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## Unlocking the potential of NHS primary care dental datasets

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89

90

91 **Three key points:**

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

97

98 **Unlocking the potential of NHS primary care dental datasets**

99

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

102

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

106

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

109

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

114

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

120

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

124

125

126 **Introduction**

127

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

138

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

143

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

149

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

161

162 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.<sup>7</sup> 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) <sup>8</sup>

- 199 • Wales: 55% of the population<sup>9</sup> (within two years)
- 200 • Scotland: 67% of the population<sup>10</sup> (within two years)
- 201 • Northern Ireland 61% of adults (within two years) and 75% of children (within 12-
- 202 months)<sup>11</sup>

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.<sup>12</sup> 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.<sup>13</sup>  
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.<sup>13</sup> 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,<sup>14</sup> the Honest Broker Service<sup>15</sup> in Northern Ireland, NHS  
233 Digital<sup>16</sup> in England and the NHS Wales Informatics Service.<sup>17</sup>

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.<sup>18,19</sup> 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.<sup>20,21</sup> 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.<sup>22</sup> In Wales, the option  
242 to record “antibiotics prescribed” on the FP17W form was recently removed.<sup>23</sup> 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, 28<sup>th</sup> January  
248 2021).<sup>24,25</sup> 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.<sup>26</sup>

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.<sup>27</sup> 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.<sup>23,28</sup>  
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.<sup>29</sup>

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.<sup>9,30–32</sup> 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.<sup>33</sup> 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).<sup>34</sup> 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.<sup>35,36</sup> To start the application process,  
280 a comprehensive form must be submitted along with an initial assessment fee.<sup>34</sup> 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.<sup>34</sup> Individual-level data considered 'potentially identifiable'<sup>37</sup> will need to be  
284 securely hosted, analysed and destroyed within an NHS-compliant secure research  
285 environment, or "Data Safe Haven".<sup>38,39</sup> All named users will need to demonstrate appropriate  
286 data protection training and access to the data will be audited.<sup>38</sup>

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.<sup>40</sup> 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.<sup>40</sup> Access to information collated by PHS (formerly ISD  
292 Scotland) requires approval from the Scottish Public Benefits and Privacy Panel (PBPP).<sup>41</sup>  
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.<sup>14</sup> 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).<sup>40</sup> Users will need to demonstrate appropriate training and sign an end-user  
300 agreement in line with the Scottish Information Sharing Toolkit.<sup>35,41</sup>

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.<sup>15</sup> 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.<sup>15</sup> 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, 1<sup>st</sup> 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.<sup>42</sup> 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, meaning important health inequalities may be unmeasured.<sup>43</sup> After  
343 'White British' the next most common categories in 2018/9 were 'N/A' and 'patient declined'  
344 (K.Gray, NHSBSA personal communication, 13<sup>th</sup> October 2020). It must also be remembered

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

353

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

367

368

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

371

372 **Methods:** The scoping review was carried out according the guidance issued by the Joanna  
373 Briggs Institute (JBI), and is reported according to the PRISMA extension for scoping  
374 reviews.<sup>47,48</sup>

375

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

378

379 **Eligibility criteria**

380

- 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.<sup>49</sup> 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.<sup>50</sup> 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 existing 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<sup>51,52</sup> only one paper was included.<sup>51</sup> 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.<sup>53-55</sup>

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<sup>49</sup> 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

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

462

463

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

465

## 466 **Narrative synthesis**

467

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

479

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

487

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

490 health investment between childhood and adolescence.<sup>82</sup> 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.<sup>7,51</sup> Two studies  
493 were randomised controlled trials; one assessing the effectiveness of individualised audit and  
494 feedback on dentists' antibiotic prescribing rate,<sup>24</sup> and the other, the effectiveness and  
495 economic value of 'scale and polish' treatments and oral hygiene advice.<sup>83</sup> One study  
496 investigated the influence of patient, treatment and performer factors on the quality of  
497 orthodontic outcome.<sup>84</sup> 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.<sup>22</sup>

501

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.<sup>70,81</sup> In contrast, four of the seven studies classified as  
505 research were approved by an NHS Research Ethics Committee (NHS REC),<sup>51,82-84</sup> and one  
506 was reviewed but was deemed not to require formal approval.<sup>24</sup> The remaining two  
507 received University ethical approval.<sup>7,22</sup>

508

509

## 510 **Discussion**

511

512

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.

523

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.<sup>85</sup>

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.<sup>86-88</sup> 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.<sup>86-88</sup> 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.<sup>89</sup> Similarly, in 2016 Hospital Episode Statistics for Admitted Patient Care were  
549 estimated to have been used in over 500 research publications.<sup>87</sup> 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<sup>84</sup> 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.<sup>90</sup> 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),<sup>42</sup> or the treatment outcomes of individual dentists; all  
567 important dimensions of technical quality.<sup>91</sup>

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.<sup>91,92</sup> 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.<sup>91</sup> Since 2013 in England all NHS services  
575 (including dental practices) are required to submit the 'Friends and Family' measure of patient  
576 experience,<sup>93</sup> 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 identification of risks to patient safety and/or professional standards,<sup>94</sup>  
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.<sup>95</sup>

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.<sup>2</sup> 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 opportunities 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.<sup>2</sup>

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.<sup>96</sup> 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.<sup>97</sup> 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

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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

673 version of the manuscript. Wendy Thompson contributed to the drafting of the manuscript and  
674 approved the final version. Blessing Nyakutsikwa contributed to the scoping review analysis  
675 and interpretation, contributed to the drafting of the manuscript and approved the final version.  
676 Iain Pretty contributed to the development and conception of the study, the drafting of the  
677 manuscript and approved the final version. Martin Tickle contributed to the conception and  
678 development of the study design, the drafting of the manuscript and approved the final version.

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680

681

682 **Tables**

683

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

686

	<b>England and Wales</b>	<b>Scotland</b>	<b>Northern Ireland</b>
<b>Data Controller</b>	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
<b>Name of dental dataset</b>	NHSBSA Dental Services Activity Data	Management Information & Dental Accounting System (MIDAS)	FPS Dental Payment System Data
<b>Number of patient records in database</b>	~269 million (from Jan 2014)	~7 million	~3 million
<b>How is the data captured?</b>	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
<b>How up to date is the data?</b>	Claims for completed treatment must be submitted within 2 months. Database updated daily	Claims for completed treatment must be submitted within 3 months. <sup>98</sup> MIDAS is refreshed monthly	Claims for completed treatment must be submitted within 6 months. Database updated daily
<b>How far back can data be accessed?</b>	Data retention period is currently 10 years but this is under review and may be reduced. Data is more complete post-2015	1999 <sup>98</sup> but data only considered complete from 1 <sup>st</sup> April 2000	2007 but data is more complete post-2015
<b>Can records be linked to individuals using a unique identifier?</b>	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
<b>What demographic information about the patient is held?</b>	Age, gender, ethnicity (optional). NHS dental charge exemption category. Multiple deprivation measure using home postcode <sup>99</sup>	Age, gender, marital status, NHS dental charge exemption category. Multiple deprivation measure using home postcode <sup>100</sup>	Age, gender, NHS dental charge exemption category. Multiple deprivation using home postcode. <sup>101</sup>
<b>How detailed is the clinical treatment data?</b>	Category of treatment and number of teeth e.g. "extraction", "filling" <sup>27</sup> . Exact tooth cannot be provided.	Exact type of treatment including material and size. <sup>21</sup> From 2013 exact tooth can be provided from 2013.	Exact type of treatment including material and size. <sup>20</sup> Exact tooth can be provided.
<b>Are there any indicators of oral health, medical or social risk factors?</b>	<b>England:</b> Number of Decayed, Missing and Filled Teeth (DMFT) from 2017 <b>Wales:</b> From 2020, number of decayed teeth, total number of teeth and clinical risk factors (ACORN) <sup>23,28</sup>	'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.

<b>What information about the treating dentist is available?</b>	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
--	--	--	--

687  
688

689

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

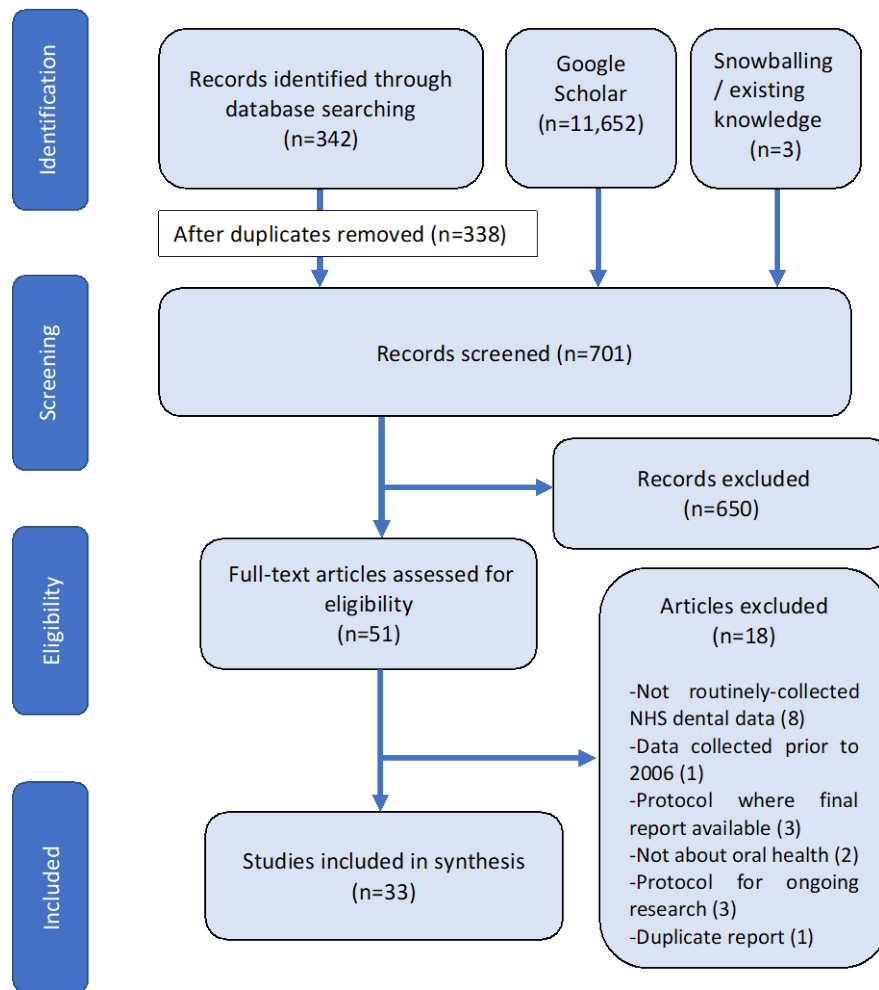
<b>Type of study</b>	<b>Key features</b>	<b>Number</b>	<b>Country where the NHS dental data collected</b>
Clinical audit	Designed to answer: <i>“Does this service reach a particular standard?”</i>	0	
PH practice	Designed to answer: <i>“What are the health issues in this population and how do we address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

691  
692  
693  
694

695 **Figures**

696

697 *Figure 3 PRISMA flow diagram illustrating search process*

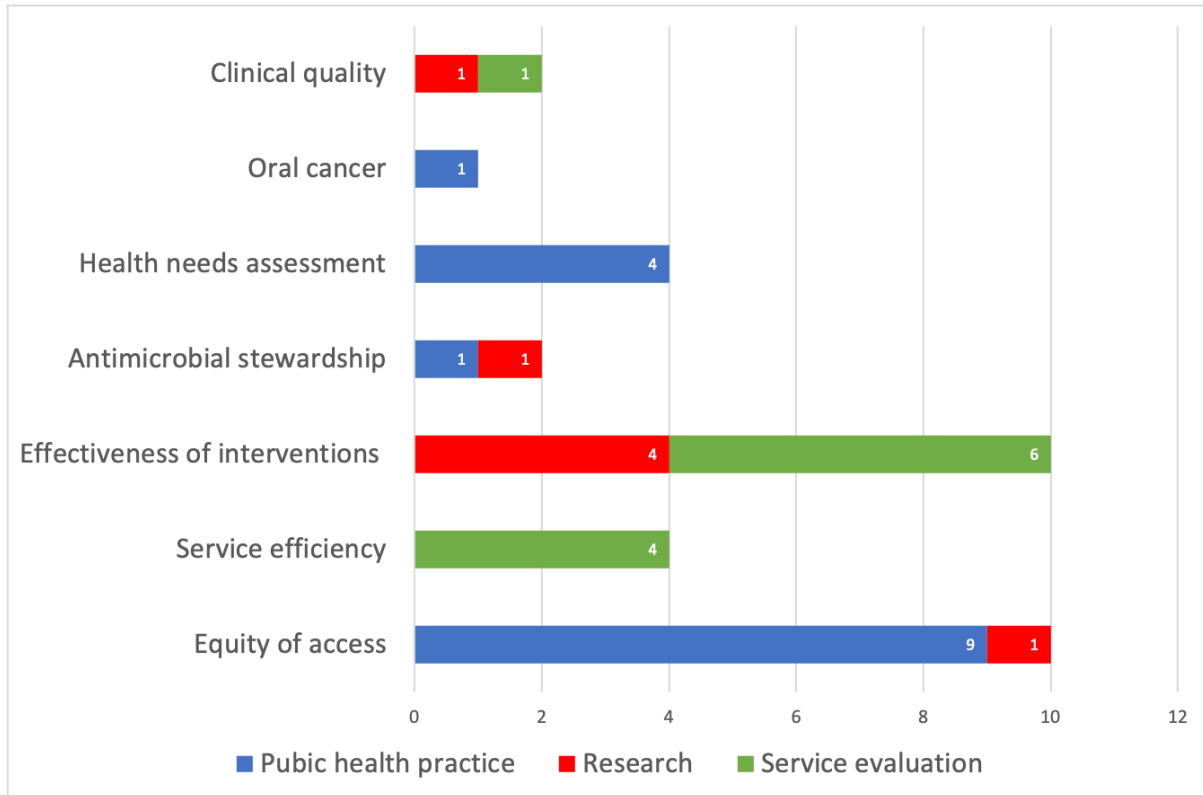


698

699

700 *Figure 4 Frequency chart illustrating subject themes of studies identified and HRA study type*

701



702



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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.  1 <sup>st</sup> Jan 2006-31 <sup>st</sup> 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
		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.  1 <sup>st</sup> Jan 2006- 29 <sup>th</sup> 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**

<b>Definitive Searches 31.03.20-29.04.20</b>						
	<b>Search focus and date</b>	<b>Databases &amp; limits</b>	<b>Search Terms</b>	<b>Records returned</b>	<b>After duplicates removed</b>	<b>Records screened</b>
	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)
<b>Total</b>				<b>11997</b> Databases (342) Google Scholar (11,652) Other (3)	<b>11993</b>	<b>701</b> Databases (338) Google Scholar (360) Other (3)

**Supplementary Table 2: Study Summary Table**

Included Studies					
	Country <sup>1</sup> , 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

<sup>1</sup> 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 population 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

**Supplementary Table 2: Study Summary Table**

			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 GPs 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**

	Salomon-Ibarra	Dental Epidemiology Programme	parenthood and caries prevalence were associated with increased rates.		
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

**Supplementary Table 2: Study Summary Table**

	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, GPs 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