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**Linking routinely collected social work, education and health data to enable monitoring of the health and health care of school-aged children in state care ('looked after children') in Scotland: a national demonstration project**

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1 **Title**

2 Linking routinely collected social work, education, and health data to enable monitoring of  
3 the health and healthcare of school aged children in state care ('looked after children') in  
4 Scotland: a national demonstration project.

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## 42 **Abstract**

### 43 Background and objectives

44 Children in state care ('looked after children') have poorer health than children who are not  
45 looked after. Recent developments in Scotland and elsewhere have aimed to improve  
46 services and outcomes for looked after children. Routine monitoring of the health outcomes  
47 of looked after children compared to those of their non-looked after peers is currently  
48 lacking. Developing capacity for comparative monitoring of population based outcomes  
49 based on linkage of routinely collected administrative data has been identified as a priority.  
50 To our knowledge there are no existing population based data linkage studies providing data  
51 on the health of looked after and non-looked after children at national level. Smaller scale  
52 studies that are available generally provide very limited information on linkage methods and  
53 hence do not allow scrutiny of bias that may be introduced through the linkage process.

### 54 Study design and methods

55 National demonstration project testing the feasibility of linking routinely collected looked  
56 after children, education, and health data.

### 57 Participants

58 All children in publicly funded school in Scotland in 2011/12.

### 59 Results

60 Linkage between looked after children data and the national pupil census classified 10,009  
61 (1.5%) and 1,757 (0.3%) of 670,952 children as, respectively, currently and previously  
62 looked after. Recording of the unique pupil identifier (Scottish Candidate Number, SCN) on  
63 looked after children returns is incomplete, with 66% of looked after records for 2011/12 for  
64 children of possible school age containing a valid SCN. This will have resulted in some  
65 under-ascertainment of currently and, particularly, previously looked after children within the

66 general pupil population. Further linkage of the pupil census to the NHS Scotland master  
67 patient index demonstrated that a safe link to the child's unique health service (Community  
68 Health Index, CHI) number could be obtained for a very high proportion of children in each  
69 group (94%, 95%, and 95% of children classified as currently, previously, and non-looked  
70 after respectively). In general linkage rates were higher for older children and those living in  
71 more affluent areas. Within the looked after group, linkage rates were highest for children  
72 with the fewest placements and for those in permanent fostering.

### 73 Conclusions

74 This novel data linkage demonstrates the feasibility of monitoring population based health  
75 outcomes of school aged looked after and non-looked after children using linked routine  
76 administrative data. Improved recording of the unique pupil identifier number on looked  
77 after data returns would be beneficial. Extending the range of personal identifiers on looked  
78 after children returns would enable linkage to health data for looked after children who are  
79 not in publicly funded schooling (i.e. those who are pre- or post-school, home schooled, or in  
80 independent schooling).

81 Word count (431)

### 82 **Keywords**

83 Child in care

84 Looked after children

85 Delivery of healthcare

86 Dental health services

87 Medical record linkage

88 Public health informatics

89 Scotland

## 90 **Introduction**

91 In Scotland, children in state care (referred to as ‘looked after children’) are those under  
92 supervision or accommodated by local authorities<sup>1-3</sup>. Children can become looked after  
93 following a voluntary agreement with their parents or a compulsory process involving the  
94 Scottish Children’s Hearing System<sup>4</sup> or the courts, and their requirement for such support can  
95 reflect care, protection, and/or offending needs. Looked after children may live at home with  
96 their parents under social work supervision (‘looked after at home’); with other family  
97 members or friends (‘kinship care’); with foster carers or prospective adopters; or in  
98 residential accommodation provided by the state (residential units, schools, and secure care)<sup>5</sup>.

99

100 Around 15,400 children in Scotland were looked after at the end of July 2015, around 1.5%  
101 of all children aged less than 18 years<sup>6</sup>. The health, educational, and wider social outcomes  
102 of looked after children are generally poorer than those of children who are not looked after<sup>7-</sup>  
103 <sup>9</sup>. Current Scottish Government policy strongly supports improving the experience and  
104 outcomes of looked after children<sup>10</sup> and emphasises the need for robust routine data to enable  
105 monitoring of care provided and outcomes achieved<sup>11</sup>.

106

107 Currently, routine data returned by local authorities to the Scottish Government on children  
108 being looked after form the basis of an annual statistical publication on children’s social  
109 work<sup>6</sup>. In addition, the Scottish Government routinely links the looked after data to  
110 administrative data returned by local authorities on education provision to enable monitoring  
111 of the educational attainment and post school destinations of looked after children compared  
112 to all children<sup>12</sup>. Scotland has a wide range of high quality routine health data that can be  
113 used to monitor child health. Health records in general do not include information on

114 children's looked after status hence they cannot be used in isolation to assess the health of  
115 looked after children. Linkage of routine looked after and health data would open up the  
116 possibility of robust population based monitoring of the health outcomes of looked after and  
117 non-looked after children, and developing such a linkage has been identified as a priority<sup>11</sup>.

118

119 Here we report the results of a national level demonstration project linking routinely available  
120 looked after children data and health data for the first time in Scotland. To our knowledge,  
121 this is the first time globally that such a national level, population based linkage study has  
122 been undertaken. This paper reports the methodology and results of the linkage process: a  
123 separate paper reports the results of a follow on analysis assessing the dental health of looked  
124 after and non-looked after children using the linked data set created (submitted for  
125 publication, available on request). With this paper we aim to provide information of use to  
126 future researchers wishing to assess the health and healthcare of looked after children using  
127 routinely available data.

## 128 **Methods**

129 We made use of three databases. These are described in full in Panel 1 and were (a) annual  
130 looked after data returns submitted by local authorities to the Scottish Government providing  
131 information on all children looked after by the local authority during the preceding academic  
132 year ('looked after data'), (b) the annual pupil census (again returned by local authorities to  
133 the Scottish Government) which is the master index of all children in publicly funded schools  
134 in Scotland at the start of each academic year ('pupil census'), and (c) the Community Health  
135 Index database which is the master patient index for the NHS in Scotland, continuously  
136 maintained primarily from General Practitioner registration data ('CHI database'/'health  
137 data'). Publicly funded schools comprise mainstream and special schools funded by the state

138 and managed by local authorities. Children who are home schooled or attending an  
139 independent or charitable day or residential school or secure unit will not be included in the  
140 pupil census, even if their school place is being funded by their local authority. The pupil  
141 census contains the Scottish Candidate Number (SCN) for every pupil. The SCN is the  
142 unique identifier used on all education records in Scotland. The looked after data should  
143 contain the SCN if it is available, for example if the child is attending publicly funded school.  
144 The Community Health Index database contains patients' CHI number, the unique identifier  
145 used on all health records in Scotland.

146 Panel 1 about here.

147

148 Linkage of records belonging to the same child across databases depends on the personal  
149 identifiers held within the databases. There are insufficient personal identifiers (date of birth  
150 and gender only) in the looked after data to enable robust direct linkage to the CHI database.  
151 We therefore used Scottish Candidate Numbers (SCNs) included in looked after data from  
152 2007/08 to 2011/12 to identify looked after children in the 2011/12 pupil census. We then  
153 used the wider range of personal identifiers available within the pupil census (date of birth,  
154 gender, and home postcode) to link this database to the CHI database. This resulted in a look  
155 up file providing an SCN (with a flag to indicate looked after status) to CHI number look up  
156 key for all children in publicly funded school in 2011/12 (see Figure 1). Further details of the  
157 linkage process are provided as supplementary material. Note that the limited personal  
158 identifiers available in looked after data returns mean that linking to the CHI database must  
159 go through this intermediate step of the pupil census. It is currently not possible to link  
160 looked after records for pre- or post-school children to their health records.

161 Figure 1 about here.

162



163 Categorisation of looked after status in the pupil census relies on accurate recording of  
164 children's SCNs within the looked after data. We therefore first assessed the quality of  
165 recording of SCN on looked after data by examining the proportion of records for children of  
166 school age that contained any SCN or a valid SCN. The looked after data validation rules  
167 define a valid SCN as one of the correct length (nine digits) that contains a correct check  
168 digit.

169

170 We then assessed the proportion of currently, previously, and non-looked after children in the  
171 2011/12 pupil census whose record could be safely linked to the child's CHI number. Using  
172 demographic information contained within the pupil census we further assessed linkage rates  
173 by pupil age group, gender, Scottish Index of Multiple Deprivation quintile, ethnicity, and by  
174 school local authority area. The Scottish Index of Multiple Deprivation is a small area based  
175 measure of deprivation: individuals are assigned to deprivation quintiles based their postcode  
176 of residence<sup>13</sup>. Finally, using information contained within looked after data we assessed  
177 linkage rates for currently looked after children by the cumulative number of looked after  
178 placements they had experienced (placements ending on or after 1<sup>st</sup> August 2007) and the  
179 type and legal reason underpinning their most recent placement. Linkage rates for currently  
180 and, separately, previously looked after children were compared to those for non-looked after  
181 children using 95% confidence intervals for the difference in two independent proportions.  
182 Similarly, linkage rates for particular categories of currently looked after children were  
183 compared to those in a relevant reference category (one placement since August 2007; looked  
184 after at home; and compulsory supervision through the Children's Hearing system (resident at  
185 home)).

186

187 Once the linkage was completed, CHI numbers were used to identify and extract a range of  
188 routinely available dental health and healthcare data held by the NHS Scotland Information  
189 Services Division (ISD) to enable comparison of the dental health of school aged looked after  
190 children to that of their non-looked after peers. The results of this analysis are reported  
191 separately (submitted for publication, available on request). Approval for this study was  
192 obtained from the Scottish Government Education Analytical Services Division Data Access  
193 Panel and the NHS Privacy Advisory Committee. Ethical approval was obtained from the  
194 University of Glasgow College of Medicine, Veterinary, and Life Sciences Ethics  
195 Committee: NHS ethical approval was not required.

## 196 **Results**

197 The quality of recording of Scottish Candidate Number (SCN) on looked after records for  
198 school aged children is shown in Table 1. A total of 20,771 children were included in the  
199 2011/12 looked after return (i.e. were looked after at some point over that school year), of  
200 whom 16,859 were of possible or definite school age (defined as aged 4 to 19 years inclusive  
201 at the start of the school year). Of the 16,859, 13,357 (79.2%) children had any SCN  
202 recorded on their looked after record and 11,182 (66.3%) had a valid SCN recorded. The  
203 completeness of SCN recording varied by local authority. Whilst most authorities returned a  
204 valid SCN on at least 80% of looked after records for children of school age a minority had  
205 noticeably poorer completeness, for example 18% in Dumfries & Galloway and 26% in  
206 Glasgow City.

207 Table 1 about here.

208

209 The number of children in a publicly funded school in 2011/12 identified as currently or  
210 previously looked after, and the proportions for whom a safe link to the CHI database could

211 be made, are shown in Table 2 (see Supplementary material for a definition of ‘safe links’).  
212 In total, 670,952 children were included in the 2011/12 pupil census. Of the 11,182 valid  
213 SCNs included in the 2011/12 looked after returns, 10,009 were also included in the 2011/12  
214 pupil census and these children (1.5% of all pupils) were classified as currently looked after.  
215 SCNs may be included in the 2011/12 looked after returns but not the 2011/12 pupil census  
216 if: the SCN recorded on the looked after return is incorrect; the child has left publicly funded  
217 school and their historical SCN has been included on their looked after return, or; they are  
218 home schooled or attending an independent school but have an SCN due to being registered  
219 for examinations with the Scottish Qualifications Authority. An additional 1,757 (0.3%)  
220 children in the 2011/12 pupil census were classified as previously looked after, that is their  
221 SCN had been included in a previous (2007/08 to 2010/11) looked after return, but not the  
222 2011/12 return. The remaining 659,186 (98.2%) children were classified as non-looked after.  
223  
224 Compared to non-looked after children, children in school in 2011/12 classified as looked  
225 after were more likely to be of compulsory secondary school age (12-15 years) rather than  
226 primary school (4-11) or post-compulsory secondary school (16-19) age. Looked after  
227 children were also more likely to be male, much more likely to live in a deprived area, and  
228 more likely to be of white British ethnicity (Table 2).  
229  
230 A safe linkage to the CHI database was achieved for 95.1% (626,732/659,186) of non-looked  
231 after children. Linkage rates were marginally lower for children classified as currently  
232 looked after (94.0%, 9,409/10,009) and similar for children classified as previously looked  
233 after (95.3%, 1,674/1,757). Amongst non-looked after children, linkage rates to CHI were  
234 slightly higher for secondary compared to primary school aged children and for those living  
235 in more affluent areas. Similar patterns (with steeper discrepancies) were seen for looked

236 after children. Linkage rates showed only moderate variation by local authority for looked  
237 after and non-looked after children.

238 Table 2 about here.

239

240 The proportion of currently looked after children that could be safely linked to the CHI  
241 database by the characteristics of looked after care received is shown in Table 3. Linkage  
242 rates were lower for children experiencing a higher number of placements and for those in  
243 residential accommodation compared to those being looked after at home. Considering the  
244 statutory basis for children's care, linkage rates were lower for children with an emergency  
245 court order and higher for those with a permanence order (a legal instrument enabling a  
246 permanent fostering arrangement or adoption) compared to those under compulsory  
247 supervision at home.

248 Table 3 about here.

## 249 **Discussion**

250 We used routinely collected looked after children and pupil census data to categorise children  
251 in publicly funded schools in Scotland in 2011/12 as currently, previously, or non-looked  
252 after. Recording of children's Scottish Candidate Number on looked after data is incomplete  
253 hence some under-ascertainment of looked after children within the general school  
254 population will occur. We linked all children in the pupil census to the NHS Scotland master  
255 patient index (Community Health Index database) and demonstrated that a safe link to the  
256 child's CHI number could be obtained for a very high proportion of looked after and non-  
257 looked after children (94% and 95% of children classified as currently looked after and non-  
258 looked after respectively).

259 **Strengths and limitations**

260 **Categorising children in the pupil census as currently, previously, or non-looked**  
261 **after**

262 Recording of the Scottish Candidate Number on looked after records is incomplete. We  
263 found that overall 79.2% of children of possible or definite school age had an SCN on their  
264 looked after record in 2011/12, with completeness varying markedly between local  
265 authorities. The recording of SCNs on looked after records by local authority staff is a  
266 manual administrative process. The variation in data quality between local authorities is  
267 therefore a reflection of differing operational practices that affect both data completeness and  
268 accuracy. We would not expect 100% completeness from any area as, even within the 4-19  
269 year old age group, some children will not have started school, some will have left school,  
270 and some may be home schooled or attending independent mainstream or special schools.  
271 Overall, fewer than 1% of all school children in Scotland are home schooled<sup>14</sup> and around 4%  
272 attend an independent school<sup>15</sup>. The proportion of looked after children receiving these types  
273 of education is unknown, although it is likely, for example, that a number of looked after  
274 children are in independent special schools.

275

276 We found that 16% of the SCNs that were included in the 2011/12 looked after records were  
277 invalid. When looked after records are returned from local authorities to the Scottish  
278 Government, all submitted SCNs are checked to ensure they are the correct length (nine  
279 digits) and contain a correct check digit. In addition, a check is run to ensure that each SCN  
280 only occurs once in the dataset submitted by any individual local authority. However,  
281 although any records failing the validation checks are brought to the attention of the  
282 submitting local authority, if it is not possible to correct an error the record is still accepted  
283 into the national looked after dataset.

284

285 Incomplete or inaccurate recording of SCN on looked after returns means that some children  
286 within the 2011/12 pupil census who were looked after during that academic year will have  
287 been misclassified as non-looked after. It is not possible to precisely quantify the extent of  
288 this under-ascertainment of ‘currently looked after’ children. The published national  
289 statistics on looked after children in Scotland suggest that as at mid 2015, 1.6% (11,990 of  
290 739,922) of the school aged population (children 5-17 years) were looked after<sup>6</sup>. We  
291 classified 1.5% of children in the 2011/12 pupil census as looked after at some point over that  
292 academic year, suggesting only a modest degree of under-ascertainment of our currently  
293 looked after group.

294

295 The degree of under-ascertainment of children in school in 2011/12 that were previously  
296 looked after is likely to be substantially higher than that for currently looked after children.  
297 Using all available looked after returns we estimate that approximately 13,000 school aged  
298 children had been looked after at some point over the academic years 2007/08 to 2010/11  
299 (but not 2011/12) and were still school aged during 2011/12. This provides a maximum  
300 estimate of the number of previously looked after children we may have anticipated  
301 identifying in the 2011/12 pupil census. In practice however we only identified 1,757  
302 children in the 2011/12 pupil census as previously looked after. This is likely to reflect a  
303 number of factors including that some of the 13,000 were not in a publicly funded school  
304 either at the time they were looked after (for example they had not yet started school) or  
305 during 2011/12 (for example they had left school early), or that their SCN was missing or  
306 inaccurately recorded on their historical looked after record hence could not be identified in  
307 the 2011/12 pupil census. The proportion of looked after returns for school aged children that  
308 contained any SCN was 67% in 2007/08 (the first year covered by the return) and 53% in

309 2008/09. Since 2009/10 it has been consistently higher than 75%, although further  
310 improvement has been lacking in recent years.

311

312 Overall, it is highly likely that children in school in 2011/12 that we identified as currently or  
313 previously looked after were correctly classified however some of the children identified as  
314 non-looked after will in fact have been currently or, more likely, previously looked after.

315 Any such misclassified children are likely to comprise a very small proportion of all ‘non-  
316 looked after’ children. In addition, any such misclassification will tend to minimise any  
317 differences observed between looked after and non-looked after groups, i.e. will  
318 conservatively bias any findings of health differences between looked after and non-looked  
319 after groups towards the null.

### 320 **Linking pupil census records to the Community Health Index**

321 Pupil date of birth, gender, and home postcode are the only personal identifiers available  
322 within the pupil census. Individuals’ names, a key variable usually used when linking  
323 together health records belonging to the same people, are not available. In addition, looked  
324 after children are likely to have relatively high residential mobility, with frequent changes of  
325 home postcode. Despite these challenges, we found that linkage rates for children in the  
326 currently looked after group were only marginally lower than those achieved for non-looked  
327 after children, with a safe link to a Community Health Index number found for 94% and 95%  
328 respectively.

329

330 Linkage rates were generally highest for older school children, probably reflecting the  
331 availability of more years’ pupil census data for older children and hence potentially multiple  
332 postcodes that could increase the chance of a match to that held on the CHI database.

333 Linkage rates were also generally higher for children living in less deprived areas, which is

334 likely to reflect lower residential mobility amongst affluent groups. Amongst currently  
335 looked after children, linkage rates showed some variation by placement number and type,  
336 again generally suggesting that more stable living arrangements were associated with higher  
337 linkage rates. The only exception to this was the relatively low linkage rate found for  
338 children living in state provided residential accommodation: the reason for this is unclear.  
339 Well established processes were used to link children's identifiers held on the pupil census to  
340 those in the CHI database. Of particular note, we have demonstrated previously that CHI  
341 numbers accepted as safe links for particular SCNs are highly likely (>99%) to be correct<sup>16</sup>.

342

343 The Scottish Candidate Number and Community Health Index number are both managed  
344 nationally. As children move between local authority or NHS Board areas they retain the  
345 same SCN and CHI number. Importantly when considering looked after children, children  
346 also generally retain the same SCN and CHI number following adoption.

347

### 348 **Findings in light of existing literature**

349 The potential contribution of population based studies involving the linkage of routine  
350 administrative data to elucidating the risk factors for, and outcomes from, state care in  
351 childhood has been well recognised<sup>17, 18</sup>. Several examples of studies based on linkage of  
352 administrative state care/looked after children data are available. Studies linking to health  
353 records have examined: risk factors for entering state care such as maternal characteristics  
354 and neonatal health<sup>19, 20</sup> and prior hospitalisation for injuries<sup>21</sup>; outcomes of children in care  
355 such as use of emergency/unscheduled health care<sup>22</sup>, self harm and suicide<sup>23</sup>, and overall  
356 mortality<sup>24</sup>; and secular trends in child maltreatment<sup>25</sup>. Studies linking to data from other  
357 sectors have examined wider social outcomes for children in state care, in particular  
358 educational attainment<sup>26, 27</sup>. Published linkage studies generally come from Australia, North



359 America, or Scandinavia and include a sub-national sample and/or lack non-looked after  
360 controls. We are not aware of any previous published linkage studies that provide whole  
361 population data on looked after and non-looked after children at national level.

362

363 Within the wider public health literature there is increasing recognition of the potential for  
364 incomplete or inaccurate data linkage to introduce considerable bias into studies<sup>28-30</sup> and  
365 reporting guidelines for data linkage studies have been suggested<sup>31, 32</sup>. To date, however,  
366 studies reporting linked analyses of looked after children data generally provide minimal  
367 information on the linkage process or the quality of linkage achieved, and no discussion of  
368 potential bias that may be introduced through differential linkage rates for different groups,  
369 focusing instead on reporting the results of linked analyses.

## 370 **Conclusions and recommendations**

371 We have shown that it is possible using currently available routine looked after and education  
372 data to categorise children in publicly funded schools in Scotland into currently, previously,  
373 and non-looked after groups. Some under-ascertainment of looked after groups occurs, with  
374 some (particularly previously) looked after children misclassified as non-looked after.

375 Children categorised to looked after and non-looked after groups can be linked to their  
376 Community Health Index numbers (and hence to all routinely collected health data) with very  
377 high completeness and accuracy. We demonstrate some variation in linkage quality by  
378 factors such as local authority area and the complexity of children's looked after journeys.

379

380 Overall our results suggest that linkage of currently available routine looked after, education,  
381 and health data is feasible and likely to provide linked data fit for epidemiological research  
382 purposes. We would caution that researchers working with linked data should always

383 scrutinise the quality of the underlying linkage and consider the extent to which bias  
384 introduced through the linkage process may exaggerate or minimise findings, particularly  
385 when making comparisons across subgroups. In general however, the health outcomes of  
386 looked after children are much poorer than those of non-looked after children hence  
387 differences are likely to be readily evident. This was demonstrated in our follow on analysis  
388 which showed much poorer dental health for looked after compared to non-looked after  
389 children, including after accounting for age, sex and deprivation differences.

390

391 Improvement to the completeness and accuracy of recording of the Scottish Candidate  
392 Number on looked after returns would improve the classification of children in the pupil  
393 census as currently, previously, and non-looked after. Due to the limited personal identifiers  
394 available on looked after records, it is not currently possible to link looked after data directly  
395 to the Community Health Index: the intermediate step of the pupil census is required. This  
396 means that it is currently not possible to link looked after records for preschool children,  
397 those who have left school, or those in non publicly funded schools to the children's health  
398 data. Expanding the identifiers included on looked after returns to allow direct linkage to the  
399 CHI database, or indeed inclusion of a unique 'citizen number' on routine administrative data  
400 from all sectors, would present further opportunities to explore the health and healthcare of  
401 these groups, although any such developments would need to carefully balance the benefits of  
402 enhanced analysis opportunities against potential privacy risk<sup>33</sup>.

403

404 Overall this novel linkage presents opportunities to develop further research on the health and  
405 healthcare of school aged looked after children compared to their peers, enabling scrutiny of  
406 whether recent policy and practice developments are resulting in discernible improvements  
407 and reduced inequalities. Researchers wishing to access linked routine health and looked

408 after data should contact the NHS Scotland Information Services Division research support  
409 service in the first instance<sup>34</sup>.

## 410 **Declarations**

### 411 **Ethics approval**

412 Approval for this study was obtained from the Scottish Government Education Analytical  
413 Services Division Data Access Panel and the NHS Privacy Advisory Committee (now the  
414 Public Benefit and Privacy Panel). The approval processes involved completion of a privacy  
415 impact assessment, a data sharing agreement between the Scottish Government and the  
416 University of Glasgow, and a data processing agreement between the University of Glasgow  
417 and the NHS Information Services Division. Ethical approval was obtained from the  
418 University of Glasgow College of Medicine, Veterinary, and Life Sciences Ethics  
419 Committee: NHS ethical approval was not required.

### 420 **Consent for publication**

421 Not applicable.

### 422 **Availability of data and materials**

423 The Pupil Census and Children Looked After Survey (CLAS) datasets are held by the  
424 Education Analytical Services Directorate within the Scottish Government. Information on  
425 how to request permission to access these datasets for research purposes is described here:

426 <http://www.gov.scot/Topics/Statistics/Browse/School-Education/DataAccess>.

427 An analysis copy of the Community Health Index (CHI) database is held by NHS National  
428 Services Scotland Information Services Division (ISD). How to request permission to access  
429 the stand alone CHI dataset (or linked health, education, and children's social work data) is  
430 described here <http://www.isdscotland.org/Products-and-Services/eDRIS/>.

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435 **Authors' contributions**

436 DC provided CHI data and conducted the linkage and statistical tests. AK provided pupil  
437 census and looked after data and contributed to conducting the linkage. KS led on securing  
438 governance permissions. RW wrote the manuscript. All authors contributed to study design  
439 and reviewing the manuscript. All authors approved the final submission.

440 **Competing interests**

441 No authors have any competing interest to declare.

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444 project steering group.

445 **List of abbreviations**

446 CHI: Community Health Index

447 CLAS: Children Looked After Survey

448 ISD: NHS National Services Scotland Information Services Division

449 LA: Local Authority

450 NHS: National Health Service

451 SCN: Scottish Candidate Number

452 SIMD: Scottish Index of Multiple Deprivation

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556 **Panel**

557 **Panel 1: Databases used in the linkage**

558 **Figures**

559 **Figure 1: Description of linkage process**

560

561 Legend for Figure 1

562 SCN – Scottish Candidate Number

563 CHI – Community Health Index

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565 **Tables**

**Table 1: Quality of recording of Scottish Candidate Number on looked after children data**

	Looked after returns for 2011/12 for school aged children*				
	Total	Containing any SCN		Containing a valid SCN	
	Number (%)	Number	%	Number	%
<b>All school aged looked after children</b>					
Total	16,859 (100%)	13,357	79.2	11,182	66.3
<b>Age group at start of school year</b>					
4-11	8,592 (51%)	6,510	75.8	5,462	63.6
12-15	6,119 (36%)	5,149	84.1	4,320	70.6
16-19	2,148 (13%)	1,698	79.1	1,400	65.2
<b>Gender</b>					
Male	9,128 (54%)	7,224	79.1	6,066	66.5
Female	7,731 (46%)	6,133	79.3	5,116	66.2
<b>Local authority area responsible for child</b>					
Aberdeen City	641 (4%)	626	97.7	567	88.5
Aberdeenshire	541 (3%)	496	91.7	455	84.1
Angus	291 (2%)	283	97.3	258	88.7
Argyll & Bute	241 (1%)	227	94.2	208	86.3
Clackmannanshire	206 (1%)	193	93.7	177	85.9
Dumfries & Galloway	456 (3%)	94	20.6	83	18.2
Dundee City	723 (4%)	660	91.3	602	83.3
East Ayrshire	495 (3%)	408	82.4	352	71.1
East Dunbartonshire	164 (1%)	160	97.6	134	81.7
East Lothian	217 (1%)	214	98.6	194	89.4
East Renfrewshire	192 (1%)	146	76.0	138	71.9
Edinburgh, City of	1,381 (8%)	1,235	89.4	1,104	79.9
Falkirk	458 (3%)	421	91.9	377	82.3
Fife	842 (5%)	634	75.3	557	66.2
Glasgow City	3,694 (22%)	1,961	53.1	950	25.7
Highland	563 (3%)	496	88.1	451	80.1
Inverclyde	349 (2%)	314	90.0	281	80.5
Island Councils	124 (1%)	119	96.0	108	87.1
Midlothian	294 (2%)	280	95.2	244	83.0
Moray	227 (1%)	178	78.4	154	67.8
North Ayrshire	575 (3%)	427	74.3	386	67.1
North Lanarkshire	810 (5%)	756	93.3	684	84.4
Perth & Kinross	232 (1%)	219	94.4	201	86.6

Renfrewshire	784 (5%)	755	96.3	673	85.8
Scottish Borders	212 (1%)	198	93.4	179	84.4
South Ayrshire	371 (2%)	364	98.1	324	87.3
South Lanarkshire	643 (4%)	395	61.4	358	55.7
Stirling	274 (2%)	261	95.3	234	85.4
West Dunbartonshire	416 (2%)	411	98.8	373	89.7
West Lothian	443 (3%)	426	96.2	376	84.9

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\*School aged children defined as 5-20 years inclusive at the end of the period covered by the looked after return (July 2012) hence assumed to be 4-19 years inclusive at the start of the school year covered (August 2011 to July 2012)  
Island Councils comprise Orkney Islands, Shetland Islands, and Na h-Eileanan Siar

571 **Table 2: Linkage rate to CHI database for currently, previously, and non-looked after children in 2011/12 pupil census**

	Currently looked after				Previously looked after				Non-looked after			All children		
	In pupil census	Linked to CHI			In pupil census	Linked to CHI			In pupil census	Linked to CHI		In pupil census	Linked to CHI	
	N (%)	N	%	Difference (95% CI)*	N (%)	N	%	Difference (95% CI)*	N (%)	N	%	N (%)	N	%
<b>All children in pupil census</b>														
Total	10,009 (100%)	9,409	94.0	-1.1 (-1.5, -0.6)	1,757 (100%)	1,674	95.3	0.2 (-0.8, 1.2)	659,186 (100%)	626,732	95.1	670,952 (100%)	637,815	95.1
<b>Age group at start of school year</b>														
4-11	4,399 (44%)	4,121	93.7	-0.8 (-1.5, -0.1)	924 (53%)	868	93.9	-0.5 (-2.1, 1.0)	384,674 (58%)	363,475	94.5	389,997 (58%)	368,464	94.5
12-15	5,235 (52%)	4,930	94.2	-1.7 (-2.4, -1.1)	731 (42%)	708	96.9	0.9 (-0.3, 2.2)	216,430 (33%)	207,596	95.9	222,396 (33%)	213,234	95.9
16-19	375 (4%)	358	95.5	-0.4 (-2.6, 1.7)	102 (6%)	98	96.1	0.2 (-3.6, 3.9)	58,027 (9%)	55,651	95.9	58,504 (9%)	56,107	95.9
<b>Gender</b>														
Male	5,319 (53%)	5,018	94.3	-0.7 (-1.3, -0.1)	931 (53%)	886	95.2	0.1 (-1.2, 1.5)	335,665 (51%)	319,004	95.0	341,915 (51%)	324,908	95.0
Female	4,690 (47%)	4,391	93.6	-1.5 (-2.2, -0.8)	826 (47%)	788	95.4	0.3 (-1.1, 1.7)	323,521 (49%)	307,728	95.1	329,037 (49%)	312,907	95.1
<b>SIMD deprivation quintile</b>														
1 (most deprived)	4,224 (42%)	3,947	93.4	-1.2 (-1.9, -0.4)	684 (39%)	641	93.7	-0.9 (-2.7, 0.9)	137,865 (21%)	130,450	94.6	142,773 (21%)	135,038	94.6
2	2,247 (22%)	2,131	94.8	-0.3 (-1.3, 0.6)	514 (29%)	499	97.1	1.9 (0.5, 3.4)	125,022 (19%)	118,979	95.2	127,783 (19%)	121,609	95.2
3	1,606 (16%)	1,517	94.5	-0.8 (-1.9, 0.3)	297 (17%)	283	95.3	0.0 (-2.4, 2.4)	129,743 (20%)	123,592	95.3	131,646 (20%)	125,392	95.2
4	1,225 (12%)	1,152	94.0	-1.3 (-2.6, 0.0)	159 (9%)	152	95.6	0.3 (-2.9, 3.5)	136,508 (21%)	130,144	95.3	137,892 (21%)	131,448	95.3
5 (least deprived)	620 (6%)	596	96.1	0.3 (-1.2, 1.8)	93 (5%)	89	95.7	-0.1 (-4.2, 4.0)	127,032 (19%)	121,713	95.8	127,745 (19%)	122,398	95.8

Ethnicity														
White British	9,422 (94%)	8,861	94.0	-1.3 (-1.8, -0.8)	1,676 (95%)	1,595	95.2	-0.2 (-1.2, 0.9)	592,412 (90%)	564,718	95.3	603,510 (90%)	575,174	95.3
Other	587 (6%)	548	93.4	0.5 (-1.5, 2.5)	81 (5%)	79	97.5	4.7 (1.3, 8.0)	66,774 (10%)	62,014	92.9	67,442 (10%)	62,641	92.9
Local authority area of school														
Aberdeen City	372 (4%)	355	95.4	0.0 (-2.1, 2.2)	84 (5%)	82	97.6	2.2 (-1.0, 5.5)	20,975 (3%)	20,009	95.4	21,431 (3%)	20,446	95.4
Aberdeenshire	427 (4%)	400	93.7	-2.1 (-4.4, 0.2)	75 (4%)	72	96.0	0.2 (-4.2, 4.7)	33,508 (5%)	32,095	95.8	34,010 (5%)	32,567	95.8
Angus	212 (2%)	205	96.7	0.5 (-1.9, 2.9)	28 (2%)	28	100.0	3.8 (3.5, 4.1)	14,998 (2%)	14,427	96.2	15,238 (2%)	14,660	96.2
Argyll & Bute	183 (2%)	168	91.8	-2.3 (-6.3, 1.7)	18 (1%)	18	100.0	5.9 (5.4, 6.3)	10,878 (2%)	10,238	94.1	11,079 (2%)	10,424	94.1
Clackmannanshire	154 (2%)	146	94.8	-0.6 (-4.1, 3.0)	19 (1%)	16	84.2	-11.2 (-27.6, 5.2)	6,461 (1%)	6,163	95.4	6,634 (1%)	6,325	95.3
Dumfries & Galloway	164 (2%)	156	95.1	-1.2 (-4.5, 2.1)	108 (6%)	97	89.8	-6.5 (-12.2, -0.8)	19,087 (3%)	18,385	96.3	19,359 (3%)	18,638	96.3
Dundee City	415 (4%)	397	95.7	-0.6 (-2.6, 1.4)	141 (8%)	134	95.0	-1.2 (-4.8, 2.4)	16,759 (3%)	16,133	96.3	17,315 (3%)	16,664	96.2
East Ayrshire	314 (3%)	289	92.0	-3.5 (-6.5, -0.5)	44 (3%)	43	97.7	2.2 (-2.2, 6.6)	15,768 (2%)	15,060	95.5	16,126 (2%)	15,392	95.4
East Dunbartonshire	94 (1%)	84	89.4	-5.9 (-12.1, 0.4)	20 (1%)	20	100.0	4.8 (4.4, 5.1)	15,758 (2%)	15,005	95.2	15,872 (2%)	15,109	95.2
East Lothian	148 (1%)	141	95.3	-0.9 (-4.3, 2.6)	39 (2%)	38	97.4	1.3 (-3.7, 6.3)	13,173 (2%)	12,662	96.1	13,360 (2%)	12,841	96.1
East Renfrewshire	102 (1%)	100	98.0	3.6 (0.9, 6.3)	16 (1%)	15	93.8	-0.7 (-12.6, 11.2)	16,075 (2%)	15,182	94.4	16,193 (2%)	15,297	94.5

Edinburgh, City of	795 (8%)	750	94.3	-1.2 (-2.8, 0.4)	131 (7%)	127	96.9	1.4 (-1.5, 4.4)	43,533 (7%)	41,578	95.5	44,459 (7%)	42,455	95.5
Falkirk	364 (4%)	346	95.1	-1.2 (-3.4, 1.0)	66 (4%)	63	95.5	-0.8 (-5.8, 4.2)	20,308 (3%)	19,548	96.3	20,738 (3%)	19,957	96.2
Fife	621 (6%)	580	93.4	-2.2 (-4.1, -0.2)	222 (13%)	215	96.8	1.3 (-1.0, 3.6)	46,983 (7%)	44,906	95.6	47,826 (7%)	45,701	95.6
Glasgow City	1,479 (15%)	1,364	92.2	-0.8 (-2.2, 0.6)	38 (2%)	37	97.4	4.4 (-0.7, 9.4)	64,284 (10%)	59,794	93.0	65,801 (10%)	61,195	93.0
Highland	365 (4%)	343	94.0	-0.9 (-3.4, 1.5)	100 (6%)	93	93.0	-1.9 (-6.9, 3.1)	30,640 (5%)	29,072	94.9	31,105 (5%)	29,508	94.9
Inverclyde	235 (2%)	220	93.6	-0.3 (-3.4, 2.9)	34 (2%)	30	88.2	-5.7 (-16.5, 5.2)	10,060 (2%)	9,446	93.9	10,329 (2%)	9,696	93.9
Island Councils	84 (1%)	83	98.8	4.1 (1.7, 6.5)	12 (1%)	11	91.7	-3.1 (-18.7, 12.6)	9,430 (1%)	8,932	94.7	9,526 (1%)	9,026	94.8
Midlothian	210 (2%)	200	95.2	-0.2 (-3.1, 2.7)	67 (4%)	65	97.0	1.6 (-2.5, 5.7)	11,387 (2%)	10,864	95.4	11,664 (2%)	11,129	95.4
Moray	145 (1%)	139	95.9	0.3 (-3.0, 3.5)	22 (1%)	20	90.9	-4.7 (-16.7, 7.3)	11,759 (2%)	11,240	95.6	11,926 (2%)	11,399	95.6
North Ayrshire	321 (3%)	300	93.5	-1.8 (-4.5, 0.9)	64 (4%)	59	92.2	-3.0 (-9.6, 3.5)	18,182 (3%)	17,315	95.2	18,567 (3%)	17,674	95.2
North Lanarkshire	599 (6%)	565	94.3	-0.6 (-2.4, 1.3)	59 (3%)	54	91.5	-3.4 (-10.5, 3.7)	48,002 (7%)	45,550	94.9	48,660 (7%)	46,169	94.9
Perth & Kinross	168 (2%)	155	92.3	-3.2 (-7.3, 0.8)	19 (1%)	19	100.0	4.5 (4.2, 4.8)	17,258 (3%)	16,479	95.5	17,445 (3%)	16,653	95.5
Renfrewshire	469 (5%)	442	94.2	-0.9 (-3.0, 1.3)	52 (3%)	51	98.1	3.0 (-0.8, 6.7)	22,957 (3%)	21,832	95.1	23,478 (3%)	22,325	95.1
Scottish Borders	154	142	92.2	-3.3	17	15	88.2	-7.3	14,748	14,088	95.5	14,919	14,245	95.5

	(2%)			(-7.6, 0.9)	(1%)			(-22.6, 8.0)	(2%)			(2%)		
South Ayrshire	243 (2%)	232	95.5	0.2 (-2.4, 2.9)	37 (2%)	36	97.3	2.0 (-3.2, 7.3)	14,024 (2%)	13,359	95.3	14,304 (2%)	13,627	95.3
South Lanarkshire	409 (4%)	380	92.9	-1.7 (-4.2, 0.8)	71 (4%)	70	98.6	4.0 (1.2, 6.7)	42,585 (6%)	40,291	94.6	43,065 (6%)	40,741	94.6
Stirling	188 (2%)	178	94.7	-0.7 (-3.9, 2.5)	31 (2%)	31	100.0	4.6 (4.3, 5.0)	12,200 (2%)	11,634	95.4	12,419 (2%)	11,843	95.4
West Dunbartonshire	228 (2%)	218	95.6	1.4 (-1.3, 4.1)	57 (3%)	56	98.2	4.0 (0.6, 7.5)	12,008 (2%)	11,314	94.2	12,293 (2%)	11,588	94.3
West Lothian	347 (3%)	331	95.4	0.4 (-1.8, 2.6)	66 (4%)	59	89.4	-5.6 (-13.1, 1.8)	25,398 (4%)	24,131	95.0	25,811 (4%)	24,521	95.0

\* Difference between linkage rate for currently/previously looked after children and that for non-looked after children with 95% confidence interval  
SIMD is Scottish Index of Multiple Deprivation

Island Councils comprise Orkney Islands, Shetland Islands, and Na h-Eileanan Siar

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**Table 3: Linkage rate to CHI database for currently looked after children by characteristics of looked after care**

	Currently looked after			
	In pupil census	Linked to CHI		
	N (%)	N	%	Difference (95% CI)*
<b>All currently looked after children in pupil census</b>				
Total	10,009 (100%)	9,409	94.0	n/a
<b>Number of looked after placements since August 2007</b>				
1	6,049 (60%)	5,715	94.5	reference
2	1,762 (18%)	1,654	93.9	-0.6 (-1.9, 0.7)
3	1,052 (11%)	978	93.0	-1.5 (-3.2, 0.1)
4+	1,146 (11%)	1,062	92.7	-1.8 (-3.4, -0.2)
<b>Type of most recent placement</b>				
Looked After at home	4,285 (43%)	4,042	94.3	reference
Kinship care	2,196 (22%)	2,064	94.0	-0.3 (-1.6, 0.9)
Foster carers/other community	2,650 (26%)	2,507	94.6	0.3 (-0.8, 1.4)
Residential accommodation	878 (9%)	796	90.7	-3.7 (-5.7, -1.6)
<b>Legal reason underpinning most recent looked after episode</b>				
Compulsory supervision through the Children's Hearing system (resident at home)	3,961 (40%)	3,732	94.2	reference
Accommodated away from home on a voluntary basis	914 (9%)	850	93.0	-1.2 (-3.0, 0.6)
Compulsory supervision through the Children's Hearing system (resident away from home)	3,415 (34%)	3,216	94.2	0.0 (-1.1, 1.0)
Emergency court order	189 (2%)	169	89.4	-4.8 (-9.2, -0.4)
Permanence order or awaiting adoption	675 (7%)	650	96.3	2.1 (0.5, 3.7)
Other/unknown	855 (9%)	792	92.6	-1.6 (-3.5, 0.3)

\* Difference between linkage rate for particular category and the relevant reference category with 95% confidence interval

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### *Children Looked After Survey (CLAS) annual return: 'looked after data'*

Since 2007/08, all 32 Scottish local authorities have been required to submit individual level data on looked after children to the Scottish Government<sup>35</sup>. An annual return is made in November each year, providing information on all children looked after by the local authority at any point over the preceding school year (August to July).

Limited personal identifiers are included in the looked after returns, specifically the child's date of birth, gender, ethnicity, their social work number (specific to that local authority only), and, if available, their Scottish Candidate Number (see below). Children's names and home postcodes are not included.

Basic information on all episodes of looked after care provided by the local authority to the child (from birth) is also included, for example the start and end dates, legal reason, and type (e.g. at home, kinship care, foster care, etc.) of each placement.

### *Pupil census annual return: 'pupil census'*

Since 2006/07, all 32 Scottish local authorities have been required to submit individual level data on children attending publicly funded schools to the Scottish Government<sup>36</sup>. An annual return is made in October each year, providing information on children in school at the start of that school year (census date mid September). Publicly funded schools comprise mainstream and special schools funded by the state and managed by local authorities. Children who are home schooled or attending an independent or charitable day or residential school or secure unit will not be included in the pupil census, even if their school place is being funded by their local authority. A wider range of personal identifiers is included in the pupil census return, specifically the child's date of birth, gender, home postcode, ethnicity, and their Scottish Candidate Number (SCN). Pupil names are not included. The SCN is the unique pupil identifier used across Scotland. Pupils are assigned an SCN when they join a publicly funded school (typically at age 4/5 years) and/or are registered to undertake assessments administered by the Scottish Qualifications Authority. The SCN is recorded on all national level education datasets held by the Scottish Government, for example those on pupil attendance, exclusions, attainment, and post school destination.

Basic information on the education of each child is included in the pupil census, for example the school and school year attended and any recognised additional educational support needs.

### *Community Health Index (CHI) database: 'CHI database'/'health data'*

The CHI database is NHS Scotland's master patient index<sup>37, 38</sup>. It was introduced in one area of Scotland in the 1970s and has had national coverage since 1997. It covers all patients registered with a General Practitioner and others provided with care from NHS Scotland, for example individuals attending emergency services.

Full personal identifiers are included in the database, specifically patient full name, date of birth, gender, home postcode and their CHI number. The database is 'live' and updated as required by authorised staff. The NHS Information Services Division (ISD) receives a monthly snapshot download of the database for statistical and data linkage purposes. The CHI number is the unique patient identifier used in NHS Scotland. The CHI number is held on all national level health datasets held by ISD, for example those on hospital admission, Accident & Emergency department and outpatient attendance, community prescriptions, and child health reviews and vaccinations.

Very limited information on health care is included in the CHI database, for example the patient's registered General Practice.

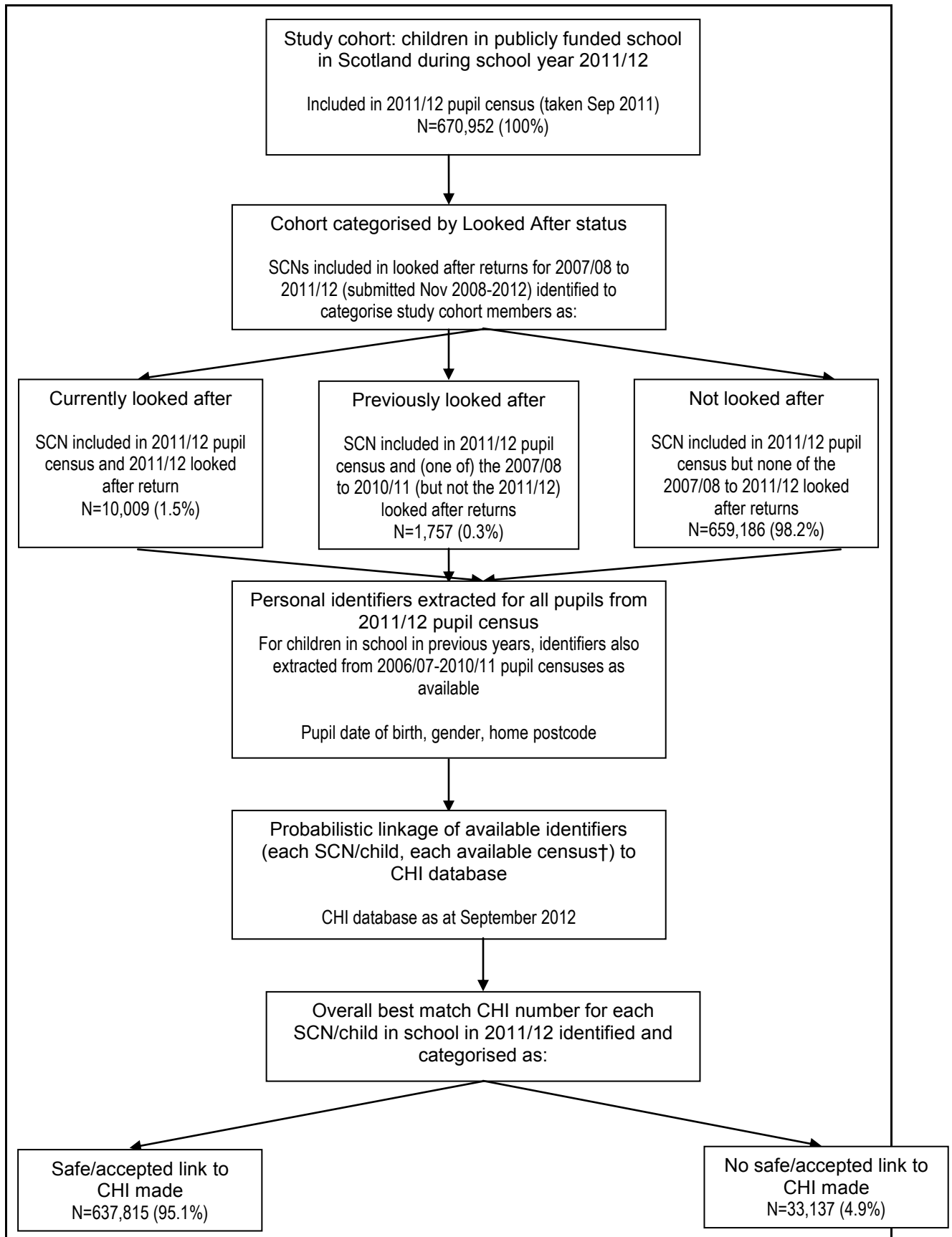
### *Data quality*

For each of the databases, validation is built into the data recording/submission process.

For the looked after and pupil census returns, additional data quality assurance is undertaken by the Scottish Government and local authorities are required to confirm the validity of returns.

627 **Figure 1**

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687 **Supplementary material**

688 We used standard probabilistic record linkage methods to link pupil census records to the  
689 CHI database<sup>39</sup>. The algorithms and decision rules used are used by NHS Information  
690 Services Division (ISD) for routine linkage of health records<sup>40, 41</sup> and have previously been  
691 extended to link education and health records<sup>16, 42</sup>. The algorithms return a suggested overall  
692 ‘best match’ CHI number for each SCN/child within the pupil census and assign each best  
693 match CHI number to a predetermined match category based on: (a) the closeness of match  
694 between each of the personal identifiers held on the pupil census and the CHI database for the  
695 respective SCN and CHI numbers and, (b) how closely the ‘next best match’ CHI number  
696 suggested for a particular SCN rivals the ‘best match’. Best match CHI numbers assigned to  
697 certain pre-specified match categories were accepted as safe links for the relevant SCNs.  
698 Best match CHI numbers assigned to other match categories were rejected and the relevant  
699 SCNs were considered not to link to a CHI number (see Supplementary table 1).

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701 As shown in Figure 1, we had personal identifiers (date of birth, sex, and home postcode) for  
702 all children in the 2011/12 pupil census and this group formed our study population. In  
703 addition, we also received pupil census records for each of the previous five years (2006/07  
704 to 2010/11) each containing the personal identifiers for each child/SCN at the time of that  
705 census. Therefore, pupils who were older could have up to six sets of identifiers (including,  
706 for example, up to six home postcodes) associated with their SCN for linkage to the CHI.  
707 Different postcodes included in the census for a particular child in different years could  
708 reflect genuine change (i.e. the child had moved house during the year) or data error (i.e. one  
709 or other of the recorded postcodes was erroneous).

710

711 The CHI database snapshot, taken for linkage to the pupil census records in September 2012,  
712 contained for every person in the database at least their current home postcode as recorded at  
713 their GP Practice as well as their last previous known postcode. In some instances, for  
714 example where a patient had moved NHS Board boundaries within Scotland, additional CHI  
715 records for that person would capture further postcodes, which were also available for  
716 linkage.

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718 Each set of pupil census identifiers for each SCN/child was linked to the CHI database as at  
719 Sep 2012 to generate up to six 'best match' CHI numbers for each child. The postcode  
720 recorded within any census record could match to any of the postcodes available within a  
721 CHI record. The overall best match CHI for each SCN/child was then taken as that with the  
722 highest overall match category. In case of ties, the best match CHI from the most recent  
723 census year was taken as the overall best match for that child.

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725 Making use of all available identifiers, in particular multiple postcodes, in this way provides  
726 an opportunity to overcome administrative mismatches between the pupil census and CHI  
727 database. For example, if a GP practice was unaware that a child had moved house, a match  
728 may be made between the postcode held on a previous pupil census to that on the CHI  
729 database. This flexibility may be particularly important for looked after children who have  
730 high residential mobility and multiple possible 'home' addresses.

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732 Since the linkage for this study was carried out, ISD has made additional enhancements to the  
733 processes used when linking education and health records. For example, ISD can now  
734 capture patients' full postcode histories from the CHI database (see

735 <http://www.isdscotland.org/Products-and-Services/eDRIS/Docs/20150421-Linking-ScotXed->

736 [Data.pdf](#)). Further developments are underway involving linkage to the national indexing  
737 spine and establishment of 'read-through' indexes to allow more efficient regular linkage of  
738 education and health records.

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**Supplementary table 1: Linkage of pupil census records to CHI database: detailed results**

Match category	Best match CHI for a particular SCN: match between personal identifiers held on pupil census and CHI database			Best match CHI compared to next best match CHI for a particular SCN	Best match CHI considered a safe/acceptable link for the SCN?	Number of children in 2011/12 pupil census in this category
	Date of birth	Gender	Postcode			
A	Exact	Exact	Exact	Unrivalled	✓	87,259
B	Exact	Exact	Exact	Distant rival	✓	482,325
C	Exact	Exact	Exact	Intermediate rival	✓	53,024
D	Exact	Exact	Exact	Close rival	✓	6,153
E	Exact	Exact	Exact	Tied	✗	12,959
F	Exact	Exact	Close	Unrivalled	✓	1,167
G	Exact	Exact	Close	Rivalled	✓	7,887
H	Exact	Exact	Close	Tied	✗	239
I	Close	Exact	Exact	Unrivalled	✗	332
J	Close	Exact	Exact	Rivalled	✗	1,428
K	Close	Exact	Exact	Tied	✗	26
L	Other combination of close matches/high overall linkage score			Unrivalled	✗	1,239
M	Other – considered a non-match				✗	16,914

Close match on date of birth indicates 2 out of 3 (of DD, MM, YY) agreed; close match on postcode indicates 6 out of 7 characters agreed

Unrivalled means the next best CHI had a much lower linkage score than the best match CHI

Tied means that the next best CHI had the same linkage score as the best match CHI; other categories are intermediate

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