Title: Community water fluoridation expansion in north east England **IA No:** 9617 **RPC Reference No:** **Lead department or agency:** Department of Health & Social Care **Other departments or agencies:**	Impact Assessment (IA) **Date:** February 2025 **Stage:** Final **Source of intervention:** Domestic **Type of measure:** Other **Contact for enquiries:** waterfluoridationconsultation@dhsc.gov.uk
Summary: Intervention and Options	**RPC Opinion:** Not applicable

Cost of Preferred (or more likely) Option (in 2024-25 prices)

Total Net Present Social Value	Business Net Present Value	Net cost to business per year	Business Impact Target Status
£201m	0	0	

What is the problem under consideration? Why is government action or intervention necessary?

Tooth decay is a significant yet largely preventable public health problem, affecting all stages of life; it is the most common oral disease in children, with significant health inequalities, can cause pain and difficulties eating and sleeping. It is progressive if left untreated but can be prevented by fluoride and minimising the amount and frequency of sugar consumption. The government proposes using powers in the Health & Care Act 2022 to expand community water fluoridation in the north-east region of England, increasing the levels of fluoride in the water supply, if needed, to levels needed to improve dental health. Legislation requires a public consultation before a final decision is made.

What are the policy objectives of the action or intervention and the intended effects?

There is strong scientific evidence that water fluoridation schemes can help reduce tooth decay and is a safe and effective public health intervention[1]. Around 6 million people in England are already covered by agreements to add fluoride to their drinking water supplies, including around 1 million people in the north-east region. This proposal would expand existing community water fluoridation to an additional 1.6 million people served by Northumbrian Water Limited. Implementation is intended to improve oral health of adults and children in the north-east region, reduce inequalities in oral health in the north-east region of England, and reduce impacts of poor oral health on dental services and the NHS in the north east region of England.

What policy options have been considered, including any alternatives to regulation? Please justify preferred option (further details in Evidence Base)

Impacts are compared to a 'do nothing' option where existing areas are fluoridated, and others are not. Existing costs continue and additional costs or risks of expansion will not be incurred. Alternative policy options considered include access to dental services and targeted oral health improvement programmes. DHSC is currently reviewing the previous Government's Dental Recovery Plan and what elements of that can be taken forward effectively. The Government does not consider the previous dental plans went far enough. To tackle the immediate crisis in NHS dentistry a rescue plan will provide 700,000 more urgent dental appointments. A targeted supervised toothbrushing programme for 3 to 5 year olds will be implemented. Expansion of community water fluoridation in the north-east region remains the preferred option This is complementary to other interventions that reduce tooth decay and does not rely on behaviour change, which is particularly important for children and vulnerable groups who may be less likely to access dental services or participate in targeted programmes. The north east region is the first area under consultation as it has existing feasibility studies, large inequalities in oral health, and the water company has experience of water fluoridation.

[1] See for example health monitoring reports 2014, 2018 and 2022 at Water fluoridation: health monitoring report for England 2022 - GOV.UK (www.gov.uk)

Is this measure likely to impact on international trade and investment?		No		
Are any of these organisations in scope?	**Micro** No	**Small** No	**Medium** No	**Large** Yes
What is the CO_2 equivalent change in greenhouse gas emissions? (Million tonnes CO_2 equivalent)		**Traded:** N/A	**Non-traded:** N/A	
Will the policy be reviewed? It will be reviewed. **If applicable, set review date: Not applicable**				

I have read the Impact Assessment and I am satisfied that, given the available evidence, it represents a reasonable view of the likely costs, benefits and impact of the leading options.

Signed by the responsible SELECT SIGNATORY: ..... Date: 06 March 2025

Summary: Analysis & Evidence Policy Option 1

Description: Do Nothing

FULL ECONOMIC ASSESSMENT

Price Base Year	PV Base Year	Time Period	Net Benefit (Present Value (PV)) (£m)		
			Low:	**High:**	**Best Estimate:** 0

COSTS (£m)	Total Transition (Constant Price) Years	Average Annual (excl. Transition)	Total Cost (Present Value)
Low	Optional	Optional	**Optional**
High	Optional	Optional	**Optional**
Best Estimate			**0**

Description and scale of key monetised costs by 'main affected groups'

These are defined to be 0.

Other key non-monetised costs by 'main affected groups'

These are defined to be 0.

BENEFITS (£m)	Total Transition (Constant Price) Years	Average Annual (excl. Transition)	Total Benefit (Present Value)
Low			
High			
Best Estimate			**0**

Description and scale of key monetised benefits by 'main affected groups'

These are defined to be 0.

Other key non-monetised benefits by 'main affected groups'

These are defined to be 0.

Key assumptions/sensitivities/risks **Discount rate**

We assume that no new water fluoridation schemes are introduced under the 'do nothing' option.

BUSINESS ASSESSMENT (Option 1)

Direct impact on business (Equivalent Annual)			Score for Business Impact Target (qualifying provisions only) £m:
Costs: 0	**Benefits:** 0	**Net:** 0	

Summary: Analysis & Evidence Policy Option 2

Description: Expansion of community water fluoridation in the north east region

FULL ECONOMIC ASSESSMENT

Price Base Year 2024-25	**PV Base Year** 2024-25	**Time Period Years** 40	**Net Benefit (Present Value (PV)) (£m)**		
			Low: £324m	**High: £77m**	**Best Estimate: £201m**

COSTS (£m)	**Total Transition** (Constant Price) Years		**Average Annual** (excl. Transition)	**Total Cost** (Present Value)
Low				Social cost: £288m (Financial cost: £47m)
High				Social cost: £535m (Financial cost: £87m)
Best Estimate				Social cost: £412m (Financial cost: £67m)

Description and scale of key monetised costs by 'main affected groups'

Expanding water fluoridation incurs discounted capital costs, estimated to be approximately £214m financial cost (£37m social), and operational costs, revenue associated with day to day running and maintenance, estimated to be approximately £198m over 40 years. These are not direct costs to business; The Secretary of State is responsible for reimbursing water companies for reasonable costs associated with water fluoridation schemes, managed through an ongoing business as usual programme.

Other key non-monetised costs by 'main affected groups'

None

BENEFITS (£m)	**Total Transition** (Constant Price) Years		**Average Annual** (excl. Transition) (Constant Price)	**Total Benefit** (Present Value)
Low				
High				
Best Estimate				£613m

Description and scale of key monetised benefits by 'main affected groups'

In England water fluoridation schemes aim for a concentration of 1 mg per litre as strong scientific evidence has shown this to be the optimal level of fluoride for a temperate climate to reduce tooth decay. Reducing caries is expected to lead to dental healthcare cost savings from avoided fillings and extractions, productivity gains from workdays missed and quality of life benefits to the individual; an economic model monetises these over a 40 year time horizon.

Other key non-monetised benefits by 'main affected groups'

Other non-monetised benefits may include benefits accrued beyond the 40 year time horizon. The likely benefit associated with partial exposure of fluoridated water over the life course. The impact from missed education, avoided out of pocket expenses from paying for extractions or fillings (where applicable) and travelling to and from dental practices and forgone need for further dental healthcare such as root canals, dentures and bridges.

Key assumptions/sensitivities/risks **Discount rate (%)**	3.5/1.5%, (after 30 years 3.0/1.29%)

We assume no population growth within the north east region, and no change to dental caries over time. Any benefits accrued by individuals moving into the area would be equally and oppositely offset by individuals moving out of the area. Some model inputs rely on England data and we assume these hold for the north east region.

BUSINESS ASSESSMENT (Option 2)

Direct impact on business (Equivalent Annual)			Score for Business Impact Target (qualifying provisions only) £m:
Costs: £0	Benefits:	Net:	

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Evidence Base

Problem under consideration

1. Tooth decay is a significant, yet largely preventable, public health problem in England. It is caused by consuming sugary food and drinks and lack of availability to fluoride. It affects people at all stages of life and is the most common oral disease in children. It can result in pain and cause people difficulties eating, sleeping and socialising. Tooth decay is a progressive disease which, if left untreated, can cause severe pain and infection.

Tooth decay in England

2. In 2022, 24% of 5 year olds in England had experienced tooth decay.[1] Those in the most deprived 20% of areas of the country were 2.5 times as likely to have experience of dental decay as those in the least deprived 20% of areas (Figure 1). There were also inequalities in the prevalence of experience of dental decay by ethnic group, which was significantly higher in the Other ethnic group (45%) and the Asian or Asian British ethnic group (38%) than for other groups.

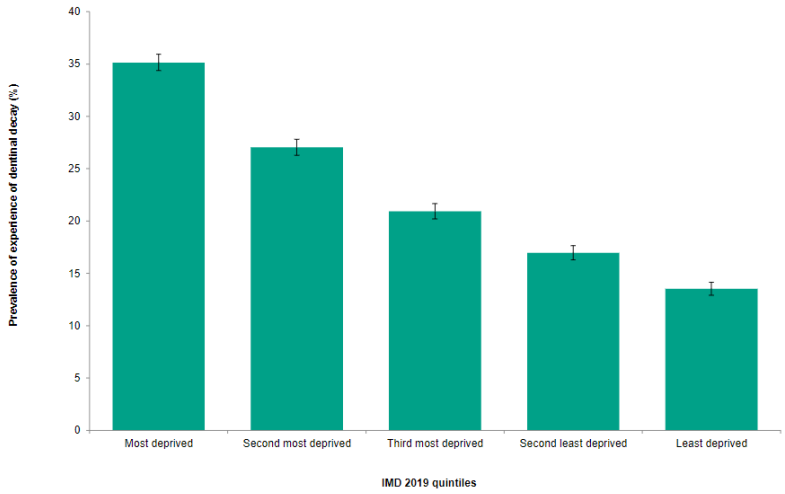

Figure 1. Prevalence of experience of dental decay in 5 year olds in England, 2022 by national IMD 2019 quintiles

3. Tooth decay can have a detrimental effect on children's learning and development as pain and infections from decayed teeth can result in school absences. In 2019, 6% of children aged under 16 in England had time off nursery or school in the last 6 months because of problems with their teeth, mouth or gums.[2]
4. In 2022/23, tooth extraction episode rates were nearly 3 and a half times higher in the most deprived 20% of areas in the country (381 per 100,000 population of 0 to 19 year olds) than the least deprived 20% of areas (109 per 100,000 population)[3]. Parents may also have to take time off work.
5. Tooth decay also has a considerable impact on the NHS and it is still the most common reason for hospital admission in children aged between 5 to 9 years. The costs to the NHS of hospital admissions for tooth extractions in children aged 0 to 19 years have been estimated based on the latest NHS national cost collection data. The costs were £64.3 million for all tooth extractions and £40.7 million for extractions due to tooth decay in the financial year 2022 to 2023.[3]

Tooth decay in the north east region

6. During 2022 to 2023, the number of Finished Consultant Episodes for children and adolescents aged 0-19 for hospital tooth extractions, with caries as primary diagnosis per 100,000 was 397 per 100,000 population in the north east region. This was the second highest rate for a region, behind only Yorkshire and The Humber, where the rate was 405 per 100,000. The rate across all England was 205 per 100,000 [3].

7. In 2022, the proportion of teeth with experience of dentinal decay that had been extracted in 5 year olds was highest in the north east region (13.4%), compared to 6.4% across England overall (see Figure 2)[1].

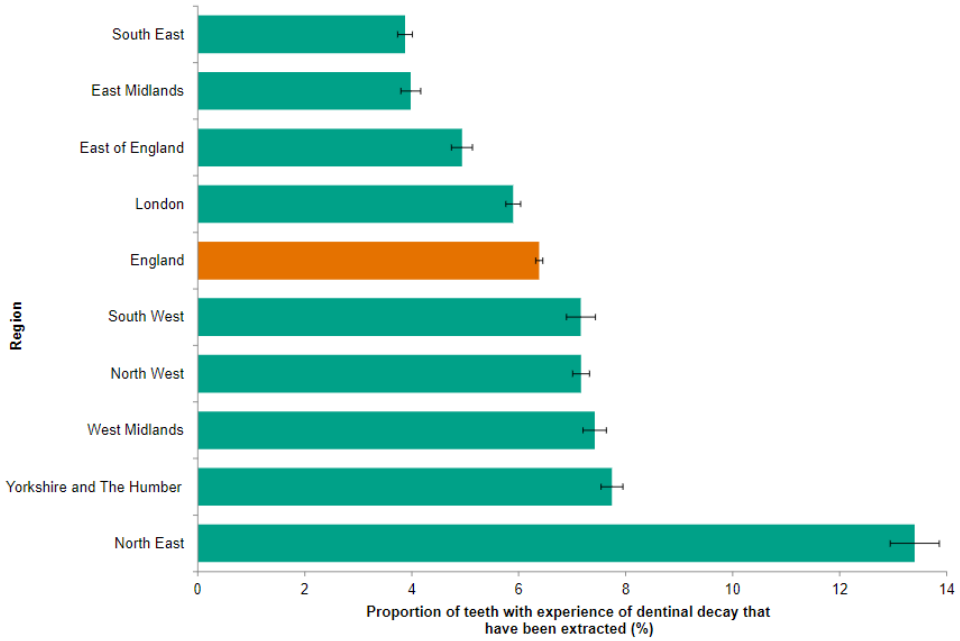

Figure 2. Proportion of teeth with experience of dentinal decay that have been extracted in 5 year olds in England by region, 2022

8. The 2009 Adult Dental Health Survey[4] showed information on adult dental health in England, and by region in England; north east region estimates are presented alongside the range across England regions for comparison:

    - 30% of adults in England and 34% of adults in the north east region had decayed teeth. Regionally this ranged from 21% in the south east coast to 39% in the west midlands.
    - 10% of adults with one or more natural teeth in the north east region had excellent oral health (defined as 21 or more teeth, 18 or more sound and untreated teeth, no active decay at any site, no periodontal pocketing or loss of attachment above 4mm, and no plaque or calculus); in England, this varied from 4% in the west midlands to 20% in the east of England.
    - 9% of adults in England and 8% of adults with teeth in the north east region reported feeling current pain related to their teeth. Regionally this ranged from 7% in the south east coast region to 11% in the north west.

Policy objective

9. The policy objectives are to reduce tooth decay in children and adults in the north east region, to reduce oral health inequalities in the north east region of England and to reduce pressures on dental services and the NHS in the north east region. This is based on existing oral health inequalities, local support and the availability of an operable and efficient scheme

proposal. In this instance, oral health is defined in terms of tooth decay. The indicators of success will be reduced tooth decay amongst the population.

Policy options

Do nothing option

10. The ‘do nothing’ option for this policy is the baseline with which the preferred option expanding water fluoridation in the north east region is compared. In the ‘do nothing’ scenario, no new water fluoridation schemes are introduced in the north east region. There would be no costs or benefits in this scenario. Government actions to improve access to NHS dentistry, introduce targeted supervised toothbrushing for 3 to 5 year olds and reduce sugar consumption would continue and have a positive effect on improving oral health. Other locally led oral health improvement work would continue based on local decision making.

Expanding community water fluoridation

11. The preferred policy option is to expand water fluoridation schemes in the north east region. There are already water fluoridation schemes in operation in some areas of the north east region, but the preferred option would be to expand them to a wider area.

12. Fluoride is a naturally occurring mineral found in soil, food and drink and also in drinking water supplies, in varying amounts. In some parts of England the level of fluoride in the public water supply already reaches the target concentration of water fluoridation schemes (one milligram per litre (1mg/l)), as a result of the geology of the area. In other areas the fluoride concentration has been adjusted to reach this level as part of a fluoridation scheme. In England water fluoridation schemes aim for a concentration of 1 mg per litre as this is the optimal level of fluoride to reduce tooth decay.

13. No new schemes have been implemented for over 40 years. From 2013, local authorities had the responsibility, through the Water Industry Act 1991, to propose and consult on new fluoridation schemes and variations to or termination of existing schemes. However, local authorities reported difficulties with that process. In particular, local authority boundaries were not coterminous with water flows which requires the involvement of several authorities in these schemes and made development of arrangements more complex. The Health and Care Act 2022 transferred to the Secretary of State of Health and Social Care the power to directly introduce, vary or terminate water fluoridation. Changes to water fluoridation schemes are subject to statutory consultation procedures.

14. The proposal to expand water fluoridation should be seen as a complementary strategy and not a substitute for other effective methods of increasing fluoride use. Water fluoridation would help to achieve the policy objective, as it would be a universal intervention to improve health for a whole area. It does not rely on behaviour change which is particularly important for children and vulnerable groups.

15. An alternative policy option would be to expand water fluoridation schemes to cover different areas, more or all of England. This is not favoured at the present time and the north east region has been prioritised as the first area under consultation to introduce new, or vary existing, water fluoridation arrangements using powers in the Health and Care Act 2022, based on several factors: in the north east region, necessary feasibility studies were well developed under the previous legislative framework for the whole area; they were also close to going out to public consultation when the legislation changed; there are large inequalities in oral health across the north east region; and the water company supplying the area has experience in water fluoridation.

Alternative options to reduce tooth decay

16. In 2014, Public Health England published an evidence-informed toolkit for local authorities to inform commissioning better oral health for children and young people.[5] This outlined a range of potential interventions that could be introduced to improve oral health:

    - **Interventions to support consistent evidence informed oral health information**, such as oral health training for the wider professional workforce and integrating oral health into targeted home visits by health and care workers.
    - **Community based preventive services**, such as targeted community-based fluoride varnish programmes and targeted provision of toothbrushes and tooth paste (i.e. postal or through health visitors).
    - **Supportive environments**, such as supervised tooth brushing, healthy food and drink policies, and fluoridation of public water supplies.
    - **Community action**, such as targeted peer support groups or school/community food co-operatives.
    - **Healthy public policy**, such as infant feeding policies.

17. Initiatives at a national and local level are already in place, addressing tooth decay from these different perspectives on the issue. A combination of interventions is required to help prevent tooth decay and improve oral health.

18. **Brushing teeth twice daily with fluoride toothpaste** also helps to prevent tooth decay. A 2013 national survey indicated that around 8 in 10 children aged 5 to 15 in England brushed their teeth twice or more a day according to parental reports[6]. Tooth brushing twice daily among 15 year olds eligible for free school meals (FSM) was lower than among their peers not eligible for FSM.[77] Expert opinion suggests that children need to be helped and supervised by an adult, when brushing, until at least 7 years of age. Supervised tooth brushing in early years settings is one way of improving oral health. However, it would not achieve the policy objective of improving oral health for both adults and children in the north east region. Furthermore, it requires behaviour change by the individual, which may be more achievable for some than others. Water fluoridation is a preventative policy which improves oral health without behaviour change and would be complementary to other locally commissioned interventions that increase fluoride use.

19. **Healthy food & drink schemes**: Sugar consumption is the main cause of tooth decay. Measures taken to reduce sugar consumption will have a positive effect on improving children's oral health. The case for change and strategic framework of the Major Conditions Strategy, published August 2023, included a commitment to continue to work with stakeholders and industry to reduce sugar, salt and calories in food, including for baby food and drink. This includes businesses continuing to work towards delivering the 20% sugar reduction target that make the biggest contributions to intake of sugar for children aged up to 18 years.

20. The most recent progress report showed that reductions in sugar were made in all food categories, with the highest reductions being in breakfast cereals (14.9%) and yogurt and fromage frais (13.5%) between 2015 and 2020. The overall reduction was 3.5% when weighted for the highest selling products. The difference between this figure and the reductions in cereals and yogurts occurs because of the increased sales of higher sugar products such as chocolate confectionary. Levels of sugar in drinks subject to the Soft Drinks Industry Levy (SDIL) reduced by 46% over the same period. Further data on juices and milk-based drinks, and drinks subject to the Soft Drinks Industry Levy (SDIL), will be published in 2024. Water fluoridation can mitigate the impact of sugar consumption and subsequent tooth decay.

21. **Facilitating access to dental services**: In July 2022, the government announced a package of reforms to improve access to NHS dentistry. This outlined steps to meet oral health need and increase access to dental care. The changes implemented include improvements to ensure dentists are remunerated more fairly for more complex work. To tackle the immediate crisis in dentistry a rescue plan will provide 700,000 more urgent dental appointments. A targeted supervised toothbrushing programme for 3 to 5 year olds will be introduced in England.

22. From 1 April 2023 responsibility for commissioning primary care dentistry to meet the needs of the local population has been delegated to all integrated care boards (ICBs) across England. ICBs are responsible for having local processes in place to involve patient groups, and for undertaking oral health needs assessments, to identify areas of need and determine the priorities for investment.

23. The NHS Long Term Workforce Plan, published on 30 June 2023, sets out the steps the National Health Service and its partners need to take to deliver an NHS workforce that meets the changing needs of the population over the next 15 years. These include a 40% increase to dentistry undergraduate training places by 2031/32.

24. Water fluoridation provides a population level intervention to reduce tooth decay that does not rely on accessing dental services.

Summary and preferred option with description of implementation plan

25. In summary, whilst alternative options to expanding water fluoridation exist which may improve oral health, these are considered complimentary rather than a substitute. Water fluoridation has unique qualities which will help address the policy objective, particularly for vulnerable groups. Other programmes and policies are already in place or could be in place via local authority commissioning structures and water fluoridation schemes would complement these initiatives. The north east region has been chosen as existing feasibility studies on water fluoridation have been carried out, the water company has experience of water fluoridation and there are large inequalities in oral health. Therefore, this impact assessment considers the costs, benefits and risks of expanding water fluoridation in the north east region, compared to a do nothing scenario. Costs and benefits of alternative options are not included.

26. Public consultation on this proposal ran between 25 March 2024 and 31 July 2024. The decision on whether or not to proceed will be made by the Secretary of State for Health and Social Care. If a decision to proceed is made and depending on the outcome of the Budget, DHSC would develop necessary and appropriate fluoridation legal agreements and/or variations to existing agreements with Northumbrian Water Ltd. Development would include settling final planning, capital and operating requirements. This would involve transition to the current work on existing water fluoridation schemes and the Secretary of State's responsibilities for reimbursing water companies for the reasonable capital and revenue costs of these schemes.

Costs and benefits

Summary table of costs and benefits

	Do nothing	**Expansion of water fluoridation**
Costs		
Capital costs	£0	£37m (financial, discounted)
	£0	£214m (social, discounted)
Operational costs	£0	£198m (social, discounted)
Total costs (social, discounted)	**£0**	**£412m**

Benefits		
Financial benefits (dental healthcare cost savings & productivity gains)	£0	£588m (social, discounted)
Quality of life benefits to the individual	£0	£25m (social, discounted)
Total benefits (social, discounted)	**£0**	**£613m**

Note: None of the above constitute direct or indirect costs to business. Costs are met by Secretary of State.

Overview of economic model

27. The Department of Health and Social Care (DHSC) has developed an economic model (the "WF model") to quantify the costs and benefits of the proposed expansion of the water fluoridation programme across the north east region of England. Further detail on the methodology is set out in Annex A: Modelling Approach. Here, we include a high-level overview of the modelling approach. Flow charts are included throughout this section; they are a high level representation of the model's functionality.

28. Water fluoridation leads to reduced caries in both deciduous (baby) and permanent (adult) teeth. For each cohort (year group) the WF model first estimates the expected reduction in caries for individuals. This is then used to assess the magnitude of health benefit to the individual as well as cost savings, from a reduction in dental resource use (fillings and extractions) and lost workplace productivity. The cost savings are then compared to the expected cost of delivering the expansion of water fluoridation to understand its value for money over time.

Cohort modelling approach

29. The WF model uses a cohort-based modelling approach which follows fixed groups of individuals over time. Each year group forms its own cohort with a new cohort entering the model each year. The cohorts are composed of a group of representative or 'average' individuals in the north east region of England in terms of their cumulative decayed, missing or filled teeth (dmft/DMFT), which is the outcome metric used to measure carious teeth. This is discussed further in Annex A: Modelling Approach.

30. The model uses a 40 year time horizon[i]. The Green Book[8] indicates that infrastructure projects, like new buildings, should be appraised over a 60 year period, whereas refurbishment of existing buildings is considered over 30 years. Given the new, or changes to existing, infrastructure required to implement water fluoridation, a 40 year appraisal period has been selected to appraise both costs and benefits. Rather than estimating a cohort's annual benefits until death, benefits and costs are capped at 40 years post introduction of the programme. This is considered a reasonable approach, as it negates the need to draw in assumptions pertaining to average cohort life expectancy which would have added an additional layer of uncertainty. Capping benefits at 40 years rather than modelling death rates ensures our value for money estimates remain a conservative reflection of the programme's potential true value.

31. Due to the cohort modelling approach taken, the WF model only estimates benefits for individuals born into the cohorts once water fluoridation is already in place. The WF model does not account for benefits that might be accrued by individuals who are already living when water fluoridation is commenced, due to uncertainty around the evidence related to the benefits of partial exposure. The potential benefits for these individuals, such as children and adults who already live in the area before it is expanded, are not quantified. As a result, the WF model produces a potentially conservative estimate of monetised benefits and they

[i] The 40 year time horizon dictates that, for example, the 40*th* cohort to enter the deciduous teeth model (born 40 years from now), will only receive 1 year of benefits.

could be larger if a larger group than the cohorts stand to benefit from expansion of water fluoridation.

Core assumptions

32. Assumptions underpinning the analysis of costs and benefits for the expansion of water fluoridation are discussed throughout this Impact Assessment and in detail in 'Annex A: Modelling Approach'; sources for assumptions are discussed in detail in the annex. Core assumptions to note include:

- No population growth within the north east region[ii].
- Any benefits accrued by individuals moving into the area would be equally and oppositely offset by individuals moving out of the area.
- Some inputs to the model rely on data for England; we assume these estimates hold for the north east region, for example the effect size from fluoride on dmft.
- As noted above, the WF model bases analysis of benefits on reduced caries, measured through dmft/DMFT. We do not use historic trends in dmft/DMFT to predict future baseline dmft/DMFT values over our 40 year time horizon, rather the baseline dmft/DMFT values observed in the control population are fixed over time. This reflects the fact we do not know if average dmft/ DMFT values in the population will increase, decrease or stay the same over the next 40 years. Data from the oral health survey of 5 year old children indicates that levels of dental decay in the north east region remained at similar levels between 2017 and 2022[37].
- We know that individuals consume different amounts of tap water, based on drinking and eating habits. This means there will be a range of amounts of fluoride that people consume. The benefits presented here are calculated from data collected from populations who will also have had variation in the amount of tap water consumed. It is assumed that the variation of tap water consumption in the target populations in the north east will reflect the variation of consumption observed in these studies.
- Capital costs are assumed to start in year 1 of the programme (2025-26); operational costs are assumed to start in year 3 of the programme (2027-28), and this is the year when fluoride is assumed to start being added to some water supplies; benefits are therefore also assumed to start accruing in year 3 of the programme (2027-28).
- The estimated operational costs have been used to calculate the proportion of the cohort born that year that will receive fluoride, and therefore receive the benefits. For the cohort born in 2027-28, 3% of the target population cohort is assumed to receive fluoride; for the cohort born in 2028-29, this figure is assumed to be 64%; for the cohorts born in 2029-30 onwards, this figure is assumed to be 100%.
- In line with the Green Book[8] a 3.5% discount rate has been applied to our financial costs and benefits, with a 3.0% rate used after year 30. A 1.5% discount rate is applied to health impacts, with a 1.29% rate used after year 30.

Evidence

[ii] Holding population growth constant over the 40 year time horizon, appears appropriate in the context of the ONS population estimates for 0-4 year olds in the North East region. The ONS estimates that our population of interest will steadily decline from 2019 to 2030 (falling to approx. 90% of its baseline 2019 value) before reversing this trend, steadily growing at a more gradual rate. By 2043 the last year of estimated ONS data the population has not returned to its 2019 baseline, but the trend remains shallowly upward. In light of these estimates and the paucity of data for the remining 20 years, 'no population grow' was adjudged a responsible simplifying assumption.

33. As well as published systematic reviews, this impact assessment and the WF model have made use of evidence from statutory health monitoring reports. There is a legal obligation for the Health Secretary to monitor health impacts of water fluoridation schemes every four years. The last three health monitoring report for England (2014, 2018 and 2022) have collectively looked at three dental health outcomes: experience and severity of tooth decay in 5 year olds and hospital admissions for removing teeth due to decay in children and young people.

34. The model also uses evidence from National Dental Epidemiology Programme surveys, for example the oral health survey of 5 year old children takes place every 2 years to collect information of children who attend mainstream, state-funded schools across England.

35. Prior to consultation we convened external experts focussed on water fluoridation and economic modelling to test appropriate outcome measures and available data sources to model impacts for children and adults.

36. We have considered all responses to the consultation. In total, there were 934 responses to the free text question asking whether responders had any scientific evidence or evidence on the cost-benefit analysis for us to consider in our final impact assessment. The key topics presented in responses were:

    - **Respondents expressed various views on the applicability of the preventative fraction (27% reduction in DMFTs due to water fluoridation[iii]) that is applied to adults in the modelling, which is based on Griffin et al[9].** The review by Griffin et al in 2007 was the first such review to attempt to summarise the effect of water fluoridation in adults in studies published after 1979. There were strict entry criteria for selecting the research for the review and the authors found 20 studies that met their initial criteria, of which nine focused on the effectiveness of water fluoridation. The review included a meta-analysis to explore how effective fluoride was in preventing caries in adults, including self- and professionally applied fluorides and community water fluoridation. The prevalence of both coronal and root caries was studied. Australian National Health and Medical Research Council[10] and authoritative evidence reviews from other national public health bodies in Canada[11] and New Zealand[12] came to similar conclusions that of Griffin et al. We are therefore content to continue to use this figure in the modelling, as it represents the best evidence that we have of the impact of water fluoridation on adults.

    - **Many respondents pointed to contemporary UK evidence, such as the CATFISH[13] and the LOTUS[14] studies. There was a roughly equal split between those pointing to these studies to evidence that water fluoridation is good value for money, and those pointing to the studies to suggest that water fluoridation is not good value for money.** On balance, and combined with the evidence from the Cochrane Review 2024[15], community water fluoridation appears to offer good value for money due to its low per capita intervention delivery costs, potential to reduce caries, even at low magnitudes of effect size, and the related impact on dental treatment costs averted. However, the magnitude of cost-effectiveness (or net cost-savings) is shown to be sensitive to the size of the fluoridated population and other factors. Cost benefit is also shown to be context specific and considered on a case by case basis according to population size, magnitude of benefit and underlying caries prevalence in the population served. As such, this impact assessment specifically assesses the proposal to expand water fluoridation into the north east of England, where it is known that there are large inequalities in oral health.

[iii] Sensitivity analysis has been conducted, in order to understand what the minimum effect size would need to be for the programme to breakeven at the expiration of the 40 year time horizon

- **Many responders pointed to a variety of scientific and evidence papers, many focussing on the potential risks of water fluoridation, including a US National Toxicology Program (NTP) systematic review on the association between fluoride exposure and neurodevelopment and cognition[16]**. The NTP concluded that there is "moderate confidence" that levels of fluoride from drinking water in concentrations *greater* than the WHO drinking water guideline of 1.5 mg/L were associated with lower IQ in children. The US NTP also reported insufficient evidence of fluoride exposure and adverse effects on cognition in adults and conclusions on fluoride exposure and the plausibility of cognitive or neurodevelopmental effects in humans could not be drawn. We consider that the overall weight of evidence and authoritative reviews of a large body of relevant and suitable studies indicate that there is no convincing evidence that fluoride at the levels permitted in fluoridated drinking water present a risk to health. The Secretary of State will continue to have a duty to monitor the effects of water fluoridation schemes on health and to produce reports at no greater than 4-yearly intervals.
- **Additionally, responders noted that within our cost benefit analysis outlined below, we have not included the potential costs of treating medical conditions caused by ingesting high doses of fluoride.** We are content that systematic reviews, which have looked at the general health effects of fluoridation, have found no credible evidence that water fluoridation is harmful to health at permitted levels. There is therefore no evidence to suggest that there will be increased costs for the NHS to treat any health harms.
- **Some responders expressed concern about the cost to treat, and the personal impacts of fluorosis.** Severe fluorosis can cause brown staining and pitting of teeth but is generally seen in those countries with very high naturally occurring levels of fluoride in groundwater. These levels of fluoride are above those used in water fluoridation schemes and this proposal, and so the cost impacts of this are not considered within the quantified cost benefit analysis. The risks of mild fluorosis are further discussed below.
- **Some responders suggested that environmental impacts should be included within the costs section of the analysis**. In 2011, the European Commission Scientific Committee on Health and Environment Risk review concluded that fluoridation of drinking water is not expected to lead to unacceptable risks to the environment[17]. The Drinking Water Inspectorate (DWI) has published a 'Code of Practice on Technical Aspects of Fluoridation of Water Supplied 2021'[18]. On balance, there is therefore no evidence to suggest that there are additional costs from environmental impacts that should be included within the analysis presented below.
- **Some responders noted that, in some cases, the costs of dental treatment fall both on the NHS and on individuals, particularly if individuals utilise private dental care, either by choice or by necessity.** While we are unable to quantify the impact of this proposal on the private dental sector, we know that private dental treatment is often more expensive than NHS care. It is therefore likely that the benefits outlined below are an underestimate of the true savings that both the NHS, and individuals, are likely to make from the oral health improvements that water fluoridation brings.

Costs

37. The costs associated with the delivery of the expansion of water fluoridation consist of:

- Capital costs such as the costs associated with the machinery and equipment needed to operate the fluoridation plant, and
- Operational costs such as the revenue costs associated with the day to day running and maintenance.

38. Neither capital nor operational costs represent direct costs to business. Before proposing a new fluoridation arrangement, the Secretary of State is required to consult the relevant water company on whether this would be "operable and efficient" (s87(11) of the Water Industry Act 1991). We have consulted Northumbrian Water Ltd (NWL) that the proposed scheme would be operable and efficient. The Secretary of State is also responsible for reimbursing water companies for reasonable capital and operating costs associated with water fluoridation schemes.
39. The capital costs account for expected cost uplifts above general inflation over the next 5 years, and we have used GDP deflators to put these into 2024-25 prices.
40. In the 'do nothing' scenario, there will be no new costs incurred as water provision will continue as normal, without fluoridation being expanded to new areas. For the expansion scenario, the estimated costs incurred by DHSC when expanding water fluoridation to more areas in the north east region are discussed below.

Capital costs

41. Capital costs represent the plants and associated equipment required to implement the proposed scheme. These estimates have been developed in consultation with Northumbrian Water Ltd during feasibility work. These set up costs would be incurred in the first 5 years of the appraisal period, as well as 20 years later, as it is assumed that equipment has a life span of 20 years and would then need to be replaced.
42. The capital cost for the lifetime of the expansion is estimated to be approximately £55 million (undiscounted), or £37m (discounted).
43. In line with Green Book supplementary guidance recommendations to address optimism bias in the estimate of costs, we have uplifted the capital costs by a factor of 1.1 to account for any potential bias in the estimate. This is a conservative measure that helps to ensure we do not underestimate the capital costs and thus overstate the value of the programme. To account for potential bias in the estimates we have applied the 1.1 cost multiplier[iv].
44. The 10% optimism bias figure was chosen based on advice presented in the cost benefit analysis guidance for local partnerships. The capital costs have been calculated by practitioner experts in the relevant water companies and have been verified with an independent engineering consultant. Given that the costs are also based on data less than 3 years old, the multiplier of 1.1 was deemed to be reasonable.

Operational costs

45. Operating costs have also been identified through consultation with Northumbrian Water Ltd. These operating costs are associated with the maintenance and administration of the water treatment plant on a day-to-day basis, such as payroll, overhead costs, as well as chemicals and maintenance expenses. Operational costs are estimated to grow each year in the first 5 years, as capital works at different plants is completed. From year 5 onwards, the deflated, undiscounted operational costs are estimated to be £1.6m each year.

Social value of the cost estimates

[iv] Supporting public service transformation: cost benefit analysis guidance for local partnerships - GOV.UK (www.gov.uk)

46. Total discounted costs of the programme are estimated to be £67m over 40 years of the programme.

47. In line with the Department impact assessment guidance the opportunity cost of the proposal has also been calculated. As this proposal will impact on DHSC budgets, it is likely this will affect the amount of funding available elsewhere in the NHS or health system. This opportunity cost impact has therefore been calculated by converting the financial costs to QALYs at a rate of £15,000 per QALY. The QALYs are then discounted before they are remonetised at the social value of a QALY; £70,000 resulting in present value total cost estimate of £412m, from the social perspective.

Total discounted costs

48. In summary, total financial and social cost estimates over the 40 years of the programme are estimated to be £67m and £412m respectively.

Uncertainties associated with costs

49. Cost estimates have been produced in collaboration with Northumbrian Water Limited. The costs include RPI inflation (in line with NWL costings) but have been deflated into real term prices using GDP deflators. This is to reflect the increase in capital costs that would be expected, above general inflation, over the 40-year appraisal period. Optimism bias has been added, as described above. Sensitivity analysis on these costs has been carried out, as described below.

Benefits

50. The World Health Organization recommends a maximum level of 1.5 milligrams per litre of water (mg/l)[19]. This is also the regulatory upper limit for fluoride set out in the Water Supply (Water Quality) regulations for England (monitored by the Drinking Water Inspectorate) and applies both to fluoridation schemes and fluoride naturally present in water. In England water fluoridation schemes aim for a concentration of 1 mg per lire as strong scientific evidence has shown this to be the optimal level of fluoride to reduce tooth decay, in both deciduous and adult teeth. In England, the water supply (water quality) regulations for England[20] applies. Evidence from multiple sources[21] suggest that the addition of fluoride (1mg of fluoride per litre of water (mg/L)) to drinking water reduces caries in both deciduous and permanent teeth. A reduction in caries because of water fluoridation expansion can be expected to lead to several types of benefit, cost savings to society and quality of life benefits to the individual and their family, dental healthcare cost savings and productivity gains. These and an overview of the WF model methodology are discussed below. Further detail on the methodology is included Annex A: Modelling Approach.

51. The benefits set out below occur because of a reduction in caries; the outcomes used to measure dental caries are ‘decayed missing or filled teeth’ (dmft for deciduous teeth and DMFT for permanent teeth). The benefits are based on the observed difference in dmft/DMFT values in populations exposed to fluoridated water (treatment population) relative to a characteristically similar population not exposed to fluoridated water (control population); monitoring data**Error! Bookmark not defined.** in England indicates that water fluoridation is associated with an observed ~20% reduction in caries at the age of 5[22].

52. To calculate the difference in average cumulative dmft/DMFT values for the control and treatment population, observed values are used where data are available[v] and linear approximation is used between ages where appropriate; for ages 12 onward for the treatment population, observed values are not available and instead the preventative fraction

[v] From the Water Fluoridation Health Monitoring Report for England (2014) and the Adult Dental Health Survey (2009)

(27% reduction in DMFTs due to water fluoridation[vi]) is applied, based on Griffin et al[23]. More information about dmft/DMFT is found in Annex A: Modelling Approach.

Dental healthcare cost savings

53. The expansion of water fluoridation is expected to result in dental healthcare cost savings associated with a reduced need for tooth extractions and fillings. Avoided dmft/DMFT drive dental healthcare cost savings because these need to be extracted, filled or in the case of deciduous teeth, natural loss of teeth. Both extractions and fillings represent a direct cost to the health care system, as they require dental time and resource to treat.

54. The methodology for estimating potential cost savings from avoided dental healthcare is set out in Figure 3 and Figure 4 for deciduous and permanent teeth respectively. For deciduous teeth, we calculate the proportion of teeth with decay that are extracted, filled, or left untreated for 0 to 5 year olds. All extractions for 0 to 5 year olds are assumed to occur in secondary care (treatment in a hospital setting), and all fillings occur in primary care (dentist and community dental services), so from there we can estimate the avoided cost of extractions and fillings. For teeth with decay that are left untreated some will be fall out (exfoliate) naturally and therefore bear no dental healthcare costs. Some will not exfoliate naturally over time and will require extraction between the age of 6 and 10; for these procedures, we estimate the costs of secondary and primary care. Taken together this gives the total possible avoided extraction and filling cost for deciduous teeth.

55. For cost savings associated with avoided decay in permanent teeth, we estimate the proportion of decayed teeth that are extracted and that are filled; the associated costs of treating these health issues, either through primary or secondary care, are calculated and summed to produce a total avoided dental healthcare cost for decay to permanent teeth (see Figure 4).

56. Finally, the cost of the additional fillings and extractions under non fluoridation conditions, will inevitably displace dental health services that would have otherwise been provided to patients; this is the opportunity cost of the proposal. Following current DH guidance, the opportunity cost is calculated at one Quality Adjusted Life Years (QALY) per £15,000. The stream of QALYs foregone is then discounted at a rate of 1.5% per year (1.29% after 30 years). The displaced QALYs are then re-monetised at the value of £70,000 a QALY; representing the social value of a QALY.

[vi] Sensitivity analysis has been conducted, in order to understand what the minimum effect size would need to be for the programme to breakeven at the expiration of the 40 year time horizon

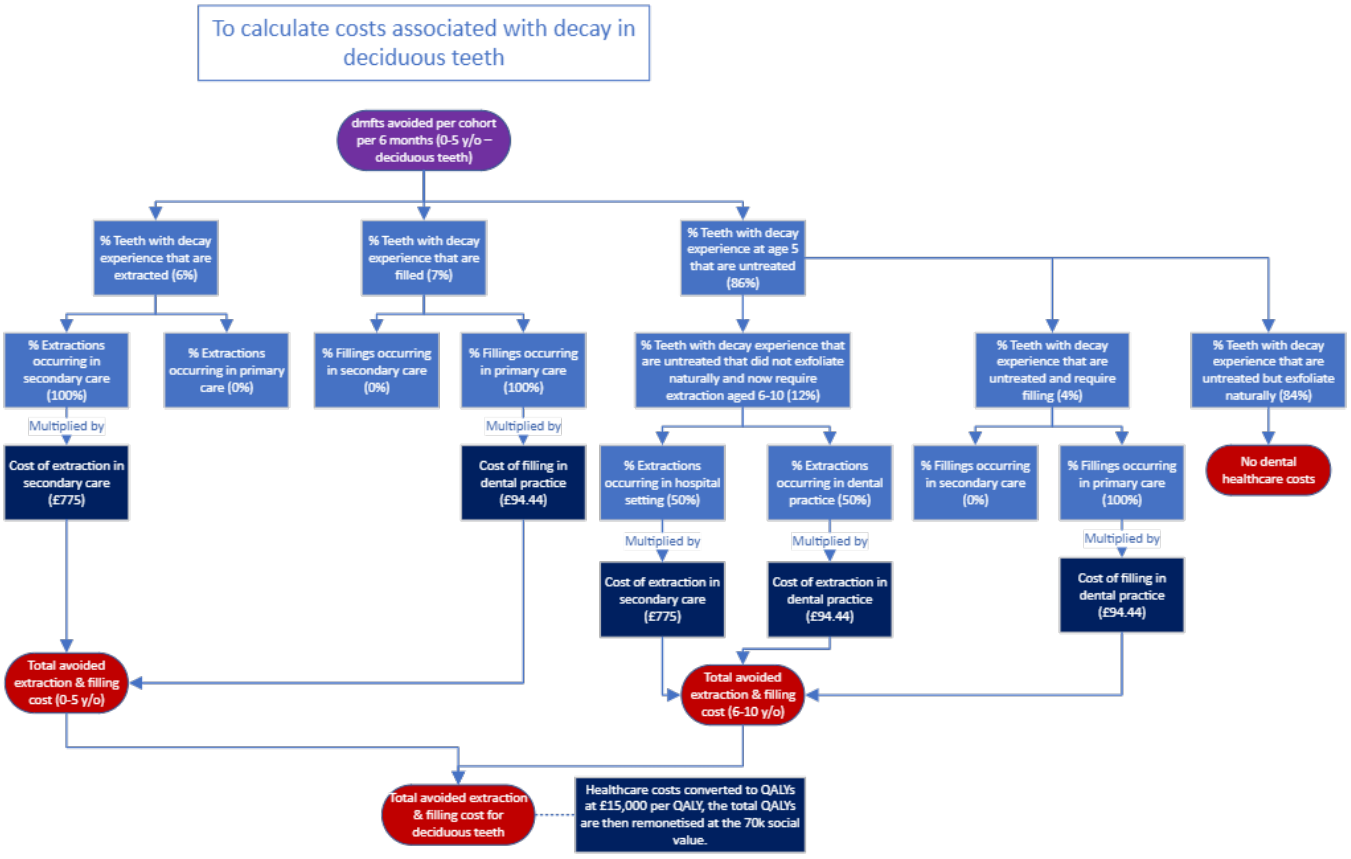

Figure 3. Methodology for cost savings associated with avoided decay in deciduous teeth (per cohort, receiving full 10 years of benefit)

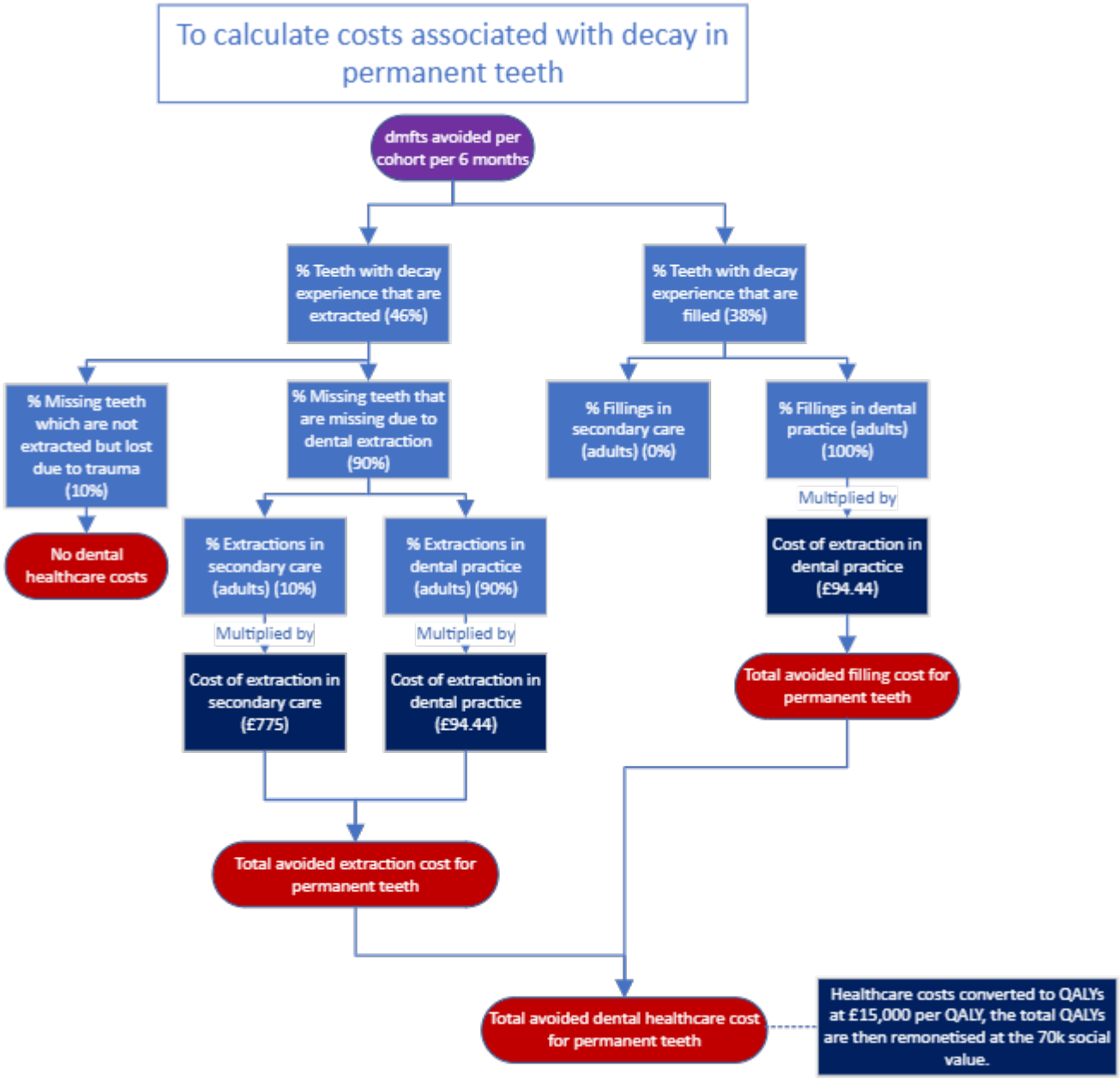

Figure 4. Methodology for cost savings associated with avoided decay in permanent teeth for the first cohort

Productivity gains

57. There may be productivity gains from a decrease in lost time at work due to a reduced need for fillings/extractions or caring for children requiring fillings/extractions.

58. We calculate the potential productivity gains for deciduous teeth and permanent teeth separately. For both, we first estimate the proportion of decayed teeth that are extracted or filled. For extractions we calculate the assumed school or work absence due to the extraction itself and assume that some school or work will also be missed while waiting for treatment. For fillings, we also estimate some school or work absence due to the filling procedure. With a total number of school or work days lost due to extractions and fillings, we are then able to estimate the total value of lost work days by multiplying for the average daily wage in the north east region. For deciduous teeth, our modelling factors in the proportion of carers who are employed and the impact on their working days; for permanent teeth, our modelling factors in the proportion of the adult population who are employed.

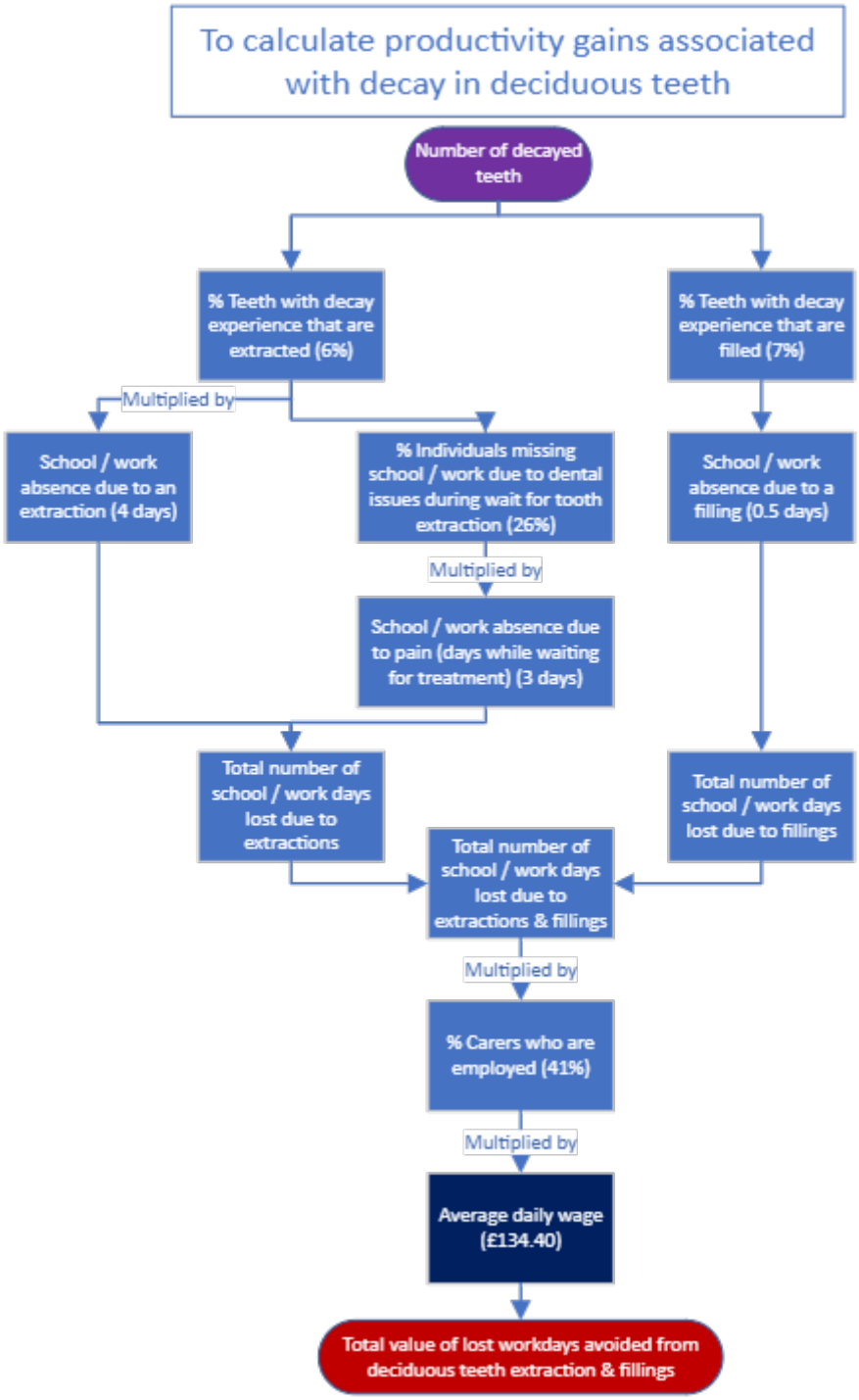

Figure 5. Methodology for productivity gains associated with avoided decay in deciduous teeth

59. Taken together, the total benefit accrued from dental healthcare cost savings and productivity gains of avoided decay to deciduous and permanent teeth is £588m (social perspective) over 40 years of the programme.

60. **Quality of life benefits to the individual** A direct health benefit may occur for the individual, in the form of improved quality of life (QoL) due to the avoidance of caries, measured through dmft/DMFT, they would have otherwise experienced in the absence of water fluoridation. Tooth decay can cause problems with eating, sleeping, communication and socialising.[24]

61. The methodology to calculate the direct health benefits that might arise from water fluoridation is set out in Figure 6. It follows the same approach to that set out in the Global burden of disease study which calculates disability adjusted life years associated with tooth decay[42].

62. To estimate these benefits, avoided decay in deciduous and permanent teeth is considered separately, but the overarching methodology as set out in Figure 6 is generalised. The total number of caries that could be avoided are calculated (as measured through dmft/DMFT) we then estimate the number of avoided caries which would have resulted in mild vs severe pain.

63. These are then multiplied by the Disability Adjusted Life Years loss for mild and severe pain respectively. Disability Adjusted Life Years averted are calculated by multiplying the proportion of the year spent with symptomatic caries by the disability weight of systematic caries estimated from the Global Burden of Disease study (GBD)[42]. For individuals suffering from mild symptoms, they are estimated to experience pain for one hour per day over the course of one year. For individuals suffering from severe symptoms, they are estimated to be in pain for ~55 days for permanent teeth and ~27 days for deciduous teeth (as evidenced in the GBD study); for the remainder of the year they are assumed to experience pain for one hour per day.

64. Disability Adjusted Life Years are converted to Quality Adjusted Life Years gained; this is then multiplied by the social value of a Quality Adjusted Life Years to give a total social cost saving for direct health impacts from avoided decay in deciduous and permanent teeth.

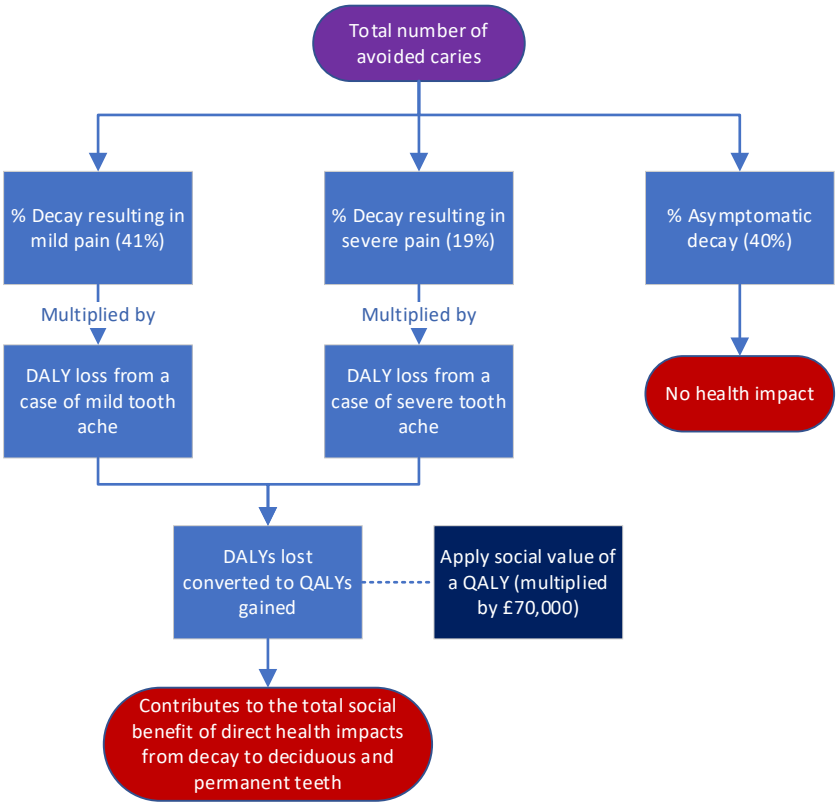

Figure 6. Methodology for calculating direct health benefits from avoided decay in deciduous and permanent teeth

65. Taken together, applying the Green Book £70,000 social value of a QALY to the estimated 342 QALYs gained (discounted) from the programme, results in an estimated total discounted cost saving of £24m associated with direct health impacts from avoided decay to deciduous and permanent teeth, over 40 years of the programme.

Non-monetised benefits

66. **Benefits beyond the age of 45:** The model observes a 40 year time horizon for cohorts beginning at birth with deciduous teeth and 5 years of age with permanent teeth. This means that benefits are cut off at the maximum age of 45 years. This cut off is arbitrary and represents a conservative approach to estimating the time horizon over which benefits accrue. It is likely that, assuming water fluoridation continues beyond the 40 year appraisal period, it continues to have an effect on DMFT values beyond 45 years of age. However, the monetised benefit of this effect is not included in the model as it would require drawing into our analysis survival/death related data and assumptions. Extending the model's time horizon to include benefits until an estimated death date for each cohort would inflate the estimated benefit water fluoridation expansion would be expected to deliver but with the addition of increased uncertainty associated with our estimates.

67. **Cost of lost education:** The model estimates the number of lost nursery or school days due to fillings and extractions in children. This parameter value is used to calculate the number of workdays lost due to the caring responsibilities of the child's parent/guardian. The time lost at work has been monetised using the wage rate. However, we do not attempt to monetise the value of the lost days at school for children undergoing extractions or fillings. Although the model quantitively captures the number of lost nursery/school days per cohort, we do not have a robust estimate of the monetary value of lost school days deemed appropriate to apply within our model. Broader evidence suggests that, generally, the higher the percentage of sessions missed across key stages at KS2 and KS4, the lower the level of attainment at the end of the key stage[vii].

68. **Out of pocket expenses:** The avoidance of travel cost associated with getting to and from dental appointments, as well as the cost of dental treatment for those who pay for it, represents a likely cost saving we have not attempted to include in our model. Water fluoridation is expected to result in avoided fillings and extractions, and by extension number of trips to an individual's dental practice. The reduced number of trips to the dental practice reduces the individual's out of pocket expense, such as those related to fuel for personal transportation, public transport costs or lost time due to time spend traveling to the appointment. It has not been possible to quantify these potential cost savings due to lack of necessary transportation data.

69. **Family health benefits:** The model focuses on the quality of life benefits to the individual. However, there may also be benefit from avoided tooth decay to their family including parents who may experience health impacts like lost sleep due to their child suffering from tooth ache.

70. **Dental practice capacity:** It is likely that the averted dmft/DMFT and the associated knock-on effect on reduced need for dental appointment would free up capacity within the dental practice. The freed-up capacity may result in reduced wait times, so we might assume that people being seen more quickly by their dentist would result in caries being picked up at an earlier, possibly reversable stage. Again, we have not attempted to monetise this effect because it would require a high degree of assumption to offset the absence of data.

71. **Benefits of partial exposure to water fluoridation:** The model assumes only children born into the proposed expansion area after the commencement will receive total benefits associated with water fluoridation. The model assumes a child born before the start of the programme will not receive any benefits associated with reduced caries in deciduous teeth, even if they are exposed to water fluoridation for a large proportion of their childhood. This reflects a conservative approach. The model also assumes that partial longitudinal exposure results in no benefits. These are highly conservative assumptions. In addition, as we assume permanent teeth erupt between the ages of 5 to 12, only children who turn 5 after

[vii] The link between absence and attainment at KS2 and KS4, Academic year 2018/19 – Explore education statistics – GOV.UK (explore-education-statistics.service.gov.uk)

the start of expansion will receive benefits to their permanent teeth. For example, a child who is 4 at the time of the commencement of expansion will begin to receive benefits accruing to their adult teeth when they turn 5, because their permanent teeth are fully exposed to water fluoridation from the point of eruption.

72. **Second order and third order health effects:** The reduction in fillings or extractions represent the first order health effect. Following an extraction or filling, in some instances, there can be second or third order health events which would also be avoided. These include:

    - a small proportion of forgone extractions/filling which would have resulted in infection and further complications requiring follow up dental or medical treatment
    - foregone need for root canals including the cost associated with crowning the tooth
    - forgone need for dentures and bridges following an extraction.

    We have not attempted to include these costs in the model, due to insufficient/quality of the data. Excluding these costs ensures that the model represents a highly conservative estimate of the true value.

73. **Dental treatment under general anaesthesia** presents a small but real risk of life-threatening complications for children and carries significant morbidity for children undergoing this procedure[25].

Summary of benefits

74. Overall, all benefits (dental healthcare cost savings, productivity gains and quality of life benefits to the individuals) are estimated to amount to £677m (social perspective) over 40 years.

Summary of Analysis & Sensitivity Analysis

75. Assuming that capital costs are incurred fully in years one and 20 of the scheme, the social benefit cost ratios are set out in the table below. This suggests that the programme would breakeven after 32 years based on social benefit cost ratios, as noted in Figure 7.

Table 1. Social cost benefit ratios, with capital costs accounted for in year 1 and 20

Time horizon (post introduction of the water fluoridation expansion)	Social benefit cost ratios
10 years	0.05
20 years	0.60
30 years	0.96
40 years	1.49

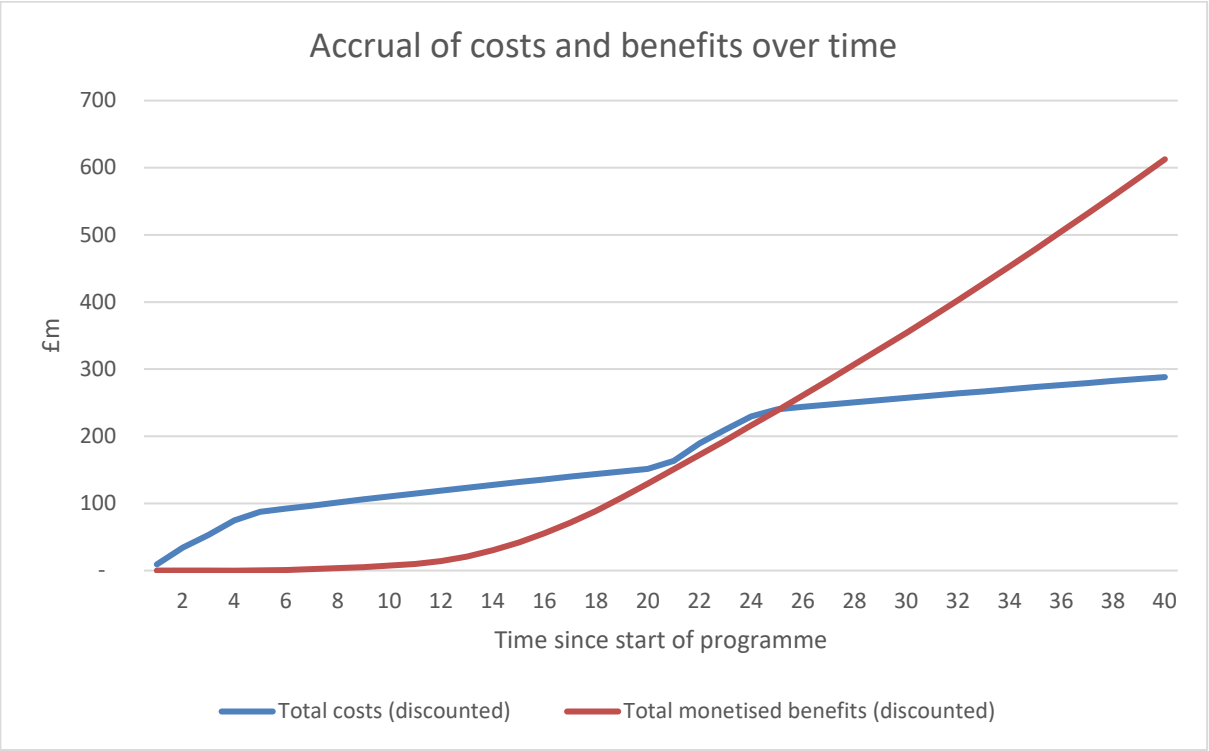

Figure 7. Accrual of costs and benefits over time

76. In the analysis, the parameter value of 27.2% was used for the reduction in DMFTs due to fluoridated water (Griffin et al.). As a form of sensitivity analysis, the minimum effect needed in permanent teeth for water fluoridation to exactly breakeven by the end of the 40 year period was calculated, and the figure came out as 18.3%.

77. In the cost benefit analysis described above, one set of costs has been used. While it is agreed that these are the up-to-date estimates have already accounted for uncertainty in costs by including optimism bias, we have conducted sensitivity analysis to test these assumptions. If both capital and operational costs were assumed to be 30% higher, the expansion into the north east is estimated to have a Net Present Value of £77m and a 40-year social benefit cost ratio of 1.14, compared to a Do Nothing option of no expansion. If costs were assumed to be 30% lower, the expansion into the north east would be estimated to have a Net Present Value of £324m and a 40-year societal social benefit cost ratio of 2.13, compared to a Do Nothing option of no expansion.

78. Feedback that we received between the initial consultation stage and this final impact assessment stage suggests that it might be more accurate to model the benefits of the programme over 60 years, rather than 40. This is in line with the Green Book guidance on how to assess capital infrastructure projects, but 40 years was initially chosen to present a conservative view of the benefits of water fluoridation in the north east. If we were to assume the same cohort approach as modelled above, and assume that each cohort continues to receive 40-45 years' worth of benefit, expansion into the north east is estimated to have a Net Present Value of £543m and a 60-year social benefit cost ratio of 1.94, compared to a Do Nothing option of no expansion.

Risks

Fluorosis

79. There is a well-established adverse association between levels of fluoride in water and the prevalence of dental fluorosis. Dental fluorosis is one of several different conditions that can affect the appearance of teeth. In England it is usually seen as paper white flecks or fine white lines, but it can vary in appearance from barely visible white lines to patches which

may be of aesthetic concern. The risk period for the development of dental fluorosis in permanent (adult) teeth is when the teeth are growing in the jaws. Dental fluorosis cannot develop after teeth are formed. The first 2 to 3 years of life are generally accepted to be the period of highest susceptibility for fluorosis affecting the front teeth. Water fluoridation schemes in England aim to achieve a level of 1mg of fluoride per litre of water, equivalent to one part per million of water. This level was chosen to reduce tooth decay and reduces the risk of severe dental fluorosis.

80. The impact of milder forms of fluorosis on measured quality of life (using the Oral Health Related Quality of Life scale) is certainly less than that of tooth decay and may be non-existent or even positive.[2627] A positive effect on quality of life may seem counterintuitive but may be explained by the fact that the white flecking of enamel associated with very mild fluorosis can give the impression of having teeth that are whiter than average[28]. More severe dental fluorosis can cause brown staining and pitting of teeth but is generally seen in those countries with very high naturally occurring levels of fluoride in groundwater rather than in areas with community water fluoridation schemes[29]. Dental fluorosis can also occur in the absence of water fluoridation, through ingestion of other sources of fluoride during tooth formation, particularly toothpaste and other fluoride supplements.

81. A study reporting on fluorosis prevalence and severity in England was commissioned to inform the 2018 health monitoring report. The population under examination was drawn from 4 cities; Newcastle upon Tyne and Birmingham, which are fluoridated, and Liverpool and Manchester that are not fluoridated)[30]. The prevalence of any positive score for fluorosis was greater in Newcastle and Birmingham compared to Manchester and Liverpool. Fluorosis of a severity that might be of aesthetic concern affected 10.3% of children from the fluoridated cities and 2.2% in the non-fluoridated cities. There was, however, no difference in satisfaction with dental appearance between the 2 groups. Further research in adults in England has suggested that the aesthetic impact of fluorosis diminishes with age[31].

General health risks

82. The Water Fluoridation Health monitoring report for England 2022 supports earlier findings and wider evidence that water fluoridation, at levels recommended in the UK, is a safe and effective public health measure to reduce dental caries and inequalities in dental health. The Water Fluoridation Health Monitoring Working Group continues to review evidence and will publish a further report in 2026.

Specific Impact Tests

Impact on small and micro businesses

83. Northumbrian Water Limited is the main business affected by the proposal to expanding water fluoridation in the north east region. They are considered a large business based on the number of employees. Costs for implementing the expansion would be incurred by government and not by the business. Therefore, we do not anticipate disproportionate burdens on small and micro business because of the proposals.

Equalities

84. A Public Sector Equalities Duty (PSED) assessment has been published separately alongside this as part of the consultation package. Adding fluoride to the water is a population level intervention that reaches everyone who lives there and uses mains water irrespective of their protected characteristics. Like many other non-communicable diseases there are significant inequalities related to deprivation in the levels of tooth decay around the country. Oral health inequalities were investigated in 2021 and for most of the protected

characteristics there was no available evidence, or inconsistent evidence, on associations between oral health, care services and the protected characteristic. The PSED assesses a positive likely effect overall in the region with some narrowing inequalities on the basis of age, disability and race.

Rural proofing

85. Where the proposed scheme is operable, we do not anticipate a disproportionate impact of the policy on rural communities. Water fluoridation schemes will apply to both rural and urban areas. Some rural areas may not receive water fluoridation as it would not be operable and efficient to do so. These areas were clearly presented in the public consultation and there are no subsequent impacts on the operable and efficient proposal.

Competition assessment

86. We do not anticipate that the expansion of water fluoridation will impact competition. It should not directly or indirectly limit the number or range of suppliers, nor should it limit the ability of suppliers to compete or reduce suppliers' incentives to compete vigorously.

Carbon assessment and sustainable development specific impact test / environmental impact

87. We do not anticipate a disproportionate impact of the policy on rural communities; water fluoridation schemes will apply to both rural and urban areas.

Human rights

88. Expansion of water fluoridation is based on primary legislation passed by Parliament. We do not consider there to be any negative impact on human rights. The consultation seeks views on any missed evidence on ethical arguments.

Justice impact test

89. We do not anticipate an impact on the justice system from expanding water fluoridation in the north east region.

Potential trade implications of measure

90. We do not anticipate an impact on trade from expanding water fluoridation in the north east region.

Monitoring and Evaluation

91. The Secretary of State for Health and Social Care, has a legal duty to monitor the effects of water fluoridation schemes on health and report on it every 4 years. Water fluoridation health monitoring reports have been published in 2014, 2018 and 2022. The next report is due in March 2026. This report is unlikely to report a significant change to population dental health if the decision to expand water fluoridation in the north east region is taken, as there will be a long lead in time to fluoridation commencing. The current and previous water fluoridation health monitoring reports have taken a national view comparing areas with fluoride to those without fluoride in the water. Future health monitoring reports will consider the health effects of fluoride on people living in areas covered by water fluoridation schemes.

92. If water fluoridation is taken forward, we will seek to commission further academic research into it's impact this has on the population of the north east, this will include the impact on:

- the dental health of adults as well as children
- dental health inequalities
- wider benefits such as reduction in days off school and work
- cost effectiveness

93. The annual National Dental Epidemiology Programme, coordinates dental surveys which describe levels of oral health in specific population cohorts. These annual surveys look at the oral health of five year old children biennially. This programme supports the collection, analysis and dissemination of reliable and robust information on the oral health needs of local populations. These surveys report the data at different geographical levels, from lower tier local authority level up to regional and national level.

94. The results of the biennial oral health surveys of five year old children in England inform the Public Health Outcomes Framework indicators[32].

95. Any evaluation requirements needed in addition to the above monitoring processes will be considered during policy development.

Annex A: Modelling Approach

A1. Cohort approach

A1.1 Cohort specification

96. The WF model is formed of two overlapping cohort-based models, a deciduous teeth model and a permanent teeth model. The cohorts enter the deciduous teeth model at birth on an annual basis, exiting at 10 years of age or at the end of the model's 40 year time horizon, whichever comes first. Individuals enter the permanent teeth model at 5 years of age and exit at the elapse of the 40 year time horizon. The overlapping nature of the cohort models dictate that between the ages of 5 to 10 years the individual is part of a cohort within both the deciduous and permanent teeth models.

97. The WF model assumes 0 to 5 year olds have only deciduous teeth, children between the ages of 5 and 10 are assumed to have a mix of deciduous and permanent teeth and after 10 years of age children have only permanent teeth. Consequently, water fluoridation benefits to deciduous teeth accrue from birth to 10 years. Benefits to permanent teeth accrue between the ages 5 up to a maximum of 45. Only the first cohort receives 40 year of benefit due to the time horizon cut off. This assumes that after the start of the programme children aged 5 to 10 exposed to water fluoridation receive benefits to both their deciduous teeth as well as to their emerging permeant teeth. There is no double counting of benefits between the ages of 5 and 10, because we use two entirely separate health outcomes to reflect the decay to permanent and deciduous teeth separately (see Figure 8).

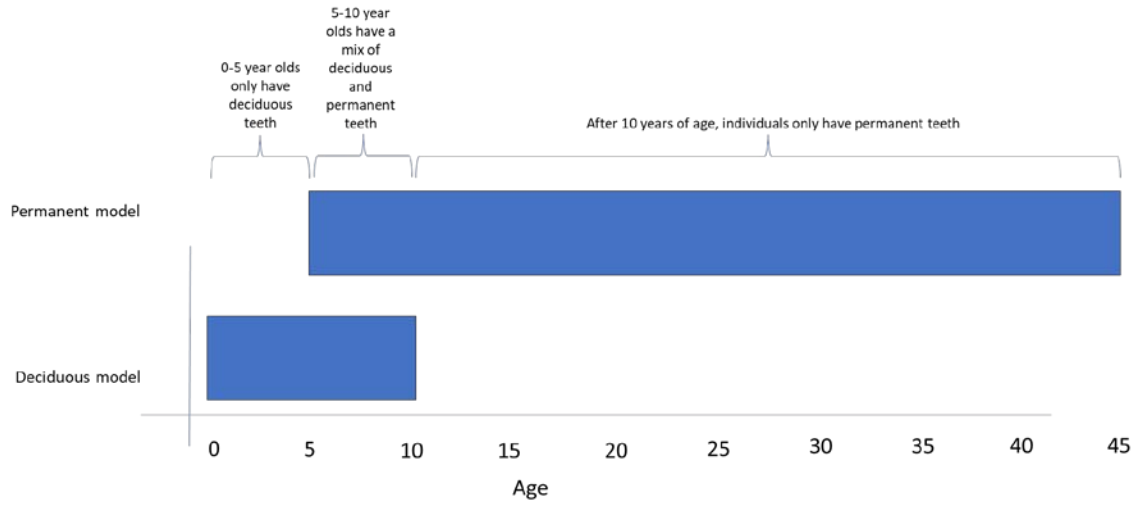

Figure 8. Permanent and deciduous model, and when different ages enter the model

A1.2 Cohort dynamics

98. Benefits associated with deciduous teeth are accrued from 0 to 10 years of age. The first cohort, those born the year expansion begins, will receive 10 years of benefits starting in year 1 to illustrate from 2023/24. Given the 40 year time horizon over which costs and benefits are observed the 31st cohort i.e. those individuals born in 2054/2055 receive benefits to their deciduous teeth from the age of 1 to 9 years and not in year 10, as year 10 would occur beyond the 'cut off' dictated by the 40 year time horizon.

99. For permanent teeth a similar approach is applied, however given the nature of deciduous and permanent dentation, benefits to permanent teeth do not begin until the individual turns 5 years old, unlike deciduous teeth. However, annual benefits are not capped by the emergence of a new set of teeth, this dictates that annual benefits accrue for each cohort until the expiration of the 40 year time horizon. As a worked example to illustrate, individuals turning 5 in 2023/24 when expansion begins, will receive annual benefits for 40 years (until they turn 45 years of age). The second permanent dentation cohort, those, aged 4 at the beginning of the programme, receive no annual benefit to their permanent teeth in year 1. Their annual benefit associated with permanent dentation begins in year two when they turn 5. Therefore they receive 39 years of annual benefit and so on until the 40th cohort who turn 5 years of age in the 40th year of the programme, receive just 1 year of benefit before the cut off imparted by the 40 year time horizon.

100. It is expected that fluoride will start to be added to the water for some populations from year 3 of the programme (2027-28). The estimated operational costs have been used to calculate the proportion of the cohort born that year that will receive fluoride, and therefore receive the benefits. For the cohort born in 2027-28, 3% of the target population cohort is assumed to receive fluoride; for the cohort born in 2028-29, this figure is assumed to be 64%; for the cohorts born in 2029-30 onwards, this figure is assumed to be 100%.

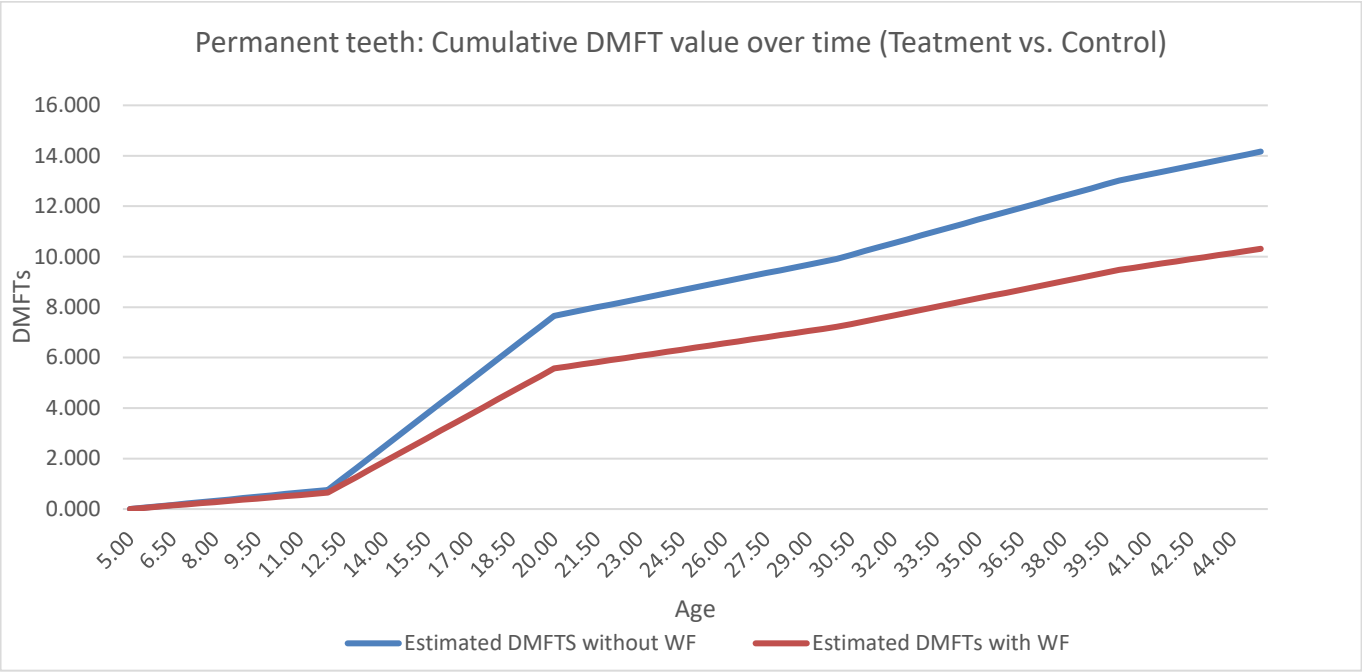

Figure 9. Cumulative DMFT values (permanent teeth) for the first cohort of individuals

A2. DMFTs

101. Water fluoridation reduces dental caries. The outcomes used to measure dental caries are 'decayed missing or filled teeth' (DMFT) for permanent teeth and 'decayed missing or filled teeth' (dmft) for deciduous teeth.

102. DMFT is an index score ranging from 0-32 based on the case for permanent teeth which are decayed missing or filled. It is a cumulative measure with a value of 0, which means no teeth are decayed missing or filled and a value of 32 constituting all teeth being missing filled or decaying. A value of 7 would reflect the fact the individual had 7 teeth which are decayed, missing or filled.

103. The benefits of water fluoridation are therefore based on the observed difference in dmft/DMFT values in populations exposed to fluoridated water (treatment population) relative to a characteristically similar population not exposed to fluoridated water (control population). For example, the Water Fluoridation Health Monitoring Report for England, 2014[33] shows that after controlling for other factors, 5 year olds in water fluoridated areas exhibit on average 0.81 dmfts per child relative to 1.01 in the population of 5 year olds not exposed to fluoridated water. This constitutes an observed ~20% reduction in caries at the age of 5 due to water fluoridation.

104. Figure 9 above shows the average cumulative number of DMFTs per individual over a 40-year time horizon from the age of 5-45 (permanent teeth). The purple line represents the average number of cumulative DMFT we would expect to see per individual in the north east region under non-fluoridated conditions (control) vs the green line, which is the average number of cumulative DMFT per individual following the introduction of water fluoridation (treatment). The average cumulative DMFT values for the control population (purple line) are observed at 12, 20, 30, 40 and 50 years of age[viii]. To estimate the values for the intermediate ages, for example ages 13 through 19, we linearly approximate the values between the 2 time points.

105. To estimate the average cumulative DMFT value for the treatment population, which is represented by the green line, for ages 5 to 12 years we use the observed values from the Water Fluoridation Health Monitoring Report for England 2014**Error! Bookmark not**

[viii] DMFT rates at 40 years and 50 years were used to derive the estimated DMFT value for a 45 year old

defined.. To estimate the average cumulative DMFT values for the treatment population from the age of 12 onward we apply the preventative fraction (% reduction in DMFT due to water fluoridation) from Griffin et al[ix], to the control population DMFT value. The cumulative DMFT values for the control population from the age of 12 onward are calculations based on data from the Adult Dental Health Survey 2009, England[34].

106. Figure 10 presents the control vs treatment cumulative dmft values for deciduous teeth (dmft) for 0 to 5 year olds. For dmft the same broad approach is applied however, instead of estimating the values for the treatment population by applying the preventive fraction to the control values, the Health Monitoring Report for England 2018**Error! Bookmark not defined.** provides observed average values for both the treatment and control population groups, negating the need to estimate treatment dmft through application of a preventative fraction to control group values.

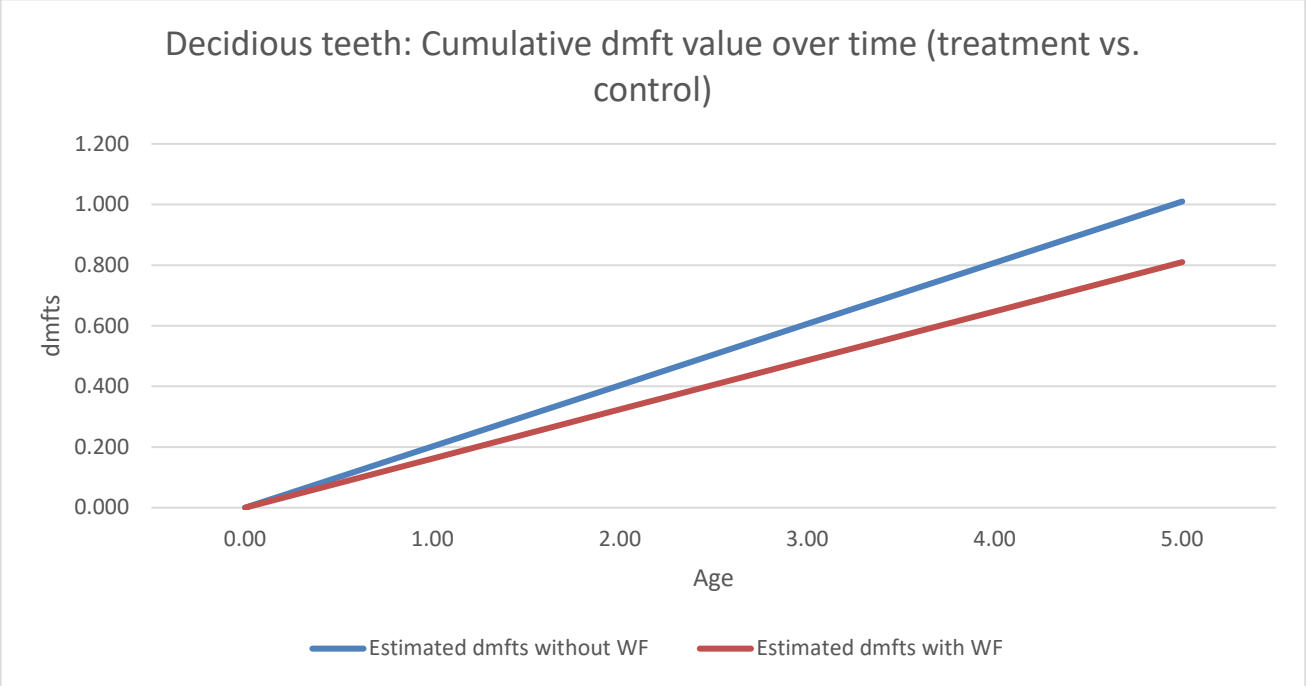

Figure 10. Deciduous teeth - cumulative dmft values for the first cohort of individuals (treatment vs control)

A3. Dental healthcare savings

107. Dental healthcare savings occur due to avoided caries, leading to avoided extractions and fillings for deciduous and permanent teeth. A flow chart outlining the methodology for calculating dental healthcare savings due to avoided caries can be seen in Figure 3 and Figure 4.

Deciduous teeth

108. **To estimate the cost of avoided extraction of deciduous teeth** (0 to 5 years):

- The number of avoided dmft per cohort per 6 months is multiplied by the proportion of teeth with decay experience that are extracted (6% is based on data from PHE's oral health survey of 5 year old children in 2022[35]).
- This is then multiplied by the proportion of extractions occurring in secondary care (0 to 5 years) which is assumed to be 100%[x]; this gives us the number of avoided extractions occurring in a hospital settings per cohort per 6 months.

[ix] Effectiveness of fluoride in preventing caries in adults - PubMed (nih.gov)

[x] Based on expert opinion

- This value is then multiplied by the cost of extraction in secondary care (£775, from the 2024/25 National Tariff Payment System[36]) to give the avoided extraction cost for deciduous teeth, per cohort per 6 months from ages 0 to 5.
- As assumed that 100% of extractions for this age group occur in secondary care, we do not need to consider extractions at the dental practice for the 0 to 5 population.

109. **To estimate the cost of avoided extractions of deciduous teeth** (6 to 10 years):

- The number of avoided dmft per cohort per 6 months is used as a starting point. To calculate the number of these avoided dmft which go untreated by the age of 5, as we know that 6% of avoided dmft are extracted and 7% are filled, based on data from PHE's oral health survey of 5 year old children in 2022[37], this dictates that 78% of these avoided dmft go untreated from years 0 to 5. Multiplying the avoided dmft per cohort per 6 months by 78% gives us the number of avoided dmft going untreated per cohort per 6 months.
- To calculate what proportion of this untreated decay did not exfoliate naturally over time, we take the number of avoided dmft which go untreated and multiply by the probability of treatment before teeth exfoliated naturally (16 %, estimated through the PHE Oral Health Return on Investment tool[38]) to give us the number of avoided dmft which went untreated yet did not exfoliate naturally and therefore now require extraction or filling between the years 6 to 10.
- This value is then multiplied by the probability that the tooth is extracted following no initial treatment or natural exfoliation (74%, estimated through the PHE Oral Health Return on Investment tool[38]) to give the number of avoided cases of decay that would have gone untreated and resulted in an extraction.
- Half of these avoided extractions (50%, based on Kay et al., 2018[39]) for the 6 to 10 year old population would have occurred in a hospital setting at a cost of £775, with the remaining 50 % taking place in the dental practice at a cost of £94.44[xiii]. Summing the avoided extraction cost in secondary care with the avoided extraction cost in the dental practice gives us the total avoided extraction cost for deciduous teeth in 6 to 10 year olds.

110. **The avoided filling cost for deciduous teeth** is calculated in a similar way to extractions, as outlined above. The only difference is that rather than a portion of fillings taking place in secondary care, 100% of fillings are carried out in the dental practice for all ages.

Permanent teeth

111. To calculate the cost of avoided extraction of permanent teeth:

- The number of avoided DMFT per cohort per 6 months is multiplied by the proportion of teeth with decay experience that are extracted (46% calculated using data from the Adult Dental Health Survey[34]) and then multiplied again by the proportion of missing teeth which are missing due to dental extraction (90%[xi]). This gives us the number of avoided extractions in permanent teeth per cohort per 6 months.
- To estimate the cost of secondary care extractions, this value is multiplied by the proportion of extractions in secondary care (for adults; 10%[xii]), and then multiplied again by the cost of extraction in secondary care (£775[36]).

[xi] Expert opinion

[xii] Expert opinion

- To estimate the cost of dental practice extractions, 90% are assumed to occur in the dental practice since 10% occur in a secondary setting. The number of extractions is multiplied by 90%, and then multiplied by the cost of extraction in primary care (£94.44[xiii]).

112. For the avoided filling cost for permanent teeth, the approach to modelling fillings mirrors the approach to calculating avoided extraction costs in permanent teeth, with the only difference being that 100% of fillings occur at the dental practice[xiv], at a cost of £94.44[xiii]); 0% of fillings occur in a hospital setting and therefore they do not need to be considered within this calculation.

A4. Productivity gains

113. Productivity gains occur due to avoided caries, leading to avoided missed school/work due to extractions. A flow chart outlining the methodology for calculating dental healthcare savings due to avoided caries can be seen in Figure 5.

Deciduous teeth

114. To calculate the total lost school days due to extractions in deciduous teeth:

- To calculate lost school days due to the extraction itself, the number of avoided extractions are multiplied by the assumed number school/work absence days due to an extraction' (4 days[xv]).
- To calculate the number of school/work days also lost for those experiencing pain in the build up to the extraction, the number of avoided extractions are multiplied by the proportion of individuals missing school/work due to dental issues during wait for tooth extraction (26%, based on data from Goodwin et al.[40]), and then multiplied by 3 days, the estimated number of days absent from school/work due to pain, while waiting for treatment (Goodwin et al.[40]).

115. To calculate the number of lost days at school due to fillings, the total number of avoided fillings are multiplied by 0.5 days, the assumed number of days absent from school/work due to a filling[xvi].

116. To calculate the productivity gains related to caries in deciduous teeth:

- The total number of school/work days absent (due to the extraction itself, due to experiencing pain in the build up to the extraction, and due to fillings) is multiplied by the proportion of carers who are employed' (41%, Goodwin et al.[40]) to arrive at a value for total number of lost days at work avoided.
- This value is then multiplied by the average daily wage (£134.40, based on the ONS Employment and Labour Market data for the north east region[41]) to give us the total value of lost workdays avoided in relation to deciduous teeth.

Permanent teeth

117. The calculation for lost working days avoided due to caries in permanent teeth follows the same method as for deciduous teeth with two key differences:

- We do not attempt to convert lost school days to lost workdays for individuals aged 12 to 18; the rationale here is that the 12 to 18 year old do not necessarily

[xiii] Expert opinion

[xiv] Expert opinion

[xv] Expert opinion was elicited as part of the development of the PHE ROI tool

[xvi] Expert opinion

require someone at home to provide care, and consequently do not require a parent or guardian to take time of off work to look after them.

- Rather than multiplying the total lost school days avoided by the proportion of carers who are employed (41%), we multiply the avoided lost work days by the proportion of the adult population who are employed (75%, based on ONS Employment and Labour Market data for England[41]).

A5. Direct health benefit

Deciduous teeth

118. To calculate the direct health benefit accruing to deciduous teeth, we start with the total number of avoided caries (per cohort per 6 months).

To estimate the DALY loss associated with mild pain:

119. We take the averted caries value and multiply it by the proportion of decay resulting in mild pain (41%, calculated from the Global Burden of Disease (GBD) study[42]). This calculation gives us the avoided caries which would have led to mild pain. DALY loss from a case of mild tooth ache for deciduous teeth (0.0004) is calculated by multiplying the proportion of the year spend in mild pain for deciduous teeth (0.04) by an estimate of symptomatic disability weight for dental caries (both calculated from the GBD study[42]; 0.01). Avoided caries which would have led to mild pain is then multiplied by the DALY loss from a case of mild tooth ache for deciduous teeth (0.0004) to give us the DALY loss associated with mild pain.

To estimate the DALY loss associated with severe pain:

120. We take the avoided number of caries (per cohort per 6 months) and multiply it by the proportion of decay resulting in severe pain (19%; calculated from the GBD study[42]). This gives us the avoided caries which would have led to severe pain. DALY loss from a case of severe tooth ache in deciduous teeth (0.001) is calculated by multiplying the proportion of a year spent in severe pain for deciduous teeth (0.11; calculated from the GBD study[42]) is multiplied by an estimate of symptomatic disability weight for dental caries (calculated from the GBD study[42]; 0.01). Avoided caries which would have led to severe pain is then multiplied by the DALY loss from a case of severe tooth ache for deciduous teeth (0.0011) to give us the DALY loss associated with severe pain.

121. With 41% of caries resulting in mild pain and 19% leading to severe pain, the remaining 40 % of caries are observed as asymptomatic. Given the asymptomatic nature of these caries, there is no health effect to be calculated from averting this caries. Consequently, the total DALYs averted per cohort per 6 months is derived from the aggregation of the DALYs associated with mild and severe pain (paragraphs 0 and 0).

122. The DALYs averted are converted to QALYs gained using the conversion factor set out in Sassi 2006[43] (1.37 for deciduous teeth and 0.66 for permanent teeth) which gives us the annual QALY gain per cohort per year. We then monetise this value by multiplying by the social value of a QALY (£70,000), before aggregating across all cohorts for each calendar year.

Permanent teeth

123. The method used to calculate the health benefit accruing to avoided caries in permanent teeth uses the same methodology as outlined above for deciduous teeth. However, it should be noted that two of the parameter values used to calculate the health benefit differ for permanent teeth relative to deciduous teeth:

    - The DALY loss for a case of severe tooth ache is higher for permanent compared to deciduous teeth.

- The DALY to QALY conversion factor used for deciduous teeth (1.37) differs to the conversion factor used for permanent teeth (0.66)[43]. This is because the factor is a function of age of disease onset; for deciduous teeth we have used the conversion factor associated with 5 year olds, for permanent teeth, we have used the conversion factor associated with 25 year olds.

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