A randomised controlled trial to measure the effects and costs of a dental caries prevention regime for young children attending primary care dental services: the Northern Ireland Caries Prevention In Practice (NIC-PIP) trial

Martin Tickle,[1]* Ciaran O'Neill,[2] Michael Donaldson,[3] Stephen Birch,[4] Solveig Noble,[5] Seamus Killough,[6,7] Lynn Murphy,[8] Margaret Greer,[8] Julie Brodison,[5] Rejina Verghis[8] and Helen V Worthington[1]

[1]School of Dentistry, University of Manchester, Manchester, UK
[2]J.E. Cairnes School of Business and Economics, National University of Ireland, Galway, Ireland
[3]Health & Social Care Board of Northern Ireland, Belfast, UK
[4]Centre for Health Economics, University of Manchester, Manchester, UK
[5]Northern Health & Social Care Trust, Antrim, UK
[6]General Dental Practitioner, Ballycastle, UK
[7]British Dental Association Northern Ireland, Belfast, UK
[8]Northern Ireland Clinical Trials Unit, Belfast Health & Social Care Trust, Belfast, UK

*Corresponding author

Declared competing interests of authors: Martin Tickle reports provision of free toothpaste and toothbrushes from Colgate-Palmolive for the trial. Seamus Killough was chairperson of the Northern Ireland Council of the British Dental Association throughout this trial.

Published September 2016
DOI: 10.3310/hta20710

Scientific summary

The Northern Ireland Caries Prevention In Practice (NIC-PIP) trial
Health Technology Assessment 2016; Vol. 20: No. 71
DOI: 10.3310/hta20710

NIHR Journals Library www.journalslibrary.nihr.ac.uk

Scientific summary

Background

Dental caries is the most common disease of childhood. In 2013, a national survey reported a prevalence of 28% in England, 39% in Wales and 38% in Northern Ireland among 5-year-old children. The disease is closely associated with deprivation and, once the disease develops, pain and extractions are common consequences. In addition, developing the disease in the primary teeth in early childhood is the strongest predictor of developing disease in the permanent teeth in late childhood into adolescence. The NHS in all four home nations wants to reorientate dental services to focus on prevention of the disease. In England, national evidence-based guidelines on prevention have been sent to all dental practices. The guidelines recommend application of fluoride varnish twice a year, use of fluoridated toothpaste containing no less than 1000 parts per million (p.p.m.) fluoride and advice about restricting sugar consumption and optimal use of fluoride toothpaste for young children. These guidelines have not been tested in a pragmatic trial in a general practice setting. If a new dental contract is to incentivise dentists to provide this care regime, the costs and effects need to be determined.

Objectives

The Northern Ireland Caries Prevention In Practice (NIC-PIP) trial was designed to address the question of whether or not an evidence-based 'prevention package' delivered in dental practice could keep a substantial proportion of young children, who attend the dentist on a regular basis, caries free. The impact of this intervention on costs for the NHS was an important element of the programme.

Aim

To measure the effects and costs of a composite fluoride intervention designed to prevent caries in young children attending dental services.

Objectives

To compare, in children aged 2–3 years who were caries free at baseline, the effectiveness of a varnish containing 22,600 p.p.m. fluoride, toothpaste containing 1450 p.p.m. fluoride and standardised health education, provided twice a year in general dental practice, as a 'preventative package' compared with standardised health education provided twice a year alone in:

- reducing the conversion of children from caries-free to caries-active states in the primary dentition
- reducing the number of carious surfaces (caries into dentine) in the primary dentition in children who convert from the caries-free to caries-active state
- reducing the number of episodes of pain and/or extraction of primary teeth.

The cost-effectiveness of the preventative package relative to standardised health education alone was also evaluated.

Methods

The study was a pragmatic, two-arm randomised controlled trial, with an allocation ratio of 1 : 1. The study population was children aged 2–3 years who were caries free and were registered with 22 NHS general dental practices across Northern Ireland, UK. Children were excluded if they had a past history of fillings or extractions due to caries, fissure sealants on primary molar teeth, and/or a history of severe allergic

reactions requiring hospitalisation. Dentists from the community dental service (CDS) screened children attending the 22 practices according to the trial inclusion and exclusion criteria. The Belfast Clinical Trials Unit centrally randomised children into intervention and control groups. The intervention was composite in nature comprising:

- a varnish containing 22,600 p.p.m. fluoride, applied to their primary teeth by their dentist
- a free toothbrush and a free 50-ml tube of toothpaste containing 1450 p.p.m. fluoride
- standardised dental health education on optimal use of fluoride toothpaste and restriction of sugar consumption.

The intervention was delivered at the child's dental check-up, twice a year at approximately 6-month intervals. The control group received the same standardised dental health education as the intervention group every 6 months when they attended their dental check-up. The trial took place over a 3-year follow-up period. Caries outcomes were assessed by 12 trained and calibrated dentists from the CDS, who were blind to the allocation, undertaking clinical examination according to a standardised, national diagnostic protocol in which caries was diagnosed at the caries into dentine level. The primary outcome measure was conversion from the caries-free to the caries-active state and secondary outcome measures included the mean number of decayed, missing, filled tooth surfaces in primary dentition (dmfs) in children with caries. Additional secondary outcomes included episodes of pain and number of extractions. All serious adverse events, and adverse reactions (ARs) associated with the fluoride varnish, were recorded. The costs of care were also compared between groups. These outcomes were assessed by parental questionnaires and data collection forms completed by the practices.

The sample size was based on the expectation of an absolute difference in the proportion of children with caries after 3 years of 0.1 between intervention and control groups. Based on epidemiological and service data available, it was estimated that 47% of children would develop caries over 3 years. A two-group chi-squared test with a 0.05 two-sided significance level would have 90% power to detect the difference between a proportion of 0.47 and a proportion of 0.37 [odds ratio (OR) 0.662] if the sample size in each group is 510. We assumed that 75% of children approached would be caries free at eligibility assessment, a 70% parental consent rate and a 15% dropout rate. Using these assumptions, we estimated we would need to invite at least 2356 children to take part in the study and recruit 1200 children to ensure that we had sufficient power at the end of the trial.

All statistical analyses were performed using Stata version 14.0 (StataCorp LP, College Station, TX, USA) using an intention-to-treat approach with a two-sided 5% significance level. The primary analysis compared the proportion of children in each group who converted from caries free to caries active over the 3 years using a binary logistic regression model and was adjusted for age and socioeconomic status measured using a small-area measure of multiple deprivation.

The economic analysis compared the mean cumulative costs per child incurred over the 3-year period in each arm of the trial. NHS costs were subdivided into those related to the intervention (intervention group only), those associated with other oral health care provided by dentists and those associated with care provided by other health service professionals.

Results

A total of 2455 were screened by CDS dentists according to the trial inclusion and exclusion criteria, and 1248 children were recruited into the trial, exceeding the planned sample size of 1200. At the 3-year follow-up period 1096 children (549 in the intervention group and 547 in the control group) were examined at outcome, which exceeded the sample size of 510 per group specified in the sample size calculation. Over the 3-year follow-up period, 87% of children in the intervention group and 85% of children in the control group attended every 6-month scheduled appointment at their practice. For the

primary outcome measure, the number and percentage of children who converted from caries free to caries active was 187 (34%) in the intervention group, compared with 213 (39%) in the control group; this difference was not statistically significant [OR 0.81, 95% confidence interval (CI) 0.64 to 1.04; $p = 0.11$]. The secondary outcome was the difference in the mean number of carious surfaces (dmfs) between caries-active children in the intervention and control groups. The mean number of tooth surfaces affected by caries was 7.2 in the intervention group, compared with 9.6 in the control group. This difference was statistically significant (adjusted mean difference –2.29 surfaces, 95% CI –3.96 to –0.63 surfaces; $p = 0.007$). There were no statistically significant differences between the intervention and control groups in the numbers of episodes of pain [negative binomial regression coefficient (in favour of intervention) –0.03, 95% CI –0.32 to 0.25; $p = 0.81$] or number of teeth extracted [negative binomial regression coefficient (in favour of intervention) –0.03, 95% CI –0.88 to 0.82; $p = 0.95$]. The impact of the disease was considerable and adverse outcomes were common: 164 out of the total of 400 (41%) children who converted to caries active reported toothache, compared with 62 out of 696 (9%) caries-free children (OR 7.1 95% CI 5.1 to 9.9; $p < 0.001$).

Of the 1248 children who were randomised, 82 reported 100 serious ARs: 45 (7.2%) in the intervention group and 37 (5.9%) in the control group [negative binomial regression coefficient (in favour of intervention) –0.19, 95% CI –0.27 to 0.65; $p = 0.42$]. Ten children in the intervention group had ARs or unexpected ARs of a minor nature that were potentially related to the fluoride varnish. The costs of care provision in the intervention group were statistically significantly greater than the costs for the control group over the 3-year period. The mean cost per carious tooth surface avoided was £251 over the 3-year period and the estimated mean cost per child kept decay free over the 3-year period was £2093.

Conclusions

Over one-third of children developed caries over the 3-year period of the study, and approximately 40% of children who developed the disease reported pain. Therefore, development of caries and its consequences was common and rapid.

There was no statistically significant difference between the intervention and control groups in the conversion of children from the caries-free to the caries-active state, and so we cannot conclude that the intervention prevented the conversion of children from the caries-free to the caries-active state. There was a significant difference in the mean number of carious tooth surfaces between the intervention and control groups. Children who received the intervention had, on average, 2.43 (95% CIs –0.77 to –4.08) fewer tooth surfaces affected by caries than children in the control group. There was no statistically significant difference between episodes of pain or extraction of primary teeth between intervention and control groups; therefore, we cannot conclude that the intervention prevented episodes of pain or extraction of primary teeth. The total cost of care was statistically significantly greater in the intervention group than in the control group. There is considerable uncertainty about what people or the NHS might be willing to pay to keep children caries free or to prevent carious surfaces. However, based on our calculations of net monetary benefit, society would need to value carious surfaces avoided at approximately 55 times the cost of restoring the same number of surfaces before the intervention was deemed to be value for money. This value may be more than society is willing to pay, but we accept that we do not know if this is the case.

Future work

Future work should assess the caries prevention effects of interventions to reduce sugar consumption at the population and individual levels. Interventions designed to arrest the disease once it is established need to be developed and tested in practice.

Trial registration

This trial was registered as Current Controlled Trials ISRCTN36180119 and EudraCT 2009-010725-39.

Funding

Funding for this study was provided by the National Institute for Health Research Health Technology Assessment programme.

Health Technology Assessment

HTA/HTA TAR

ISSN 1366-5278 (Print)

ISSN 2046-4924 (Online)

Impact factor: 4.058

Health Technology Assessment is indexed in MEDLINE, CINAHL, EMBASE, The Cochrane Library and the ISI Science Citation Index.

This journal is a member of and subscribes to the principles of the Committee on Publication Ethics (COPE) (www.publicationethics.org/).

Editorial contact: nihredit@southampton.ac.uk

The full HTA archive is freely available to view online at www.journalslibrary.nihr.ac.uk/hta. Print-on-demand copies can be purchased from the report pages of the NIHR Journals Library website: www.journalslibrary.nihr.ac.uk

Criteria for inclusion in the *Health Technology Assessment* journal

Reports are published in *Health Technology Assessment* (HTA) if (1) they have resulted from work for the HTA programme, and (2) they are of a sufficiently high scientific quality as assessed by the reviewers and editors.

Reviews in *Health Technology Assessment* are termed 'systematic' when the account of the search appraisal and synthesis methods (to minimise biases and random errors) would, in theory, permit the replication of the review by others.

HTA programme

The HTA programme, part of the National Institute for Health Research (NIHR), was set up in 1993. It produces high-quality research information on the effectiveness, costs and broader impact of health technologies for those who use, manage and provide care in the NHS. 'Health technologies' are broadly defined as all interventions used to promote health, prevent and treat disease, and improve rehabilitation and long-term care.

The journal is indexed in NHS Evidence via its abstracts included in MEDLINE and its Technology Assessment Reports inform National Institute for Health and Care Excellence (NICE) guidance. HTA research is also an important source of evidence for National Screening Committee (NSC) policy decisions.

For more information about the HTA programme please visit the website: http://www.nets.nihr.ac.uk/programmes/hta

This report

The research reported in this issue of the journal was funded by the HTA programme as project number 08/14/19. The contractual start date was in October 2009. The draft report began editorial review in October 2015 and was accepted for publication in April 2016. The authors have been wholly responsible for all data collection, analysis and interpretation, and for writing up their work. The HTA editors and publisher have tried to ensure the accuracy of the authors' report and would like to thank the reviewers for their constructive comments on the draft document. However, they do not accept liability for damages or losses arising from material published in this report.

Published by the NIHR Journals Library (www.journalslibrary.nihr.ac.uk), produced by Prepress Projects Ltd, Perth, Scotland (www.prepress-projects.co.uk).