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Three key points:

- Profiles routinely-collected dental services data in England, Scotland, Wales and Northern Ireland
- Maps how different studies have used these data to date
- Makes recommendations for how the utility of these nationally important datasets can be increased

Unlocking the potential of NHS primary care dental datasets

Authors: Deborah Moore, Thomas Allen, Dwayne Boyers, Kate McKenzie, Wendy Thompson, Blessing Nyakutsikwa, Iain Pretty, Martin Tickle

Introduction: Maximising the use of routinely-collected health data for research is a key part of the UK Government's Industrial Strategy. Rich data are generated by NHS primary care dental services, but the extent of their use in research is unknown.

Aims: To profile the utility of the post-2006 NHS dental datsets for research, map how they have been used to date, and develop recommendations to maximise their utility.

Methods: The content of and access to the four UK NHS dental datasets was collated using publicly available information and a free-text questionnaire completed by the relevant data controllers. A scoping review was carried out to identify and map literature that has utilised NHS dental activity data.

Results: The contents of the UK NHS dental activity datasets are described, alongside how they may be accessed for research. Strengths and weaknesses of these datasets for research are highlighted. The scoping review identified 33 studies which had utilised NHS dental activity data since 2006. We classified 15 as public health practice, 11 as service evaluation and seven as research.

Conclusion: In comparision to other NHS activity datasets, it appears that the UK dental datasets have been underutilised for research. We make 11 recommendations on how their utility for research may be increased.

Introduction

Maximising the use of health data for research, innovation and improvements in health and care services is a key element of the UK Government's Industrial Strategy.[1] The ambition is for the UK to be at the centre of the health data science revolution within the next twenty years.[2,3] The size of the NHS and the national health research infrastructure that has been set in place over the last fifteen years means that the UK is already well placed to achieve this aim.[4] Further recent progress includes the introduction of 10 new standards for data security across all of health and social care, the implementation of the national data opt-out consent service and the establishment of the UK Health Data Research Alliance, a new national institute for health data science with the aim of supporting access to health data for research and innovation in an ethical and trustworthy environment.[3,5,6]

The NHS dental datasets were originally designed as an accounting and payments system and represent a largely untapped resource that could provide world-leading opportunities for research and innovation. More specifically the datasets could have significant application in three important areas:

- Epidemiological surveillance of population disease and service use
- Applied research, both observational studies and interventional studies to support clinical trials
- Quality improvement by the collection of quality indicators and support of iterative quality improvement cycles

NHS dental datasets have key qualities which make them well-suited to support these activities. They are centrally processed and held, providing the potential for ready access for the above purposes. They have national coverage enabling the use of very large sample sizes, contain standardised information on service use, costs, and in some cases, health status. The data have the advantage of being quality assured for payment purposes, and individuals can be tracked over time enabling long term follow-up; crucially the data are a by-product of care provision therefore data collection costs are miniscule compared to traditional methods used in surveys and trials. With appropriate consent or approvals they are linkable to other datasets at an individual level using a unique identifier and at geographical level via postcode. These data also represent what is happening in real time to patients and services so are of direct relevance for decision makers.

Since the introduction of the 2006 NHS contract in England & Wales, the NHS dental contracts

163   in the four home countries have been diverging with this divergence likely to widen as each
164   country undertakes contract reform.[7] If the promise of exploiting NHS dental datasets is to be
165   fully realised, data produced through these new contracts needs to be compatible to enable
166   UK-wide approaches to surveillance, research and quality improvement. It would seem timely
167   prior to any significant contract changes to assess how these datasets have been used for
168   research and whether divergence in the data collected is an obstacle to NHS dentistry
169   participating in the health data science revolution.
170
171   The aims of this paper are to:
172
173   1. Profile the utility of the UK NHS dental datasets for research
174
175   2. Understand how these datasets have been used for research to date
176
177   3. Make recommendations for their future development to support research
178
179   **Part 1: Profile the utility of UK NHS dental datasets for research**
180
181   **Methods:** Publicly available information regarding the dental data in England, Wales,
182   Scotland and Northern Ireland was reviewed; this included reports, websites and
183   downloadable datasets. In addition, a free text questionnaire was sent to the relevant data
184   controller for each country, alongside a request for any reports that would be useful in
185   understanding the datasets. Any clarifications were resolved through direct communications
186   with the relevant department.
187
188   **Results:** Table 1 provides an overview of the contents of the UK NHS dental datasets.
189
190   *Table 1 Comparison of NHS primary care dental activity datasets across England, Wales, Scotland and Northern*
191   *Ireland*
192
193   **Population coverage and scope:**
194
195   The most recent data indicate that NHS dental services regularly see more than half of the UK
196   population:
197

198   - England: 50% of adults (within two years) and 59% of children (within 12-months) [8]

199   • Wales: 55% of the population[9] (within two years)

200   • Scotland: 67% of the population[10] (within two years)

201   • Northern Ireland 61% of adults (within two years) and 75% of children (within 12-
202   months)[11]

203

204 Large volumes of data are submitted by NHS dental practitioners at the end of every course
205 of treatment, including urgent episodes of care.[12] These data are used to administer payments
206 to dental practitioners, to facilitate the collection and processing of NHS patient charges, to
207 inform the monitoring of dental services and service planning, and to guard against fraud.
208 Whilst there are broad similarities in terms of coverage and purpose of the dental datasets
209 across the UK, there are several important differences. Historically, all dentists providing care
210 on behalf of the NHS in the UK received a payment for each 'item of service' that had been
211 carried out on a patient, with hundreds of designated codes for each type of procedure, size
212 of restoration and material. In 2006, a new dental contract was introduced in England and
213 Wales, which paid dentists a set monthly fee, in return for a pre-specified level of activity.[13]
214 Rather than the hundreds of individual items of service that were recorded previously, activity
215 in England and Wales is now measured in just three 'bands' of treatment complexity, covering
216 19 clinical procedure categories.[13] Therefore, the level of detail on the treatment provided is
217 now much lower than in Scotland and Northern Ireland, who have retained item of service
218 coding (Table 1).

219

220 The type of dental services that submit data via this system varies across the UK. In all
221 countries the majority of data will be related to care provided in high-street general dental
222 practices; including care delivered on a domiciliary or emergency basis and by orthodontists
223 and specialist oral surgeons working in primary care. In England, the same data are also
224 submitted by the community dental service (CDS) and, from 2020, will also be submitted by
225 the Welsh CDS. The CDS are a specialised primary care referral service who treat adults and
226 children with complex needs. In Scotland, CDS data is only available from 2014 and in
227 Northern Ireland the CDS does not submit data via this route. Data about dental treatment
228 that is provided in secondary care is recorded under a different system to that profiled in Table
229 1. Briefly, patient-level data for dental outpatient, in-patient and day case treatment is recorded
230 with all other hospital activity and will include specialty, diagnosis and procedure code, as well
231 as demographic variables. Further information on accessing secondary care data can be
232 provided by Public Health Scotland,[14] the Honest Broker Service[15] in Northern Ireland, NHS
233 Digital[16] in England and the NHS Wales Informatics Service.[17]

234

235   The availability of information on dental prescribing is also variable across the UK. In each of
236   the nations, dentists complete NHS prescription forms by hand.[18,19] The issuing of a
237   prescription is a chargeable item of service for dentists in Scotland and Northern Ireland, so
238   is recorded within the core dental activity datasets described in Table 1. However, no details
239   of the drug prescribed or the dose are included.[20,21] In England, "antibiotics prescribed" can
240   be optionally recorded by the dentist on the FP17 form, but these data have been found to be
241   so incomplete as to be unusable for monitoring or research purposes.[22] In Wales, the option
242   to record "antibiotics prescribed" on the FP17W form was recently removed.[23] The detail of
243   the dose and type of medication prescribed is collated when the medications are dispensed,
244   as part of the system to remunerate pharmacies. In Scotland, Wales and Northern Ireland,
245   electronic pharmacy systems now enable dental prescriptions data to be linked to the dental
246   practice (Scotland), dentist (Wales), or dentist and dental practice (Northern Ireland), but not
247   to individual patients (A.Karki, Public Health Wales, personal communication, 28th January
248   2021).[24,25] In England, it is not possible to relate dental prescriptions data to individual dentists,
249   patients or dental practices. A dashboard is available that illustrates the type and number of
250   dental prescriptions in relation to the English geographic region of the pharmacy where the
251   items were dispensed, but this was last updated in March 2020.[26]
252
253   The datasets were not originally designed to provide information on the health of individual
254   patients, but in recent years additional data fields have been added which may increase their
255   utility for research. In England in 2017 the epidemiological index commonly used to summarise
256   lifetime experience of dental decay (number of Decayed, Missing and Filled Teeth, DMFT)
257   was added to the mandatory clinical dataset.[27] As part of the dental contract reform
258   programme in Wales, from April 2020 the treating practitioner is asked to submit the number
259   of decayed teeth and the total number of teeth. Furthermore, dentists in Wales now submit a
260   summary assessment of the patient's medical, social, and dental, risk and need status.[23,28]
261   Dental contract reform is also ongoing in England, with the intention for dental practices to
262   submit a patient-level risk assessment for future decay, periodontal (gum) disease, tooth wear
263   and oral cancer.[29]
264
265   **Data access:** In all countries, routinely published reports and datasets provide data on
266   population access to primary care dentistry, the activity of the services and the profile of the
267   dental workforce.[9,30–32] This is aggregated data, presented at the level of health and social
268   care board, local authority or clinical commissioning group. In addition, the relevant data
269   controllers can be contacted for data requests under the Freedom of Information Act.[33] To
270   avoid the potential for re-identification, small numbers are suppressed in these releases. For

271 access to more detailed data, a specific application process must be followed which will incur
272 a processing fee and a data sharing agreement between parties:

273

274 **England and Wales:** To access individual-level dental data, an application must be submitted
275 to the NHS Business Services Authority (NHSBSA).[34] The NHSBSA advise researchers to
276 discuss their project with the UK Health Research Authority (HRA) first to determine which
277 regulatory approvals are required. Depending on the level of anonymisation and linkage
278 involved, this approval from an NHS Research Ethics Committee (NHS REC) and the HRA's
279 Confidentiality Advisory Group (CAG) may be necessary.[35,36] To start the application process,
280 a comprehensive form must be submitted along with an initial assessment fee.[34] NHSBSA can
281 then advise on feasibility, timescales and estimated processing costs. The only reference
282 made to other data sets that are available for linkages are the Hospital Episode Statistics held
283 by NHS Digital.[34] Individual-level data considered 'potentially identifiable'[37] will need to be
284 securely hosted, analysed and destroyed within an NHS-compliant secure research
285 environment, or "Data Safe Haven".[38,39] All named users will need to demonstrate appropriate
286 data protection training and access to the data will be audited.[38]

287

288 **Scotland:** The first step is to make an enquiry to the electronic Data Research and Innovation
289 Service (eDRIS) team within Public Health Scotland.[40] After submission of a brief enquiry
290 form outlining the research proposal, a research coordinator will review the enquiry, advise on
291 feasibility and provide a cost estimate.[40] Access to information collated by PHS (formerly ISD
292 Scotland) requires approval from the Scottish Public Benefits and Privacy Panel (PBPP).[41]
293 Linking the dental data to other sources of information is supported and a wide range of health
294 and social care datasets are available.[14] If data linkage is required, this will be carried out by
295 a trusted third party using the available personal identifiers, before anonymisation and addition
296 of a unique identifier specific to the project. The completed anonymised dataset will then be
297 transferred to the National Safe Haven, which is an approved secure environment for storage
298 and analysis hosted by the University of Edinburgh but accessible remotely via a virtual private
299 network (VPN).[40] Users will need to demonstrate appropriate training and sign an end-user
300 agreement in line with the Scottish Information Sharing Toolkit.[35,41]

301

302 **Northern Ireland:** The Family Practitioner Services Information Unit, within the HSC Business
303 Services Organisation, can undertake data linkage and follow-up for research studies where
304 participant consent is in place. For studies without consent where anonymised data is required
305 applicants can apply to the HSC Honest Broker Service for Health and Social Care.[15] The
306 Honest Broker Service is the main Trusted Research Environment for accessing health-
307 related data for research purposes in Northern Ireland. A range of datasets from across health

308   and social care are held, including pharmaceutical services and secondary care activity data.

309   For anonymised data, ethical approval is only required if the request includes linkage to

310   external datasets. Applications are reviewed and approved by the Honest Broker Service

311   Governance Board and charges apply to cover the processing costs.[15] Any data provided must

312   be hosted and analysed within the HBS's Data Safe Haven. At present there is no remote

313   access to the Safe Haven and researchers must physically go to the building in Belfast, but

314   plans are in place for this to be made possible via the UK Secure electronic Research Platform

315   (UK SeRP) from early 2021 (N.Mill, HSC BSO, personal communication, 1st December 2020).

316

317   This review of the contents of the NHS dental activity datasets has revealed both strengths

318   and weaknesses in their utility for research:

319

320   **Strengths:** The increased use of unique identifiers in recent years opens up the potential for

321   linkage to other administrative datasets and the creation of longitudinal cohorts, although this

322   is more complete in Scotland and Northern Ireland than England and Wales. In Scotland and

323   Northern Ireland, detailed information about the treatment provided obtained from item of

324   service codes as well as the ability to identify tooth level data provides opportunities for

325   research into the longevity and real-world effectiveness of different treatments at both the

326   patient and tooth level. In England and Wales, the move towards collecting information on

327   dental disease and medical, social, dental and behavioural risks, offers the potential for

328   greater insight into predictors of disease, preventive interventions, and greater consideration

329   of confounding factors and effect modifiers. The availability of an individual measure of socio-

330   economic status, in the form of the NHS charges exemption category, is a strength of all of

331   the datasets. The approach in Scotland and Northern Ireland of accessing the data via a

332   central repository containing multiple datasets from health and social care is appealing from

333   a researcher's perspective. Having a dedicated service may smooth the application process

334   and offer greater potential for linkages.

335

336   **Weaknesses:** The identified strengths are not all found within any one dataset. In particular,

337   none of the datasets contain information on both the level of existing dental disease or risk

338   factors, in combination with detailed tooth-level treatment information. The removal of tooth-

339   level data from the datasets in England and Wales in 2006 limited the potential for longitudinal

340   follow-up of the survival of individual restorations, or teeth.[42] Patient ethnicity is not recorded

341   in Scotland and Northern Ireland and in England and Wales it is an optional field which is not

342   well completed completed, meaning important health inequalities may be unmeasured.[43] After

343   'White British' the next most common categories in 2018/9 were 'N/A' and 'patient declined'

344   (K.Gray, NHSBSA personal communication,13th October 2020). It must also be remembered

that some private dental treatment can be provided for a patient who is mostly receiving NHS dental care. Therefore, the NHS record may not include all dental treatment that the patient has undergone. The DMFT data in England has not been formally validated and its completion relies on an accurate and up to date dental charting, which is not always available.[44,45] A further issue with the DMFT measure is that the guidance on completing the return advises practitioners to include any extracted teeth within the 'missing' count, rather than only those extracted due to caries.[27] Thus, it is not directly comparable with the DMFT measure as commonly reported in epidemiological surveys.[46]

Most, but not all, dental practices now use electronic software to record their clinical notes. These systems are not networked into wider NHS records systems (for example the patient's general medical practice records). At present there is no requirement for symptoms or diagnosis codes to be included in the data extract that is transmitted to the NHS, limiting the potential for research into the natural history of oral conditions and the impact of medical comorbidities on patient outcomes. Although computer-issued prescriptions and electronic prescribing are now widespread across the NHS, they are not yet available to NHS dentists.[22] Furthermore, there is currently no requirement to include unique identifiers for patients on handwritten prescriptions, and no statutory requirement for dentists to communicate with a patient's medical practitioner when prescribing for dental use.[18] Linkage of dental prescribing data to wider healthcare datasets is, therefore, a manually intensive process which has been attempted but abandoned in England (M. Dockett, NHS BSA, personal communication, 2nd July 2020).

Part 2: Scoping Review: How the NHS routinely-collected dental datasets have been used for research to date

Methods: The scoping review was carried out according the guidance issued by the Joanna Briggs Institute (JBI), and is reported according to the PRISMA extension for scoping reviews.[47,48]

Research question: How extensively have the NHS dental datasets been utilised for oral health research purposes from 2006 onwards?

Eligibility criteria

381   • Studies utilising routinely-collected NHS dental activity data to understand the oral
382   health of individuals or populations in England, Wales, Northern Ireland or Scotland
383   • Only studies which use NHS data collected to support the monitoring of dental
384   contracts after 2006 were included. This was to ensure that the research reflects the
385   datasets as they currently are.
386   • Studies exclusively concerned with dental workforce were excluded to maintain the
387   focus on the use of data to understand the oral health of populations or individuals
388
389   The following databases were searched in March and April 2020: PubMed, Medline, All EBM
390   reviews and Embase. The search terms were adapted for the particular database (see
391   Supplementary Table 1 for details of the search dates, terms and limits used in each search).
392   For Medline, All EBM reviews and Embase the search terms were (Dental OR Dentistry) AND
393   (NHS Business Services Authority OR NHS BSA OR NHS Business Services Organisation
394   OR NHS BSO OR NHS Information Services Division OR NHS ISD). After feedback from
395   stakeholders, the search term "*HSC* Business Services Organisation" (rather than *NHS*) was
396   also tested. Using this term a smaller number of results were returned and no further
397   potentially relevant studies were identified, therefore the original search searches using "NHS"
398   were retained. Where possible, database searches were limited to human, English language
399   and studies published between 2006-2020. Google Scholar searches were carried out with
400   the focus on each of UK dental data controllers in turn, for example (NHS ISD dental data
401   Scotland). The Google Scholar results were screened until there was a full page (10 results
402   per page) where no results appeared relevant to oral or dental health. No restrictions were
403   placed on study type and grey literature was included where routinely-collected NHS dental
404   data had been used. The reference lists of retrieved full-text articles were scanned for further
405   relevant studies and studies identified through existing knowledge were also assessed at full-
406   text.
407
408   Study titles and abstracts were screened in duplicate by two review authors and potentially
409   relevant studies were read in full. Authors agreed on study inclusion in pairs (DM & KMcK and
410   TA & DB). To separate out studies that had used the routinely-collected data for research from
411   those that had used it for other purposes, we planned apriori to map the study type against
412   the HRA's guidance on defining research.[49] Data charting was carried out in duplicate, using
413   an Excel template with the following headings: First author, year, country, protocol / final
414   report, aim, ethical approval (Y/N), type of NHS data used, date of NHS dental data collection,
415   key findings, study topic, HRA study type, reviewer notes. Review authors resolved any
416   differences in their initial data extraction in pairs (DM & KMcK and TA & DB).
417

418   After initial data extraction, the study classifications and topics were then further refined as a
419   whole dataset, to create the final synthesis. For study type, this was achieved by comparing
420   the initial HRA study classifications and evaluating the coherence of the decisions across all
421   studies and referencing back to the HRAs guidance. The aim was to ensure that the
422   classifications were coherent and consistent. Similarly, the initial subject topics were reviewed
423   and, in some cases, combined or separated, to create the 'subject themes' presented in Figure
424   2. The aim was to provide sufficient detail to be of value to the reader without becoming
425   unmanageable, as well as achieving internal homogeneity and external heterogeneity within
426   the themes.[50] Modifications from the initial classification were discussed and agreed by three
427   review authors (DM, DB, TA).

428
429 **Results**

430
431   A PRISMA flow chart illustrating the search process is presented in Figure 1. The total number
432   of records that were screened was 701 (338 from database searches and 363 from Google
433   Scholar searches and exisiting knowledge). Based on their titles and abstracts, 51 articles
434   were selected for assessment in full. After reading, 18 were excluded and 33 met the inclusion
435   criteria and were included in the analysis. Protocols where the final report was available were
436   excluded in favour of the final report and if there were separate papers related to the same
437   study[51,52] only one paper was included.[51] We identified three protocols for ongoing research
438   studies that plan to utilise routinely-collected NHS data that were not included in the analysis,
439   but may be of interest to the reader.[53–55]

440

441

442 *Figure 1 PRISMA flow diagram illustrating search process*

443

444   The references for the included studies and the classification of the type of study according to
445   the HRA's Defining Research[49] table, alongside the country where the data was collected, are
446   shown in Table 2. The identified subject themes are illustrated in Figure 2. Further detail on
447   the type of NHS data used, main findings, subject topic and HRA study classification is
448   presented for each study in the Study Summary Table (Supplementary Table 2).

449

450 *Table 2 HRA study type, country and references of included studies*

451

452   Most of the studies identified could have been classified as more than one of the HRA's study
453   types. For the purposes of this review, studies where the key focus of the paper was how the

population has interacted or is projected to interact with dental services in the future, were classed as public health practice. This includes issues like equity of access to services. Studies that considered the outcomes, efficiency, quality or volume of services, sometimes in addition to equity, were classed as service evaluations. Studies classified as research made use of wider theoretical models or attempted to derive estimates or conclusions that could be applied to other contexts, through the use of experimental methods including sampling and / or a control or comparator group. HRA guidance states that NHS REC approval is normally "but not always" required for research studies.

Figure 2 Frequency chart illustrating subject themes of studies identified and HRA study type

Narrative synthesis

We did not identify any studies that were classified as clinical audits. This may be because most clinical audit is carried out in a local setting and whilst it is used for clinical governance and quality improvement purposes, may not be written up for publication. The most common type of study were those we classified as public health practice.[49] The main health issue being investigated was equity of access to different types of NHS dental services for particular population groups.[56–64] Inequalities were investigated in terms of age,[62,65] deprivation,[56–59,62,64,65] geography,[59,62,63] ethnicity,[64] and family structure.[61,64] Other studies combined historic NHS dental data with wider demographic data to inform service planning as part of health needs assessments.[66–69] One study investigated the potential utility of NHS dental data to support dental antimicrobial stewardship[25] and one was investigating the pre-diagnosis dental attendance of patients diagnosed with oral cancer, to inform early detection strategies.[70]

The majority of service evaluations that we identified were evaluating the effectiveness of new interventions.[71–76] The interventions being assessed were community oral health improvement programs,[71–73] policies (NICE guidance on third molar extractions [74] and the introduction of a new dental contract[76]), and a training initiative.[75] Four considered the efficiency (costs, level of activity and / or outcomes achieved) of an existing service.[77–80] One made reference to the quality of clinical preventive care that was delivered in general dental services, in view of high rates of dental general anaesthesia in children.[81]

We classified seven studies as research. One linked dental registration data to socio-demographic and vital statistics data, informed by a theoretical framework on the changes in

490 health investment between childhood and adolescence.[82] Two investigated the effectiveness
491 of different dental contracting policies on the treatments provided by dental practitioners, using
492 experimental methods such as matched-control and difference-in-difference.[7,51] Two studies
493 were randomised controlled trials; one assessing the effectiveness of individualised audit and
494 feedback on dentists' antibiotic prescribing rate,[24] and the other, the effectiveness and
495 economic value of 'scale and polish' treatments and oral hygiene advice.[83] One study
496 investigated the influence of patient, treatment and performer factors on the quality of
497 orthodontic outcome.[84] Finally, a study seeking to develop a complex intervention to reduce
498 antibiotic prescribing compared information from the NHSBSA dental services dataset to that
499 in the NHSBSA prescription services dataset, to investigate the utility of the dental data as an
500 outcome measure.[22]

502 None of the studies classified as public health practice or service evaluations had formal
503 ethical approval from an NHS Research Ethics Committee (NHS REC), but two received
504 approval from a University committee.[70,81] In contrast, four of the seven studies classified as
505 research were approved by an NHS Research Ethics Committee (NHS REC),[51,82–84] and one
506 was reviewed but was deemed not to require formal approval. [24] The remaining two
507 received University ethical approval.[7,22]

510 **Discussion**

513 The aims of this paper were to profile the utility of the NHS dental activity datasets and
514 evaluate how they have been used for research purposes to date, with a view to making
515 recommendations for the future. Our review of the coverage, content and accessibility of these
516 datasets has identified substantial potential in terms of population coverage and there are
517 some features which lend themselves well to oral health research, particularly the increased
518 use of unique identifiers. Despite this, the majority of studies that we identified in our scoping
519 review were focused on the performance of specific services or the way the population
520 interacts with them. This is understandable given that the data was designed to support
521 operational delivery and monitoring, but a tally of just eight research studies in 13 years
522 indicates that the true research potential of these datasets has yet to be fully realised.

524 A strength of our approach was that we were able to draw on existing networks and
525 relationships to identify and engage with the relevant data controllers in each country. This
526 ensured we were able to add additional detail to publicly available information, cross-check

527   the accuracy of our findings and ensure that the information presented was up to date. With
528   regards to the scoping review, the main strengths are the use of a defined scoping review
529   process, the reproducible search strategy, the wide range of databases searched and the
530   inclusion of review authors from dental and non-dental backgrounds. Using the HRA's
531   guidance on defining research also gave us a clear framework against which to map the
532   studies, although some interpretation was required. The limitations of our review are that we
533   only included studies in English, although for a paper concerned with UK data, we do not
534   expect that this had a significant impact. A further limitation is that we did not register the
535   protocol in advance, in accordance with more recent guidance on scoping reviews.[85]

536

537   There is a growing body of literature regarding the use of routinely-collected data to support
538   research. The number of papers returned when searching "routine$ NHS data" in PubMed
539   has increased every year over the last decade, from 154 results in 2010 to 710 in 2020. In
540   addition to primary research, many of these papers are "data resource profiles", which provide
541   a detailed description of specific administrative datasets.[86–88] This is the first paper that we
542   know of which has profiled the four UK primary care dental activity datasets and mapped their
543   previous use for research purposes. In common with researchers in other fields, we identified
544   both strengths and weaknesses of these routinely-collected datasets for research, but the
545   dental datasets have been little used for research compared with others. [86–88] For example,
546   the Clinical Practice Research Datalink (CPRD) database, which contains anonymised patient
547   data from a network of GP practices, has been utilised in over 2,600 peer-reviewed
548   publications.[89] Similarly, in 2016 Hospital Episode Statistics for Admitted Patient Care were
549   estimated to have been used in over 500 research publications.[87] An exploratory PubMed
550   search suggests a further 394 such papers have been published since then. Application of
551   NHS datasets for purposes other than payment is valuable and it is important to support
552   developments to enable this use within dentistry.

553

554   The current NHS routinely-collected dental data primarily measures treatment activity and is
555   therefore extremely limited as a source of information about the quality of care provided. Our
556   scoping review only identified one paper[84] which addressed the factors influencing the quality
557   of treatment outcomes and this was specifically with regards to orthodontics, where the routine
558   data submission contains an assessment of the level of need at both the start and end of
559   treatment. This is not a feature of any of the UK data collection systems for general dentistry.
560   A 2009 review of dental service provision in England, commonly referred to the 'Steele review',
561   made recommendations regarding quality improvement of dental care.[90] The review stated
562   that both dentists and service commissioners reported a lack of information to support quality
563   improvement, and recommended a return to the collection of tooth-level treatment data, as is

564   still the case in Scotland and Northern Ireland. This has not occurred and limits the potential

565   for studies into the survival of different types of dental treatments or teeth (as per Lucarotti

566   and Burke using pre-2006 data),[42] or the treatment outcomes of individual dentists; all

567   important dimensions of technical quality.[91]

568

569   At present there is no universally accepted understanding of what 'quality' means in dentistry,

570   but recent work has contributed to progressing this and could offer additional insights into how

571   routinely-collected data might be adapted to support improvements in patient care.[91,92] Facets

572   of quality such as patient reported outcomes and experiences, and provision of interventions

573   that are evidence-based and appropriate for the need and risk level of the patient are also

574   important topics for health services research.[91] Since 2013 in England all NHS services

575   (including dental practices) are required to submit the 'Friends and Family' measure of patient

576   experience,[93] but there is no minimum response rate requirement and no such centrally-

577   collated system exists in Scotland, Wales or Northern Ireland. The recent addition of an annual

578   patient-level need and risk rating to the routinely-collected data in Wales may support work

579   regarding the appropriateness of the care delivered, but again this is not currently in place in

580   the other UK countries.

581

582   There are a diverse range of stakeholders with an interest in routinely-collected NHS dental

583   services data. In addition to the original function of financial management of the dental system,

584   in an ideal world, these datasets would be able to support patient choice, practice-level quality

585   improvement initiatives, dental epidemiology, evaluation of health promotion interventions,

586   and to inform the early identificiation of risks to patient safety and/or professional standards,[94]

587   Collectively, the authors of this paper have recent experience of applying to access NHS

588   dental data for research, across England, Wales, Scotland and Northern Ireland. Drawing on

589   this experience and the findings of this review, we offer the following recommendations for

590   maximizing the utility of dental activity datasets for research:

591

592

593   1. A shared understanding between key stakeholders of what the routinely-collected dental

594   activity data can and should be used for, and how best to support this, is required. This should

595   be developed in partnership, including patients, dentists, data controllers, policy makers,

596   regulators and academics.

597

598   2. Alignment of some core information across the four UK datasets would create many more

599   opportunities for research. The ten priority topics for oral and dental research in the UK were

600   identified by the James Lind Alliance in 2018 using a priority setting partnership approach.[95]

601   These topics should inform any future modifications of the NHS dental datasets to support
602   research. A similar type of consensus / priority setting partnership approach could be
603   employed to inform any future developments of the datasets more generally.

604

605   3. Custodians of NHS dental data and dental research institutes should join the UK Health
606   Data Research Alliance.[2] The alliance is working to remove common barriers to health data
607   research and encourage responsible access to clinical and administrative data.

608

609   4. A single point of access for a range of health and social care datasets, with end-to-end
610   support to navigate the application process would be very helpful for researchers in all UK
611   countries. Greater detail is needed on the opportunies for linkages to other datasets in England
612   and Wales.

613

614   5. Meta-data, including a comprehensive data dictionary, should be publicly available for the
615   dental datasets. Ideally, this would be aligned across the different countries and
616   understandable to non-dental professionals. Supporting the creation of such meta-data is a
617   key part of the Health Data Research Innovation Gateway, hosted by the UK Health Data
618   Research Alliance.[2]

619

620   6. A key initial step in the process of accessing routinely-collected data for research is for the
621   data controller and the research team to develop a common understanding of the
622   categorisation of the data that is being requested. The boundaries between anonymised,
623   pseudonymised and potentially-identifiable data are open to interpretation and this cannot be
624   decided by the research team alone. This step should be undertaken prior to contacting
625   external bodies for advice (such as the HRA), as this classification impacts on which regulatory
626   approvals will be required.

627

628   7. The addition of unique identifiers (e.g. NHS numbers) to dental records should be as high
629   as possible in all areas of the UK, to support the linkage of longitudinal data and to other health
630   and social care datasets.

631

632   8. Dental prescriptions should include unique identifiers for both the patient and the dentist
633   and this information should be collated electronically. This is necessary for clinical audit and
634   quality improvement, patient safety, health economics and to support antimicrobial
635   stewardship.

636

637 9. The 2009 Steele review's recommendation to return to the collection of tooth-level treatment
638 data in England and Wales should be implemented.

639

640 10. In England, the National Information Standard has been adapted to require healthcare
641 providers to use SNOMED CT in their electronic patient record systems, and Scotland,
642 Northern Ireland and Wales also have programmes of work underway.[96] SNOMED is a
643 consistent means of recording conditions, treatments, diagnoses and procedures. Initially the
644 SNOMED roll out replaced the used of Read codes in GP systems, but, since April 2020 dental
645 software systems must now also include SNOMED reference data.[97] By ensuring the use of a
646 consistent coding system there is the opportunity to use practice based clinical data in a
647 vendor agnostic manner; offering the potential for more detailed assessment of longitudinal
648 data. It is important to ensure that research teams are involved in developing the systems to
649 access and utilise these data.

650

651 11. A network of general dental practices that are supported to submit enhanced clinical data,
652 equivalent to the G.P equivalent (CPRD), would be a huge asset for dental research, including
653 clinical trials. The feasibility of such a programme should be considered as part of future
654 developments.

655

656

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658

665

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667 design, the scoping review search, analysis and interpretation, and drafting and submission
668 of the manuscript. Thomas Allen contributed to the scoping review search, analysis and
669 interpretation, contributed to the drafting of the manuscript and approved the final version.
670 Dwayne Boyers contributed to the scoping review search, analysis and interpretation,
671 contributed to the drafting of the manuscript and approved the final version. Kate McKenzie
672 contributed to the scoping review search, analysis and interpretation, and approved the final

Tables

Table 3 Comparison of NHS primary care dental activity datasets across England, Wales, Scotland and Northern Ireland

	England and Wales	**Scotland**	**Northern Ireland**
Data Controller	NHS Business Services Authority Dental Services	Public Health Scotland Data and Intelligence (ISD Scotland until end of 2020)	HSC Business Services Organisation Family Practitioner Unit
Name of dental dataset	NHSBSA Dental Services Activity Data	Management Information & Dental Accounting System (MIDAS)	FPS Dental Payment System Data
Number of patient records in database	~269 million (from Jan 2014)	~7 million	~3 million
How is the data captured?	Submitted electronically or on paper based FP17 forms (England) or FP17(W) forms (Wales)	Submitted electronically or on GP17 forms	Submitted electronically or on HS45 forms
How up to date is the data?	Claims for completed treatment must be submitted within 2 months. Database updated daily	Claims for completed treatment must be submitted within 3 months.[98] MIDAS is refreshed monthly	Claims for completed treatment must be submitted within 6 months. Database updated daily
How far back can data be accessed?	Data retention period is currently 10 years but this is under review and may be reduced. Data is more complete post-2015	1999[98] but data only considered complete from 1st April 2000	2007 but data is more complete post-2015
Can records be linked to individuals using a unique identifier?	From 2016 onwards NHS number can be populated in around ~78% of records	Community Health Index Number is recorded in ~95% of records	Health and Care Number is included on all records since 2015
What demographic information about the patient is held?	Age, gender, ethnicity (optional). NHS dental charge exemption category. Multiple deprivation measure using home postcode[99]	Age, gender, marital status, NHS dental charge exemption category. Multiple deprivation measure using home postcode[100]	Age, gender, NHS dental charge exemption category. Multiple deprivation using home postcode.[101]
How detailed is the clinical treatment data?	Category of treatment and number of teeth e.g. "extraction", "filling"[27]. Exact tooth cannot be provided.	Exact type of treatment including material and size.[21] From 2013 exact tooth can be provided from 2013.	Exact type of treatment including material and size.[20] Exact tooth can be provided.
Are there any indicators of oral health, medical or social risk factors?	**England:** Number of Decayed, Missing and Filled Teeth (DMFT) from 2017 **Wales:** From 2020, number of decayed teeth, total number of teeth and clinical risk factors (ACORN) [23,28]	'Special Needs' indicator if the patient has a severe mental/physical disability or severe learning disability.	'Special Needs' indicator if the patient has a severe mental/physical disability or severe learning disability.

What information about the treating dentist is available?	Age, gender, General Dental Council (GDC) registration number, date of first registration with GDC, place of qualification	Age, gender, GDC number, date of first registration with GDC	Age, gender, GDC number, date of registration with GDC

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690 *Table 4 HRA study type, country and references of included studies*

Type of study	Key features	Number	Country where the NHS dental data collected
Clinical audit	Designed to answer: *"Does this service reach a particular standard?"*	0	
PH practice	Designed to answer: *"What are the health issues in this population and how do we address them?"*	15	England [56,59,62–69] (10) Scotland [57,58,61,70] (4) Wales[25] (1)
Research	Attempt to derive: *"…generalisable or transferrable new knowledge"*	7	England, Scotland and Northern Ireland[51] (1) England and Scotland[83] (1) England[22] (1) Scotland [24] (1) Northern Ireland[7,82] (2) Wales[84] (1)
Service evaluation	Designed to answer: *"What standard does this service achieve?"*	11	England, Wales and Scotland[74] (1) England[13,72,75,79,81] (5) Scotland[71,73,77,80] (4) Wales[78] (1)
Total		**33**	

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695   **Figures**
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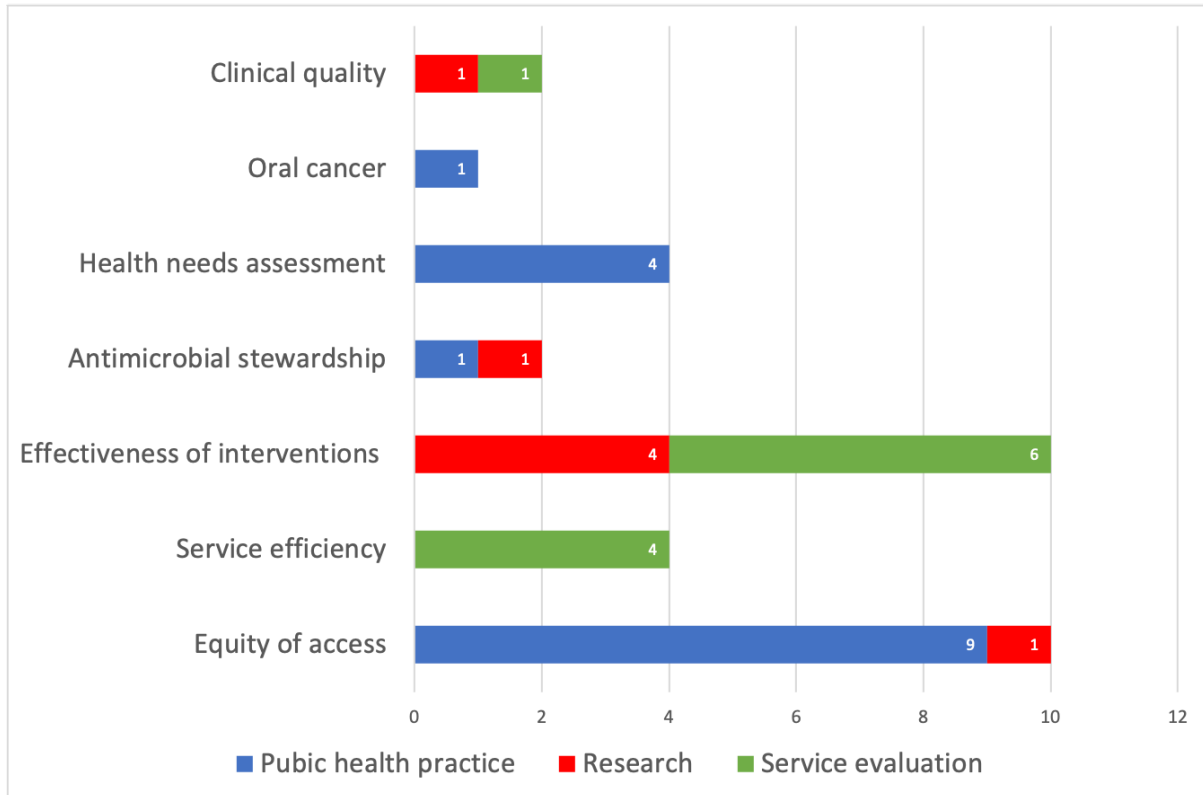697   *Figure 3 PRISMA flow diagram illustrating search process*
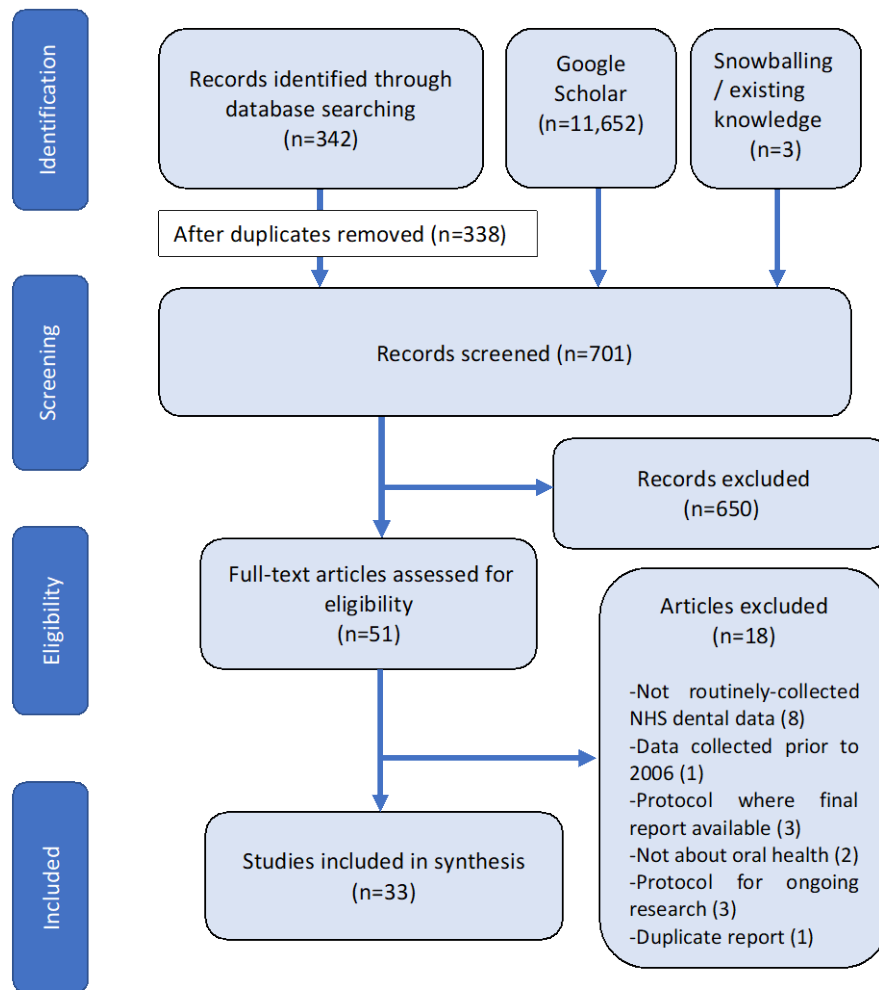
698
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700 *Figure 4 Frequency chart illustrating subject themes of studies identified and HRA study type*

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Supplementary Table 1: Search Strategies

Definitive Searches 31.03.20-29.04.20						
	Search focus and date	**Databases & limits**	**Search Terms**	**Records returned**	**After duplicates removed**	**Records screened**
1	NHS BSA England & UK 31.03.20	PubMed. All fields. 1st Jan 2006-31st March 2020	(((("dental health services"[MeSH Terms] OR ("dental"[All Fields] AND "health"[All Fields] AND "services"[All Fields]) OR "dental health services"[All Fields] OR "dental"[All Fields]) OR ("dentistry"[MeSH Terms] OR "dentistry"[All Fields])) AND (("nhs"[All Fields] AND BSA[All Fields]) OR (("commerce"[MeSH Terms] OR "commerce"[All Fields] OR "business"[All Fields]) AND Services[All Fields] AND Authority[All Fields]))) AND (("compensation and redress"[MeSH Terms] OR ("compensation"[All Fields] AND "redress"[All Fields]) OR "compensation and redress"[All Fields] OR "payment"[All Fields]) OR (claims[All Fields] AND "data"[All Fields]))) AND (("england"[MeSH Terms] OR "england"[All Fields]) OR UK[All Fields]) AND (all[sb] AND ("2006/01/01"[PubDate] : "2020/12/31"[PubDate]))	293	293	293
		Google Scholar 2006-2020	NHS BSA dental data	9740	9740	120 (first 12 pages of results)

Supplementary Table 1: Search Strategies

Definitive Searches 31.03.20-29.04.20					
Search focus and date		**Databases & limits**	**Search Terms**	**Records returned**	**After duplicates removed**	**Records screened**

Supplementary Table 1: Search Strategies

Definitive Searches 31.03.20-29.04.20						
	Search focus and date	**Databases & limits**	**Search Terms**	**Records returned**	**After duplicates removed**	**Records screened**
		Existing knowledge		1	1	1
		Snowballing / forward backwards citation searches		2	2	2
2	UK wide 29.04.20	Medline 2016 to April 28, 2020 All EBM Reviews Embase 1980 to 2020 Week 17 Limits 2006 to 2020	1 (dental or dentist&).mp. [mp=ti, ab, tx, kw, ct, ot, sh, hw, tn, dm, mf, dv, fx, dq, nm, kf, ox, px, rx, ui, sy] (429431) 13 (NHS Business Services Authority or NHS BSA or NHS Business Services Organisation or NHS BSO or NHS Information Services Division or NHS ISD).mp. [mp=ti, ot, ab, tx, kw, ct, sh, hw, tn, dm, mf, dv, fx, dq, nm, kf, ox, px, rx, an, ui, sy] (44) 14 1 and 13 (14) 15 remove duplicates from 14 (10)	14	10	10
3	Scotland and Northern Ireland 29.04.20	PubMed All Fields. 1st Jan 2006- 29th Apr 2020	(((dentistry or dental)) AND "nhs business services organisation") OR "nhs information services division"	35	35	35
4	Scotland	Google Scholar 2006-2020	NHS ISD dental data Scotland	647	647	80 (8 pages)

Supplementary Table 1: Search Strategies

Definitive Searches 31.03.20-29.04.20						
	Search focus and date	Databases & limits	Search Terms	Records returned	After duplicates removed	Records screened
	29.04.20					
5	Wales 29.04.20	Google Scholar 2006-2020	NHS BSA dental data Wales	1,200	1,200	110 (11 pages)
6	Northern Ireland (NHS BSO) 29.04.20	Google Scholar 2006-2020	NHS BSO dental data Northern Ireland	65	65	50 (5 pages)
Total				**11997** Databases (342) Google Scholar (11,652) Other (3)	**11993**	**701** Databases (338) Google Scholar (360) Other (3)

Supplementary Table 2: Study Summary Table

	Included Studies				
	Country[1], year and first author	**Routine NHS data used**	**Key Findings**	**Topic**	**Study classification (HRA)**
1	Eng, Wales & Scot. (2012) McArdle	NHS Hospital Episodes Statistics (HES) database, NHS Business Support Agency (NHSBSA) database and data from the Information Services Division (ISD) of the NHS in Scotland.	There was an increase in the mean age of patients receiving third molar surgery (TMS) (25 years in 2000 to 32 years in 2010). The most common age for TMS increased from 26 to 29 years. The introduction of clinical guidelines led to a decrease of 30% in the number of patients needing third molar removal in a secondary care setting. However, there was a 97% increase in the number of patients since 2003. The number of dental caries resulting in third molar removal also increased.	Effectiveness of Interventions	Service Evaluation
2	Eng. & Scot. (2018) Ramsey	Resource utilisation data for NHS treatments at dental practices over the trial follow-up period were collected using routine sources held by the ISD of the Scottish Government and the NHSBSA in England. Dental claims data were linked to the trial data set on an individual level to each trial participant	Scheduling 6 monthly or 12-monthly periodontal instrumentations (PIs) did not provide any additional benefit compared to not providing this treatment unless desired or recommended. There was also no difference between gingival inflammation/bleeding and patient-centred outcomes. Participants thought both interventions were of value and were willing to pay for both with a higher financial value placed on PI in comparison to oral hygiene advice (OHA)	Effectiveness of Interventions	Research
3	Eng, Scot, N.Ireland. (2016) Brocklehurst	Data recording the extent of NHS clinical activity undertaken by the practice held by the Business Services	Many dental services were noted as not performing to maximum capacity compared to the most efficient practice in the sample. The management of inputs and outputs in NHS dentistry in Northern Ireland was influenced by Capitation. No improvement in the levels of	Effectiveness of Interventions	Research

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[1] Country refers to the country where the NHS routine dental data was collected

Supplementary Table 2: Study Summary Table

		Authority (the Information Services Division in Scotland and the Business Services Organisation in Northern Ireland provided the corresponding data for those jurisdictions). Data on Units of Dental Activities, Courses of Tx and patients seen were linked to role substitution data to look at the effect of role substitution on efficiency at generating outputs	prevention following capitation remuneration was noted. The number of extractions did increase, however.		
4	Scotland (2010) Turner	Dental service, Fluoride varnish and Referrals linked to community health index numbers which show children's participation in Childsmile	These linkages have greatly improved the comprehensive assessment of the Childsmile programme on Children's health in Scotland. The data has helped determine factors that promote the programme intake as well as the cost-effectiveness of the programme	Effectiveness of Interventions	Service Evaluation
5	Scotland (2012) Ulhaq	Orthodontic treatment claims and deprivation data. GP17 (O) forms submitted to NSS Practitioner Services Division (PSD) for payment authorisation by the Scottish Dental Practice Board (SDPB) provided the necessary data for this study	There was a higher uptake of orthodontic services in the least deprived areas. Orthodontic treatment uptake was nearly twice as high for patients from the least disadvantaged areas (OR 1.90, 95% CI 1.86 – 1.94) in comparison to those from the more deprived areas.	Equity	Public Health Practice
6	Scotland (2012)	Restorative activity data collected from the Information Services Division (ISD) of the NHS	There is a considerable need for specialist restorative dentistry services. Restorative dentistry requests and complexity of treatment seem to increase with age.	Service efficiency	Service Evaluation

Supplementary Table 2: Study Summary Table

	Yeung	National Services Scotland and National Records of Scotland (NRS)			
7	Scotland (2013) Jones	Routine administrative data collected from the ISD of NHS National Services Scotland. Some of the data utilised included: a) Dental registrations for all ages were used and were split into adults (>18 years) and children (<18 years) b) Service registration (non-salaried General Dental Services (GDS) or salaried General Dental Service (SGDS)) and c) The Scottish Index of Multiple Deprivation (SIMD) quintile based on the area of residence	Nearly 70% of the Scottish population were registered with an NHS dental service (September 2010). Only 5% of these registrations, however, were with the SGDs. An inverse dental care relationship was observed for children getting NHS dental care in the GDS but not for adults. The registration rates of adults and children for the SGDS were highest amongst the most deprived.	Equity	Public Health Practice
8	Scotland (2015) Rogers	ISD, MIDAS (Management Information and Dental Accounting System), Orthodontic claims, adult / child / costs	Recommendations for future orthodontic services in Scotland	Service Efficiency	Service Evaluation
9	Scotland (2015) Anopa	NHS dental claims data for 2009/10	The nursery toothbrushing programme ran at an estimated annual cost of £1.8 million per year. There was decrease overtime on the costs of dental treatments for five-year-old children. The expected savings from the toothbrushing programme were two and a half times higher than	Effectiveness of Interventions	Service Evaluation

Supplementary Table 2: Study Summary Table

			the expenses associated with programme implementation		
10	Scotland (2016) Elouafkaoui	The Prescribing Information System for Scotland (PRISMS) database and the MIDAS database which contains information relating to all NHS treatment claims made by dentists in the General Dental Service	There was a significant reduction (-5.7%, 95% CI -10.2% TO -1.1%; p = 0.01) in dentists' antibiotic prescribing rate in the audit and feedback (A&F) intervention in comparison to dentists in the control group.	Effectiveness of Interventions	Research
11	Scotland (2017) McMahon	MIDAS—primary care dental service data SMR01—hospital discharge data NDIP—5-year and 11-year dental treatment need data	Following adjustments for sociodemographic factors, looked after children were 2.65 times more likely (95% CI 2.30 to 3.05) to have an urgent need for dental treatment at five years of age. They were also almost twice as likely (OR 1.91, 95% CI 1.78 to 2.04) to have their teeth extracted under general anaesthesia.	Equity	Public Health Practice
12	Scotland (2018) Purkayastha	OCC cases in the Scottish Cancer Registry and MIDAS NHS dental claims database records	It was estimated that dentists potentially came across one case of Oral Cancer every ten years. Oral Cavity Cancer (OCC) was encountered every 16.7 years, and Oropharyngeal cancer (OPC) every 25 years. Half of all OC patients, however, had not had a dental consultation two years before diagnosis	Oral Cancer	Public Health Practice
13	England (2010) Landes	Dental practice records provided by NHSBSA	It was observed that practice location had a significant effect on the oopulation accessing a service. People from the most deprived sections of the North East Community were more likely to access services close to where they lived	Equity	Public Health Practice
14	England (2011) Tickle	Number of new interventions on FP17s under different types of contracts using NHSBSA dental activity data	In the post-2006 dental contract there was an increase in the uptake of treatments such as dental extractions which require the least amount of time and a decrease in the uptake of time-consuming procedures such as bridgework, crowns, root fillings and radiographs. Adjustments made to	Effectiveness of Interventions	Service Evaluation

			financial incentive structures result in substantial and sudden changes in professional behaviours.		
15	England (2013) Simons	NHS BSA dental attendance data	Utilising a community based mobile dental unit presents an opportunity to eliminate barriers to dental care access, in both the treatment of vulnerable children and as the first step in the dental care pathway	Effectiveness of Interventions	Service Evaluation
16	England (2014) Csikar	NHS BSA dental claims data including Fluoride Varnish applications	Fluoride varnish application training for Dental Nurses was observed to increase the use of fluoride varnish in dental practice	Effectiveness of Interventions	Service Evaluation
17	England (2015) Roper (Cheshire)	NHS BSA data on access and treatment	Recommendations for future dental services in Cheshire	Health Needs Assessment	Public Health Practice
18	England (2015) Roper (Mersey)	NHS BSA data on access and treatment	Recommendations for future dental services in Merseyside	Health Needs Assessment	Public Health Practice
19	England (2016) Wanyonyi	NHS Dental sedation claims FP17s	Sedation of patients in dental care practice increased with increasing social deprivation with the most deprived quintile having 31.5% of all patients being sedated at least once in primary dental care. However, this gradient was only noticeable amongst children and young adults and flattened amongst middle-aged and older adults.	Equity	Public Health Practice
20	England (2017)	NHS BSA claims data (FP17s) submitted by general dental practitioners in the North West of	NHS dental care visits decreased with increasing age; From 49% in the 65-74 age group, 39% in the 75 – 84 years age group and 23% in the over 85 years age group. Among the older age	Equity	Public Health Practice

Supplementary Table 2: Study Summary Table

	McKenzie	England (Greater Manchester, Lancashire and Merseyside)	stratifications, they had higher rates of examinations, extractions, dentures and preventive advice in more deprived patients. The rate of fillings and complex restorative treatment was higher for the least deprived patients.		
21	England (2017) Price	NHSBSA orthodontic activity data submitted by primary care dentists who were working under state-funded NHS contracts in North West England	Significant inefficiencies were noticeable in the NHS orthodontic services, with an estimated £2.3 million lost due to discontinuation (7.6% of all treatments) and an additional £1.6 million needed for residual services (5.2% of all treatments). Over a third of cases had unrecorded IOTN outcome scores. Children from deprived communities were observed to have worse outcomes compared to those from more well-off communities.	Efficiency	Service Evaluation
22	England (2018) Crosse	Orthodontic activity data for children using data provided by NHSBSA	To meet the projected need for orthodontics in Northamptonshire, Bedford Borough, Central Bedfordshire, Luton, Milton Keynes and Hertfordshire, it is estimated that between thirteen and fifteen thousand orthodontic case starts per annum need to be commissioned	Health Needs Assessment	Public Health Practice
23	England (2018) Geddis-Regan	Number of courses of domiciliary care provided using data supplied by NHSBSA	There was a sizeable variation in the number of domiciliary claims made across various England regions in 2015, with a limited association between the number of claims and population size. An association between area levels of deprivation and the number of domiciliary claims made per 100,000 population was observed, but this association lacked consistency. No association was found between area proportions of adults aged 60+ and the numbers of domiciliary claims per 100,000 population	Equity	Public Health Practice
24	England (2018)	Anonymised, aggregated data sets supplied by NHSBSA, summarising activities by neighbourhood	40% of children abstained from dental visits in one year. Fluoride varnish was only included in 1 out of 7 courses of treatment and 1 out of 83 fissure sealant. For children under 16 years, seven in	Clinical Quality	Service Evaluation

Supplementary Table 2: Study Summary Table

	Lucas	(electoral ward), patient characteristics and (Course of Treatment) CoT for all <18-year-olds in the area	every thousand were admitted for dental general anaesthetic, with one in thirteen being repeat admissions. Incidence rates were highest among 5–9-year-olds, in the most deprived neighbourhoods, and areas with higher fluoride varnish use rates. Most children had more than four teeth removed, with younger children having more teeth removed than older children. Preventive interventions were found to be underutilised by GDPs in this region, given the high needs.		
25	England (2018) Patel	NHS BSA data on Fluoride Varnish rates by Middle Layer Super Output Areas (MSOA), fissure sealant rates by MSOA.	Recommendations related to local general dental service provision.	Health Needs Assessment	Public Health Practice
26	England (2019) Thompson	NHS BSA data on antibiotics prescribed from FP17s and dental attendance figures	According to NHS prescription service records, 3.4 million antibiotic items were dispensed NHS dental patients by community pharmacists across England in 2015. However, the NHS Dental Services identified 1.3 million antibiotic items prescribed by NHS primary care dentists in England during the same reporting period. Therefore, they were 2.6 million fewer antibiotics recorded as prescribed by dentists than were known to be dispensed by pharmacists.	Antimicrobial Stewardship	Research
27	England (2019) Maguire	NHSBSA data on activities of NHS contracted services and sedation claims. Data on hospital admissions for dental extractions under general anaesthesia provided by PHE	There are extensive and important variations in population experience of sedation across England. Such differences are difficult to explain on purely clinical grounds	Equity	Public Health Practice
28	England (2020)	NHS administrative data, Office for National Statistics and 2016/2017 National	Deprivation was associated with decreased dental attendance rates. White ethnicity, single	Equity	Public Health Practice

Supplementary Table 2: Study Summary Table

		Dental Epidemiology Programme	parenthood and caries prevalence were associated with increased rates.		
	Salomon-Ibarra				
29	Wales (2012) Richmond	NHSBSA data on orthodontic activity for Wales	Apparent inefficiencies in the orthodontic services in Wales for the period of 2008/2009 were observed with children having varied access to services in the 22 local health boards. Around £12 million was spent on orthodontics. A potential shortfall of 508 orthodontic treatment was also observed for children between 12 to 17 years. Out of 135 GDS/PDS orthodontic contracts, 27 provided no active treatment (only assessments), and 62 provided less than 50 treatments annually. Cost per units of orthodontic activity (UOA) ranged from £58 to £74. With improved contracts and efficiency, the orthodontic budget seems sufficient to meet the population's orthodontic needs.	Service Efficiency	Service Evaluation
30	Wales (2019) Quach	Performer and patient information were obtained by use of a questionnaire and FP17OW forms, respectively. A calibrated investigator recorded the Index of Orthodontic Treatment Need (IOTN), Peer Assessment Rating (PAR) and the Index of Complexity, Outcome and Need (ICON) on start- and end-study models for each case.	The highest quality of orthodontic outcomes was achieved by dual arch fixed appliances carried out by orthodontic specialists in non-corporate environments. Individuals with the greatest need for treatment according to IOTN Dental Health Component (DHC) and Aesthetic Component (AC) AC gain the most with regards to improvement completed in PAR score.	Clinical Quality	Research
31	Wales (2019)	Dispensing data submitted by community pharmacies in Wales compiled by NHS Wales Shared Services	Linking routinely collected antibiotic dispensing data and NHS general dental services data to produce personalised feedback profiles for general	Antimicrobial Stewardship	Public Health Practice

	Cope	Partnership (NWSSP), linked to data relating to NHS general dental service activity, obtained from the NHS BSA	dental practitioners working in NHS Wales is achievable.		
32	N. Ireland (2012) Telford	Data on adolescents aged 11 or 12 years in April 2003 obtained from the Northern Ireland Longitudinal Study (NILS) and monthly dental registration data	There is a decrease in dental registration rates during the transition from childhood to adulthood. This could reduce the population's dental health with the risk being higher in males than females. There is a need to review the role of children's services within dentistry.	Equity	Research
33	N. Ireland (2020) Brocklehurst	Data extracted from submitted HS45 forms by the BSO	A shift to the capitation-based payment system seems to suppress clinical activity, including prevention. Equally, GDPs returning to a Fee-for-service (FFS) remuneration system seem to return to levels observed in the baseline period. A permanent change to Capitation would likely lead to immediate changes similar to those reported in the pilot, but that behaviour in terms of availability and usage would find an equilibrium somewhere between the FFS and capitation levels listed in the pilot.	Effectiveness of Interventions	Research