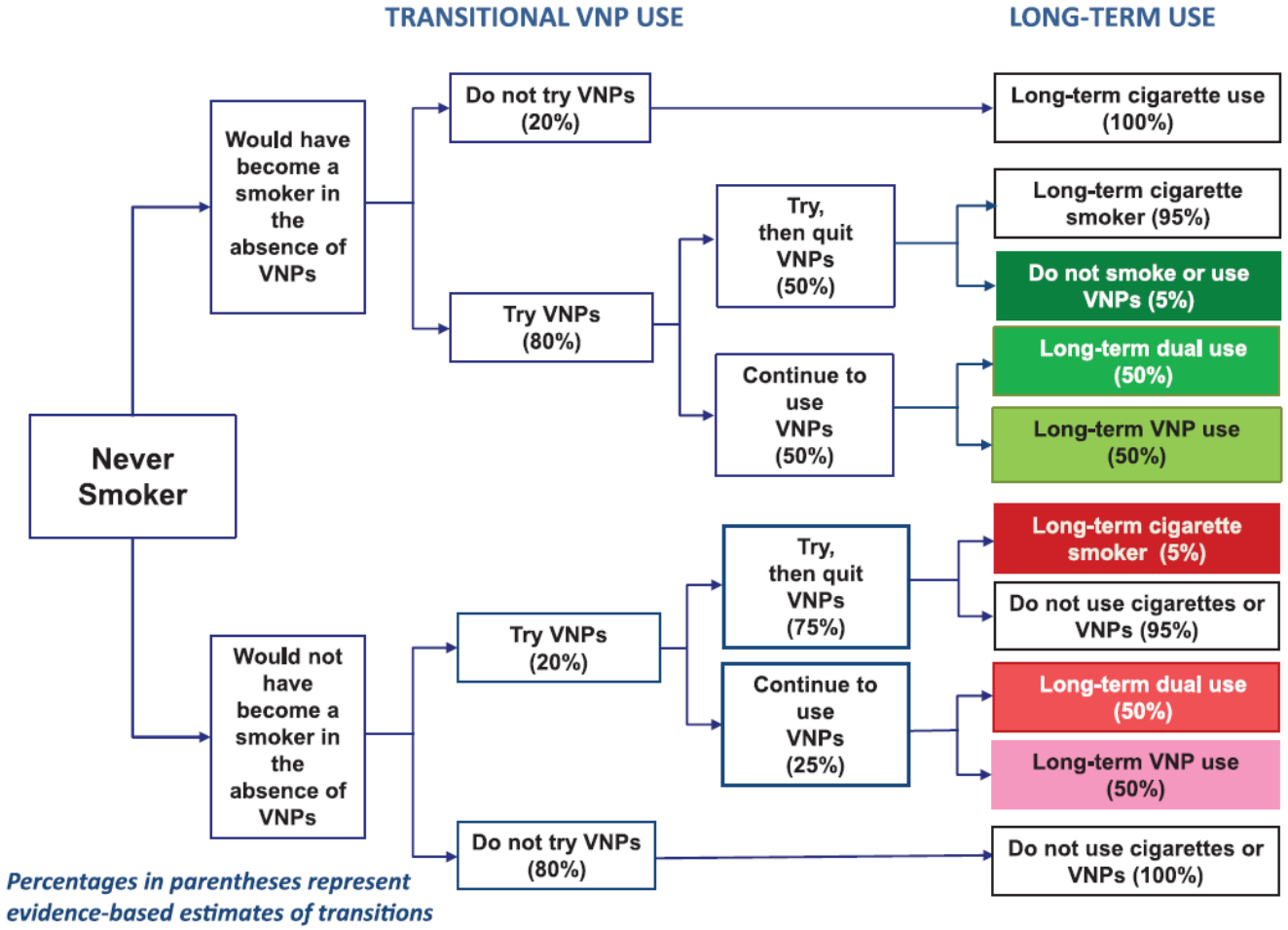
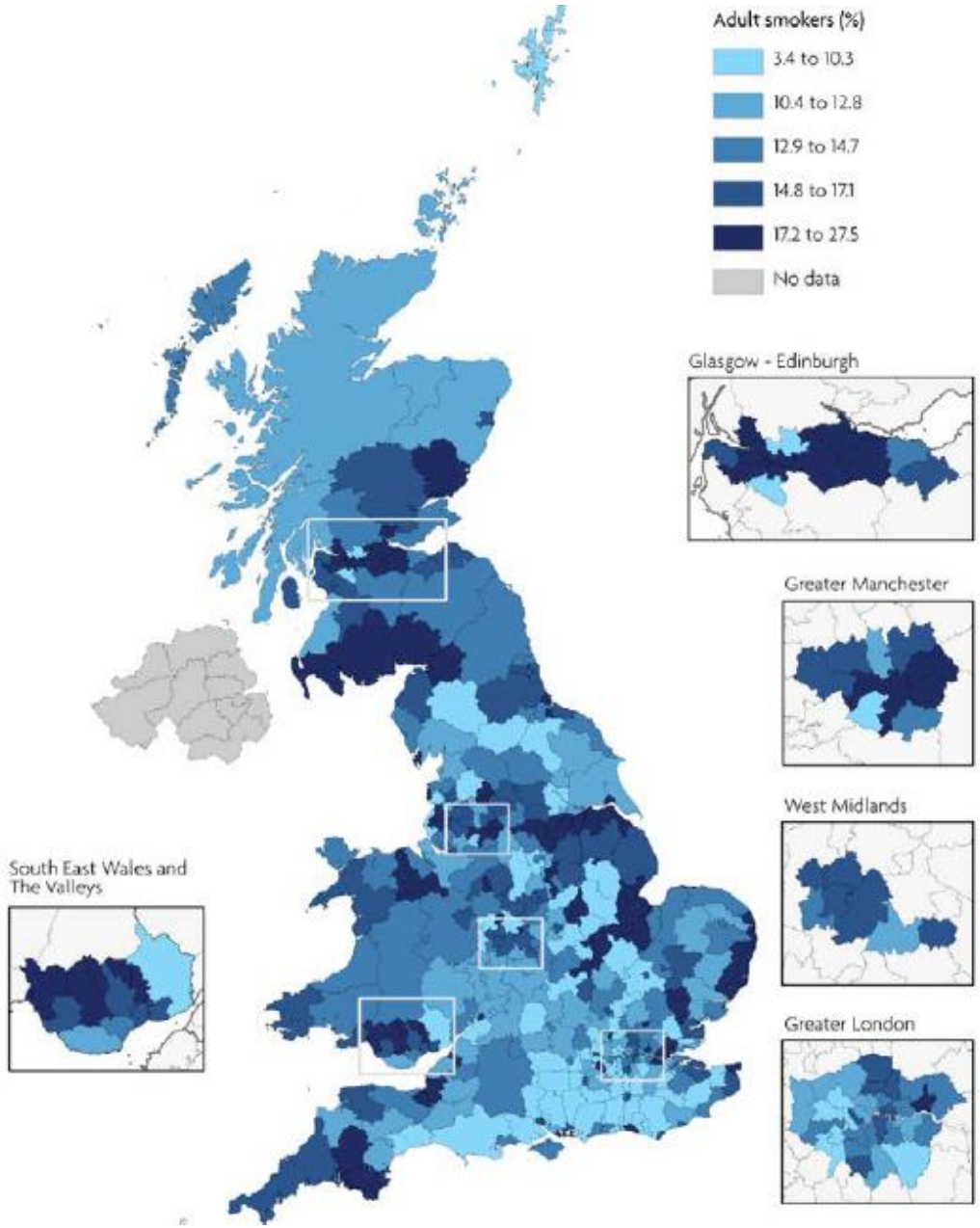


Figure 1. Transitional vaporized nicotine product (VNP) use. Percentages in parentheses represent evidence-based estimates of transitions.

% of adult current smokers, by local authority in the UK in 2019



Source: Office for National Statistics data reproduced in the Khan review, 2022