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

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### **Abstract:**

Bacillus Calmette-Guerin (BCG) uptake amongst infants in England has not been measured since targeted infant vaccination replaced universal schoolchildren 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%-71%), slightly higher in PCTs with universal (72% 95%CI=64-80%) than selective (66% 95%CI=61-70%) policy; and also 13% higher in areas vaccinating in postnatal wards compared to community settings.

**Key words:** Bacillus-Calmette-Guerin, BCG, Tuberculosis, Vaccination, Surveillance

## **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 Primary Care Trusts (PCTs) with annual 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  $\geq 40/100,000$  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 three-year average infant-BCG uptake in each PCT by dividing the number of BCG doses in children aged  $\leq 1$  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 ethnic group and PCT of residence was obtained from the Office for National Statistics (ONS). We obtained BCG doses 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 vs. community setting), and provision of infant-BCG since the 1970-1980s. Multiple linear regression was used, weighted by the

population eligible for BCG, adjusting for PCT-level age-and-sex standardised TB incidence, and for ONS PCT-level Index of Multiple Deprivation, and proportion of ethnic minority among live-births.

Using Stata 12.0<sup>®</sup> 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 missing for at least one year between 2006 and 2008, and were excluded from analyses. Their characteristics were not different from the 123 PCTs included (supplementary table 1). The three-year average BCG uptake varied from 5% to 100%, with a weighted average of 68% (95% CI =65%-71%) across the 123 PCTs. BCG uptake was on average higher in PCTs with universal (72%; 95%CI=64%-80%) than selective (65%; 95%CI=62%-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 to those doing so in community settings. There was also evidence of higher uptake in 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 2-18%; p=0.01) higher in PCTs that provided infant-BCG since the 1970-1980s than those that did not, and 13% (95%CI 6-20; p<0.001) higher in areas immunising primarily in postnatal wards compared to community settings. Results were similar when analyses were restricted respectively either to PCTs with universal or selective policies. When

adjusting for all factors, uptake was not different between universal and selective policy PCTs ( $p=0.38$ ) (see supplementary table 2 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 eight years no denominator has been readily available for continuous monitoring of uptake.

We used numerator data (BCG doses) from the NHS Information Centre (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 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; coterminous 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 three 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 pre-2005 in several PCTs contributed to the smooth transition from routine schoolchildren vaccination; this is supported by higher uptake in areas who offered infant-BCG since 1980s. By 1991, 82% (153/186) English health districts already offered some infant-BCG services, although there was much variability on targeted groups[3]. Contributing factors could also include increased awareness and allocation of more resources to 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 of 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 immunisations in PCTs during the study period (supplementary figure 1). 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 [4]. 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[5]. “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 eight years later, this has not yet been implemented. Collection through the Cover of Vaccination Evaluated Rapidly (COVER) 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 multi-drug resistant strains, with tuberculous meningitis and miliary 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.

**Table 1: Three-year average BCG uptake\* (2006-08) and association with PCT-level characteristics**

Variables	Average BCG uptake (%) (95%CI)	Unadjusted beta coefficient** (95% CI)	p-value	Adjusted beta coefficient*** (95% CI)	p-value
<b>Current infant BCG Policy</b>					
Selective (n=106)	65.6 (61.6 to 69.5)	-	0.073	-	0.38
Universal (n=17)	71.6 (63.7 to 79.5)	6 (-0.6 to 12.7)		4.2 (-5.3 to 13.6)	
<b>Past infant BCG policy</b>					
No previous infant BCG (n=53)	60.0 (54.4 to 65.6)	-	0.004	-	0.013
Infant BCG since 1980s (n=66)	71.0 (66.7 to 75.1)	10.9 (3.6 to 18.2)		9.9 (2.1 to 17.6)	
<b>Index of Multiple deprivation</b>					
Most deprived (n=40)	73.0 (68.1 to 77.8)	-	0.008	-	0.07
Moderately deprived (n=42)	62.5 (56.4 to 68.7)	-10.4 (-17.8 to -3.0)		-9.5 (-17.6 to -1.2)	
Least deprived (n=41)	62.7 (55.6 to 69.7)	-10.3 (-19.1 to -1.5)		-2.5 (-15.7 to 10.8)	
<b>Age-and-sex standardised 3-year average annual TB incidence (per 100,000 person-years)</b>					
0 – 19.9 (n=84)	65.2 (61.2 to 69.2)	-	0.001	-	0.015
20-39.9 (n=25)	62.5 (54.0 to 71.0)	-2.7 (-10.5 to 5.1)		-5.6 (-20.9 to 9.8)	
40+ (n=14)	76.5 (68.8 to 84.2)	11.3 (3.4 to 19.2)		7.6 (-10.2 to 25.4)	
<b>Percentage ethnic minority among 2006-2008 live-births</b>					
0-19.9% (n=72)	63.8 (58.2 to 68.8)	-	0.16	-	0.87
20-39.9% (n=25)	64.8 (67.6 to 77.6)	0.9 (-9.3 to 11.2)		-3.7 (-17.6 to 10.2)	
40%+ (n=26)	70.9 (64.1 to 77.7)	7.0 (-1.6 to 15.7)		-3.4 (-21.4 to 14.7)	
<b>Primary place of infant BCG vaccination</b>					
Community settings (n=48)	63.5 (58.2 to 68.8)	-	0.01	-	0.0005
Postnatal ward (n=54)	72.6 (67.6 to 77.6)	9.1 (1.86 to 16.3)		12.9 (5.9 to 20.0)	

\*28 PCTs excluded because they had missing data for infant-BCG doses at least one year over the study period

\*\*For categorical variables, the beta coefficient represents the respective difference between average coverage in each stratum and the baseline category

\*\*\* adjusted for all other variables in the table



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**Competing interest statement:** All authors have completed the Unified Competing Interest form at [www.icmje.org/coi\\_disclosure.pdf](http://www.icmje.org/coi_disclosure.pdf) (available on request from the corresponding author) and declare: no financial relationships with any organisations that might have an interest in the submitted work in the previous three years, no other relationships or activities that could appear to have influenced the submitted work.

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