AUDIT, RESEARCH AND GUIDELINE UPDATE

Uptake of neonatal BCG vaccination in England: performance of the current policy recommendations

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ABSTRACT

BCG uptake among infants in England has not been measured since targeted infant vaccination replaced universal schoolchild vaccination in 2005, mainly because of the challenges in defining denominators. We estimated uptake between 2006 and 2008 by dividing number of BCG doses administered to infants by number of all live births (where BCG vaccination is universal) or ethnic minority/Eastern Europeans live births (where infant-BCG vaccination is selective). Weighted average uptake was 68% (95% CI 65% to 71%), slightly higher in primary care trusts with universal (72% (95% CI 64% to 80%)) than selective (66% (95% CI 61% to 70%)) policy; and also 13% higher in areas vaccinating in postnatal wards compared with community settings.

INTRODUCTION

England’s policy since 1953 of universal BCG vaccination of schoolchildren was replaced in 2005 by targeted immunisation of infants at higher risk of disease. Selective immunisation of eligible infants in PCTs with annual tuberculosis (TB) incidence <40/100 000, notably those with family ties to high TB-incidence countries and universal vaccination of all neonates in PCTs with annual TB incidence ≥40/100 000 is recommended. It is essential that the performance of the BCG vaccination programme, like other components of TB control efforts, is continuously and rigorously monitored and evaluated. This is challenging in the current programme because appropriate denominators to measure infant-BCG uptake are not routinely available, especially in areas with selective vaccination.

METHODS

We estimated the 2006–2008, 3-year average infant-BCG uptake in each PCT by dividing the number of BCG doses in children aged ≤1 year by the number of eligible delivered live births (according to local BCG policy). The average national uptake was calculated using each PCT’s eligible population as weights. Live-birth information per PCT was obtained from the Ofﬁce for National Statistics (ONS). We obtained BCG dose numbers from the National Health Service Information Centre (NHS-IC) annual reports, based on PCTs’ returns of immunisation activities (KC50 forms). For PCTs with universal BCG, uptake was in all live births. For PCTs with selective BCG vaccination, the eligible population was live births to parents born in countries joining the European Union (EU) since 2004 and non-EU European countries (mostly former Soviet Union) and to ethnic minority parents.

We also investigated how BCG uptake at PCT-level differed by current (universal or selective) vaccination policy, primary place of vaccine delivery (postnatal ward versus community setting) and provision of infant-BCG since the 1970 to the 1980s. Multiple linear regression was used, weighted by the population eligible for BCG, adjusting for PCT-level age-standardised and sex-standardised TB incidence, and for ONS PCT-level Index of Multiple Deprivation, and proportion of ethnic minority among live births.

Using Stata V12.0 for analyses, means were compared by t test and analysis of variance (ANOVA) as appropriate. Proportions were compared using Fisher’s exact test. Signiﬁcance testing in the regression models was conducted by using ANOVA.

RESULTS

Twenty-eight of 151 (19%) PCTs had data on number of infant-BCG doses that were missing for at least 1 year, between 2006 and 2008, and were excluded from analyses. Their characteristics were not different from the 123 PCTs included (see online supplementary table S1). The 3-year average BCG uptake varied from 5% to 100%, with a weighted average of 68% (95% CI 65% to 71%) across the 123 PCTs. BCG uptake was on average higher in PCTs with universal (72% (95% CI 64% to 80%)) than selective (66% (95% CI 62% to 70%)) vaccination policy (p=0.21) (see table 1). Thirty PCTs (24%) had uptake lower than 50% (respectively 3/17 (18%) with universal and 27/106 (25%) with selective policy).

At univariable analysis, uptake was roughly 11% (95% CI 4% to 18%) higher in areas that offered infant-BCG vaccination since 1980 (p=0.004) and 9% higher (95% CI 2% to 16%; p=0.01) in PCTs that vaccinate primarily on postnatal wards compared with those doing so in community settings. There was also evidence of higher uptake in the most deprived areas (p=0.008) and those with high TB incidence (p=0.001). After controlling for PCT-level TB incidence, deprivation rank and proportion of ethnic minority live births, uptake was 10% (95% CI 2% to 18%; p=0.01) higher in PCTs that provided infant-BCG since the 1970s–1980s than those that did not and 13% (95% CI 6% to 20%; p<0.001) higher in areas immunising primarily in postnatal wards compared with community settings. Results were similar when analyses
were restricted either to PCTs with universal or selective policy, respectively. When adjusting for all factors, uptake was not different between universal and selective policy PCTs (p=0.38) (see online supplementary table S2 for details).

**DISCUSSION**

We present the first estimates of infant-BCG uptake in England since the 2005 change in policy from routine universal BCG vaccination of schoolchildren to infant-BCG. For the past 8 years, no denominator has been readily available for continuous monitoring of uptake.

We used numerator data (BCG doses) from the NHS-IC, which carefully assess the data for validity, including checking of unusual year-on-year variations. We only analysed PCTs that have reported BCG doses every year from 2006 to 2008; but as they are estimates the results should be treated with some caution. The denominators used to calculate uptake were only available for a limited number of years (2005–2008) to assess uptake in areas with a selective policy that included infants born to parents from ethnic minorities and to parents from European countries with annual TB rate >40/100 000 (mostly Eastern Europe and the former Soviet Union); they constitute the main population groups targeted by the infant-BCG programme. Although these data are imperfect, we believe the results provided a fair approximations of infant-BCG uptake in the eligible population, especially given the current paucity of alternative data sources in England. These estimates provide a useful insight in the effectiveness of the delivery of BCG under the current BCG vaccination programme in England.

Targeted infant immunisation is challenging to implement and monitor, in areas where only selected groups are vaccinated. It requires close coordination between antenatal services, which usually identify eligible infants before birth and childhood vaccination services that administer the vaccine after birth. Collaboration between commissioning bodies is also important; coterminal PCTs may have different local policy or delivery systems, yet share areas covered by the same maternity wards. Several European countries have reported drops in BCG vaccination uptake after switching from universal to targeted policy. In Sweden, uptake among eligible infants dropped from over 95% to 2% when universal neonatal BCG was replaced by a targeted programme in 1975.1 Similarly, in France coverage fell from 77% to 58% in 2007.2 This highlights the need to closely monitor BCG uptake.

It could be argued that 68% infant-BCG uptake within 3 years of the policy change reflects fairly successful implementation of the new guidance in most areas in spite of the limited data monitoring. We speculate that experience of infant-BCG may have contributed to the relatively higher uptake in PCTs; BCG uptake was not correlated to routine infant TB control activities around the study period. In the 2009 national tuberculosis survey, 60% (67/112) PCTs reported an increase in the funding of their TB services and 74% (83/112) routinely carried TB health promotion and awareness raising activities.

The average uptake hides the heterogeneity between areas. Our estimate implies roughly one in three infants at high risk for tuberculosis did not receive BCG vaccine over the study period, and one in four PCTs had uptake lower than 50%, including three with universal infant-BCG policy. This does not reflect a wider problem with vaccine delivery services in some PCTs; BCG uptake was not correlated to routine infant

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**Table 1** Three-year average BCG uptake* (2006–2008) and association with Primary Care Trust (PCT)-level characteristics

<table>
<thead>
<tr>
<th>Variables</th>
<th>Average BCG uptake (%)</th>
<th>Unadjusted β coefficient† (95% CI)</th>
<th>p Value</th>
<th>Adjusted β coefficient‡ (95% CI)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current infant BCG policy</td>
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</tr>
<tr>
<td>Selective (n=106)</td>
<td>65.6 (61.6 to 69.5)</td>
<td>—</td>
<td>0.073</td>
<td>0.38</td>
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<tr>
<td>Universal (n=17)</td>
<td>71.6 (63.7 to 79.5)</td>
<td>6 (−0.6 to 12.7)</td>
<td></td>
<td></td>
<td>0.38</td>
</tr>
<tr>
<td>Past infant BCG policy</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>No previous infant BCG (n=53)</td>
<td>60.0 (54.4 to 65.6)</td>
<td>—</td>
<td>0.004</td>
<td>0.013</td>
<td></td>
</tr>
<tr>
<td>Infant BCG since 1980s (n=66)</td>
<td>71.0 (66.7 to 75.1)</td>
<td>10.9 (3.6 to 18.2)</td>
<td></td>
<td></td>
<td>0.013</td>
</tr>
<tr>
<td>Index of multiple deprivation</td>
<td></td>
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</tr>
<tr>
<td>Most deprived (n=40)</td>
<td>73.0 (68.1 to 77.8)</td>
<td>—</td>
<td>0.008</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>Moderately deprived (n=42)</td>
<td>62.5 (56.4 to 68.7)</td>
<td>−10.4 (−17.8 to −3.0)</td>
<td></td>
<td></td>
<td>0.07</td>
</tr>
<tr>
<td>Least deprived (n=41)</td>
<td>62.7 (55.6 to 69.7)</td>
<td>−10.3 (−19.1 to −1.5)</td>
<td></td>
<td></td>
<td>0.07</td>
</tr>
<tr>
<td>Age-and-sex standardised 3-year average annual TB incidence (per 100 000 person-years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>0–19.9 (n=84)</td>
<td>65.2 (61.2 to 69.2)</td>
<td>−2.7 (−10.5 to 5.1)</td>
<td>0.001</td>
<td>0.015</td>
<td></td>
</tr>
<tr>
<td>20–39.9 (n=25)</td>
<td>62.5 (54.0 to 71.0)</td>
<td>−2.7 (−10.5 to 5.1)</td>
<td>0.001</td>
<td>0.015</td>
<td></td>
</tr>
<tr>
<td>40+ (n=14)</td>
<td>76.5 (68.8 to 84.2)</td>
<td>11.3 (3.4 to 19.2)</td>
<td>0.015</td>
<td>0.015</td>
<td></td>
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<tr>
<td>Percentage ethnic minority among 2006–2008 live-births</td>
<td></td>
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<tr>
<td>0–19.9% (n=72)</td>
<td>63.8 (58.2 to 68.8)</td>
<td>−0.9 (−10.0 to 9.1)</td>
<td>0.16</td>
<td>0.87</td>
<td></td>
</tr>
<tr>
<td>20–39.9% (n=25)</td>
<td>64.8 (67.6 to 77.7)</td>
<td>0.9 (−9.3 to 11.2)</td>
<td>0.37</td>
<td>0.37</td>
<td></td>
</tr>
<tr>
<td>40%+ (n=26)</td>
<td>70.9 (64.1 to 77.7)</td>
<td>−0.6 (−6.9 to 7.8)</td>
<td>0.015</td>
<td>0.015</td>
<td></td>
</tr>
<tr>
<td>Primary place of infant BCG vaccination</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community settings (n=48)</td>
<td>63.5 (58.2 to 68.8)</td>
<td>—</td>
<td>0.01</td>
<td>0.0005</td>
<td></td>
</tr>
<tr>
<td>Postnatal ward (n=54)</td>
<td>72.6 (67.6 to 77.6)</td>
<td>1.86 (1.86 to 21.3)</td>
<td>0.12</td>
<td>0.12</td>
<td></td>
</tr>
</tbody>
</table>

*Twenty-eight PCTs excluded because they had missing data for infant-BCG doses at least 1 year over the study period.
†For categorical variables, the β coefficient represents the respective difference between average coverage in each stratum and the baseline category.
‡Adjusted for all other variables in the table.
immunisations in PCTs during the study period (see online supplementary figure S1). PCTs with longer experience of infant-BCG pre-2005 had higher uptake. PCTs vaccinating primarily in postnatal wards also had better uptake than in community settings (mostly clinics). Immunisation of eligible newborns before they leave hospital may be easier than having parents return later on. An audit found that 40% newborns who left hospital without BCG did not attend later appointments. However, the effectiveness of a postnatal strategy will depend on adequate numbers of trained staff in postnatal wards relative to the number of eligible newborns. A study in areas with high number of eligible newborns found that the high staff turnover and brief neonatal stay affected BCG uptake in postnatal wards. ‘Drop-in’ vaccination clinics have been suggested as an alternative to circumvent the issue of low attendance in community settings, and the idea has since been used in several areas. In summary, the organisation of vaccine delivery can affect uptake, and while local circumstances should be taken into account, continuous monitoring is essential in shaping services. The absence of denominators is the main impediment to adequately measure BCG uptake to monitor the BCG vaccination programme in England; the absence of rigorous data of number of vaccine doses given could also improve. As part of his 2004 action plan for stopping tuberculosis in England, The Chief Medical Officer recommended the effective monitoring of BCG immunisation; it is worrying that over 8 years later, this has not yet been implemented. Collection through the Cover of Vaccination Evaluated Rapidly programme of the number of BCG doses administered is under discussion. These efforts should be welcomed by policy makers and supported by commissioners and healthcare providers who have the responsibility to collect and provide accurate information. It is also essential that suitable denominators are collected as part of these efforts, notably in areas with selective infant-BCG vaccination. The monitoring system implemented for the hepatitis B vaccine, which is also only administered to selected groups of infants, could be used as a model. In such a system, for instance, it would be statutory for midwives in areas with selective vaccination policy to flag and notify pregnant women whose newborn will be eligible for BCG, with linkage of information to maternities and the local child health information system. In an era of tuberculosis re-emergence, emergence of multidrug-resistant strains, with tuberculous meningitis and military cases still reported among UK-born children, adequate monitoring of the BCG vaccination programme is critical to ensure its future performances, especially in the context of recent structural changes to the NHS.

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Contributors IA, PM and LR had the initial idea of the study, PND collated data, performed the analysis, interpreted findings and drafted the manuscript, with assistance from PM, DP, IA and LR. All authors contributed to the final manuscript. All authors had full access to all the data (including statistical reports and tables) in the study and take responsibility for the integrity of the data and accuracy of the data analysis. IA is guarantor for the study.

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Provenance and peer review Not commissioned; internally peer reviewed.

REFERENCES


Supplementary material

Additional table 1: Characteristics of PCTs not included in final multiple regression models (because of missing information on at least one variable in the model)

<table>
<thead>
<tr>
<th>Variable</th>
<th>PCTs not in final models (Total=21)</th>
<th>PCT in final models (Total=102)</th>
<th>p-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vaccination policy (%)*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Universal (n = 17)</td>
<td>5%</td>
<td>16%</td>
<td>0.30</td>
</tr>
<tr>
<td>Selective (n=106)</td>
<td>95%</td>
<td>84%</td>
<td></td>
</tr>
<tr>
<td>Index of Multiple Deprivation*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Most deprived (n=40)</td>
<td>38%</td>
<td>32%</td>
<td></td>
</tr>
<tr>
<td>Moderately deprived (n=42)</td>
<td>33%</td>
<td>34%</td>
<td>0.53*</td>
</tr>
<tr>
<td>Least deprived (n=41)</td>
<td>29%</td>
<td>34%</td>
<td></td>
</tr>
<tr>
<td>Age-and-sex standardised 3-year average TB incidence (per 100,000)*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-19.9 (n=84)</td>
<td>86%</td>
<td>65%</td>
<td></td>
</tr>
<tr>
<td>20-39.9 (n=25)</td>
<td>6%</td>
<td>22%</td>
<td>0.23</td>
</tr>
<tr>
<td>&gt;=40 (n=14)</td>
<td>5%</td>
<td>13%</td>
<td></td>
</tr>
</tbody>
</table>

*Column percentages
Supplementary material

Additional table 2: Comparison of mean infant-BCG uptake by primary place of immunisation, stratified by current vaccination policy

<table>
<thead>
<tr>
<th>Current infant BCG policy / Primary place of infant BCG vaccination</th>
<th>Unadjusted beta coefficient (95% CI)</th>
<th>p-value</th>
<th>Adjusted beta coefficient** (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Universal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community settings (n=10)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Postnatal ward (n=6)</td>
<td>1.2 (-17.7 to 20.1)</td>
<td>0.90</td>
<td>14.4 (-12.4 to 41.1)</td>
<td>0.26</td>
</tr>
<tr>
<td>Selective</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community settings (n=38)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Postnatal ward (n=48)</td>
<td>19.5 (11.6 to 27.4)</td>
<td>&lt;0.0001</td>
<td>18.3 (9.3 to 27.3)</td>
<td>&lt;0.0005</td>
</tr>
</tbody>
</table>

**Adjusted for all other variables in the main model: past infant BCG policy, PCT-level index of multiple deprivation, standardised 3-year average TB incidence, and ethnic minority population in the birth cohort.
Supplementary material

Additional figure 1: Scatter plot of average DPT coverage* in infants against BCG uptake between 2006 and 2008 in PCTs included in the study

Scatter plot of DPT coverage against BCG in infants from 2006 to 2008

*Data from NHS Information Center Immunisation statistics annual report

This scatter plot suggests that there is no association between infant-BCG uptake and that of other routine infant vaccines within PCTs. Therefore, low BCG uptake in some PCTs is most likely not due to wider difficulties with infant-vaccines delivery services.