Coverage of the English National human papillomavirus (HPV) Immunisation Programme among 12 to 17 year-old females by area-level deprivation score, England, 2008 to 2011

A Hughes[1], D Mesher (david.mesher@phe.gov.uk)[1], J White[2], K Soldan[1]
1. Public Health England, HIV and STI Department, London, United Kingdom
2. Public Health England, Immunisation, Hepatitis and Blood Safety Department, London, United Kingdom

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The English national human papillomavirus (HPV) immunisation programme has offered vaccination to girls aged 12 years at the start of each school year since September 2008. A catch-up programme has offered vaccination to girls up to 18 years. Delivery is predominantly school-based, with some general practitioner (GP)-based immunisation. The relationship between HPV immunisation coverage and deprivation (index of multiple deprivation, IMD) was assessed by geographical area (N=151) for each school year offered the HPV vaccine between 2008 to 2011 using the Spearman's rank correlation coefficient, and compared to that for adequate cervical screening of women aged 25 to 49 years. Coverage at age 12 showed no significant association with IMD at the area-level (p=0.12). Within the catch-up years, there was some suggestion of higher deprivation being associated with lower coverage. This was not significant for girls offered immunisation under 16 years (in compulsory education) (p=0.09), but was more marked and statistically significant for older girls (p<0.0001). The proportion of women aged 25 to 49 years with an adequate cervical screen was negatively associated with deprivation (p<0.0001). School-based HPV immunisation delivery appears to be successfully reducing inequalities in cervical cancer control at area-level. However, the catch-up cohorts above the age of compulsory education may face increased inequality. Further investigation is needed into individual-level factors associated with coverage.

Introduction

The human papillomavirus (HPV) immunisation programme was launched in England in September 2008, offering all girls aged 12 years HPV vaccination as part of the routine immunisation schedule. Additionally, a catch-up programme (during 2008–2010) offered vaccination to all girls up to the age of 18 years. The vaccine was offered free of charge for both the routine and catch-up programmes. The routine programme is almost entirely delivered through school-based immunisation sessions. The older, catch-up, girls were offered vaccination through a combination of school-based and general practitioner (GP) immunisation. There was more reliance on GPs in the first year of the catch-up programme for 17 year-old girls, which had originally been planned to start in September 2009 but was implemented sooner following a cost analysis of the programme. This allowed an extra cohort to be offered the vaccine from September 2008 but the acceleration of the catch-up programme meant GPs had a relatively short time to prepare to deliver that part of the programme [1]. Full-time education is compulsory up to 16 years of age in the United Kingdom (UK): a high proportion of girls stay on in full-time education, but attendance decreases with increasing age. High coverage has been achieved across England for HPV immunisation, with coverage nationally of 89% for one dose and 84% for all three doses in the routine programme in 2010/11 and of 66% for all three doses for all routine and catch-up cohorts combined [1].

Coverage within the total eligible population is one important measure of the success of an immunisation programme. HPV vaccination coverage has been reported by many countries around Europe [2,3] and worldwide [4-6] where HPV immunisation has been introduced. The distribution of coverage by sub-groups within the eligible population is also important, especially at lower levels of coverage where less indirect protection from herd-immunity can be expected. Higher or lower coverage in sub-groups that are at higher risk of HPV-related disease should increase or decrease the effectiveness of immunisation programmes respectively, compared to predictions based on expectation of uniform uptake.

A striking negative association between state-level HPV immunisation coverage and cervical cancer mortality and positive association with median household income was reported by Bach et al. using state-level ecological data from 2009, soon after the start of the immunisation programme in the United States (US) [7], with the worrying conclusion that the vaccination coverage was lower in the states which stood to gain the most. A first look at available coverage data in 2009, from the first year of the English programme, showed little evidence of inequality in coverage among 12 year-olds by deprivation of local area (least deprived quintile 86% vs most deprived quintile 83%) and a small correlation among 17 year-olds (53% vs 47%) [8].

Here we present analyses of coverage by geographical area for the first three years of the routine immunisation programme and for all five birth cohorts offered catch-up immunisation at age 14 to 17 years, by an area-level measure of deprivation. For comparison, we also look at the prevalence of adequate cervical screening amongst older females by area-level deprivation.

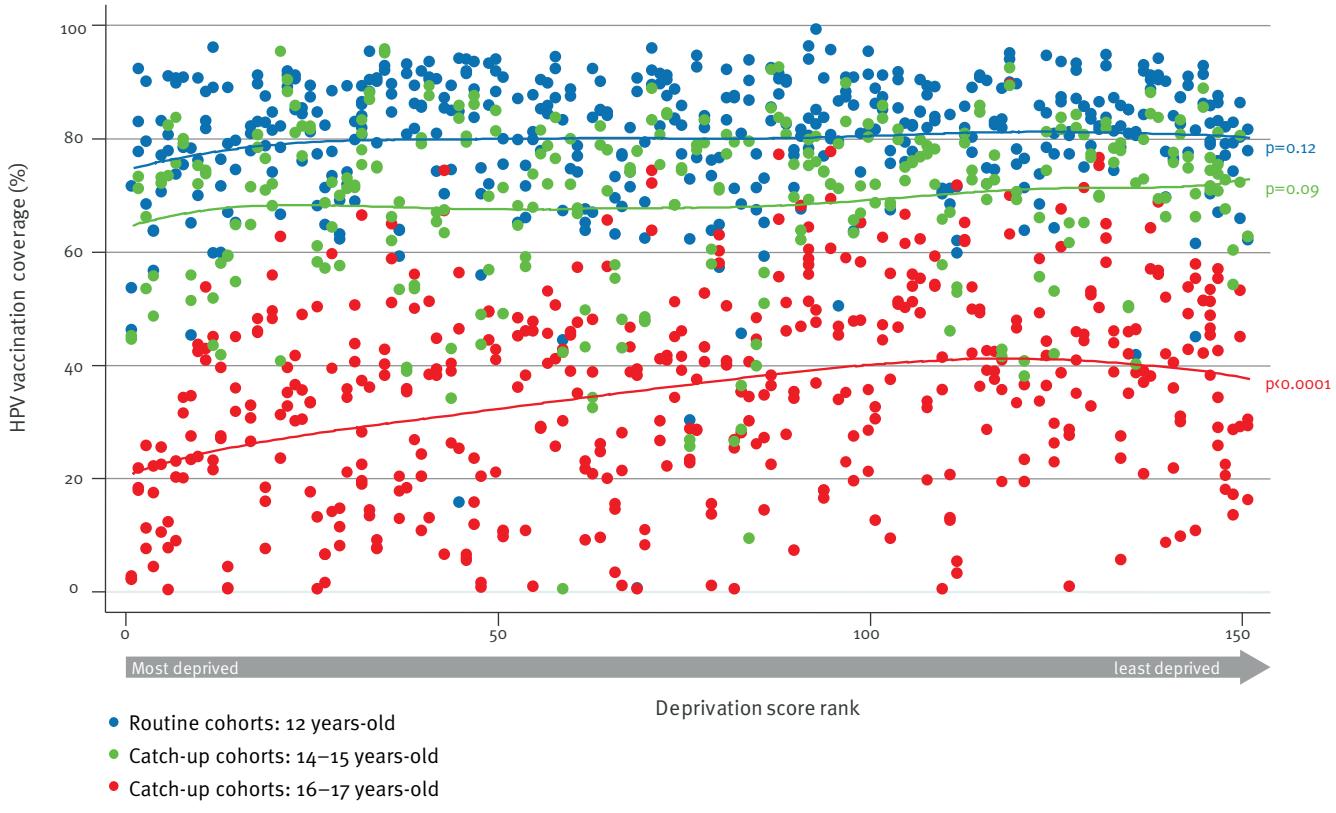
Methods

The routine programme and catch-up programme three-dose coverage data were compiled from the Annual Reports of HPV vaccine coverage for all 151 Primary Care Trusts (PCTs) in England for the years 2008/09 [9], 2009/10 [10] and 2010/11 [1]. The methods of data collection are described in full in these annual reports. In brief, all PCTs completed an annual web-based survey at the end of each academic year, including the total denominator of females eligible for HPV immunisation in their area and the number of females who had received at least one, at least two, or all three doses of vaccine, for each academic birth cohort offered immunisation that year. Additionally, where possible, PCTs provided an update on the vaccination of birth cohorts offered immunisation in previous years, i.e. mop-up vaccination. The latest published data were used, including mop-up immunisation where this had been incorporated at PCT level in subsequent annual reports.

The rank of average index of multiple deprivation (IMD) score for each PCT and was obtained from the English indices of deprivation for 2010 [11]. In brief, the IMD score is constructed for each of 32,482 defined small areas (around 1,500 resident population) in England by combining scores derived largely from routine administrative data for the following seven domains (weighted for importance): income (22.5%), employment (22.5%), health and disability (13.5%), education, skills and training (13.5%), barriers to housing and services

Figure 1

Area-level human papillomavirus (HPV) immunisation coverage (3 doses) by deprivation score rank, England, 2008–2011



P-values calculated using the Spearman's correlation coefficient.

Table

Estimated human papillomavirus vaccination coverage and cervical screening uptake by area groups (n=5) according to level of deprivation, England, 2008–2011

Groups (n=5) of areas according to level of deprivation	Percentage vaccination coverage mean (95% CI)			Percentage cervical screening uptake mean (95% CI)[a] 25–49 year-olds
	Routine cohorts (n=3) 12 year-olds	Catch-up cohorts (n=2) 14–15 year-olds	Catch-up cohorts (n=3) 16–17 year-olds	
Q1 (most deprived)	77.3 (74.7–79.9)	67.9 (64.7–71.2)	26.5 (23.3–29.6)	69.0 (67.8–70.1)
Q2	82.9 (80.2–85.5)	70.8 (67.1–74.5)	33.3 (29.6–37.0)	73.8 (72.4–75.2)
Q3	77.6 (74.7–80.4)	66.3 (61.6–71.1)	35.4 (30.8–40.0)	72.4 (70.4–74.3)
Q4	81.0 (78.9–83.1)	71.9 (69.6–74.2)	43.9 (40.5–47.2)	76.0 (74.6–77.4)
Q5 (least deprived)	80.9 (78.7–83.1)	71.8 (68.7–74.9)	41.7 (38.4–45.0)	76.5 (75.8–77.3)
Total	80.2 (79.1–81.3)	70.2 (68.7–71.7)	37.4 (35.7–39.1)	74.0 (73.2–74.7)
P-value for trend[b]	p=0.211	p=0.074	p<0.001	p<0.001

CI: confidence interval; Q: quintile.
Numbers shown are estimated mean coverage adjusted for the population of each Primary Care Trust with 95% confidence intervals.

[a] Defined as having had an adequate screen within the preceding 3.5 years.
[b] Using Wald test for trend.

(9.3%), crime (9.3%), living environment (9.3%). This measure of deprivation covers a broad range of issues and refers to unmet needs caused by a lack of resources of all kinds, not just financial. The population weighted average of the combined scores for all the small areas in a PCT is then calculated, and ranked. The PCT with an IMD rank of 1 is the most deprived, and 151 the least deprived.

As a measure of uptake of cervical screening by PCT, we took the proportion of women aged 25 to 49 years who had received an adequate test in the last 3.5 years as reported by the National Health Service (NHS) Cervical Screening Programme for 2011 [12].

Three-dose HPV immunisation coverage (i.e. completed courses only) for each academic birth cohort offered HPV immunisation, and the proportion of 25 to 49 year-old women with an adequate cervical smear test in the last 3.5 years, was plotted against rank of average IMD score for each PCT. The association between intervention uptake and IMD was assessed using the Spearman's rank correlation coefficient.

To plot a smoothed line, a locally weighted regression of the three-dose HPV immunisation coverage on rank of average IMD score for each PCT was performed [13]. These smoothed lines were plotted with the data.

The PCTs sorted by rank of average IMD score were split into five equal groups (quintiles). To calculate the estimated vaccination coverage within each quintile we calculated the mean coverage weighted by the population of girls eligible for vaccination in each PCT. The Wald test for trend was used to compare coverage across the ordered quintiles.

For all analyses, the three routine cohorts were grouped and the catch-up cohorts were grouped as follows: the two cohorts offered immunisation when aged 14 to 15 years (age at start of academic year), who would have been in compulsory full time education, and the three cohorts offered immunisation aged ≥16 years, who would have had access to school/college-based immunisation sessions only if choosing to remain in full-time education.

Statistical analyses were performed using Stata version 12.0.

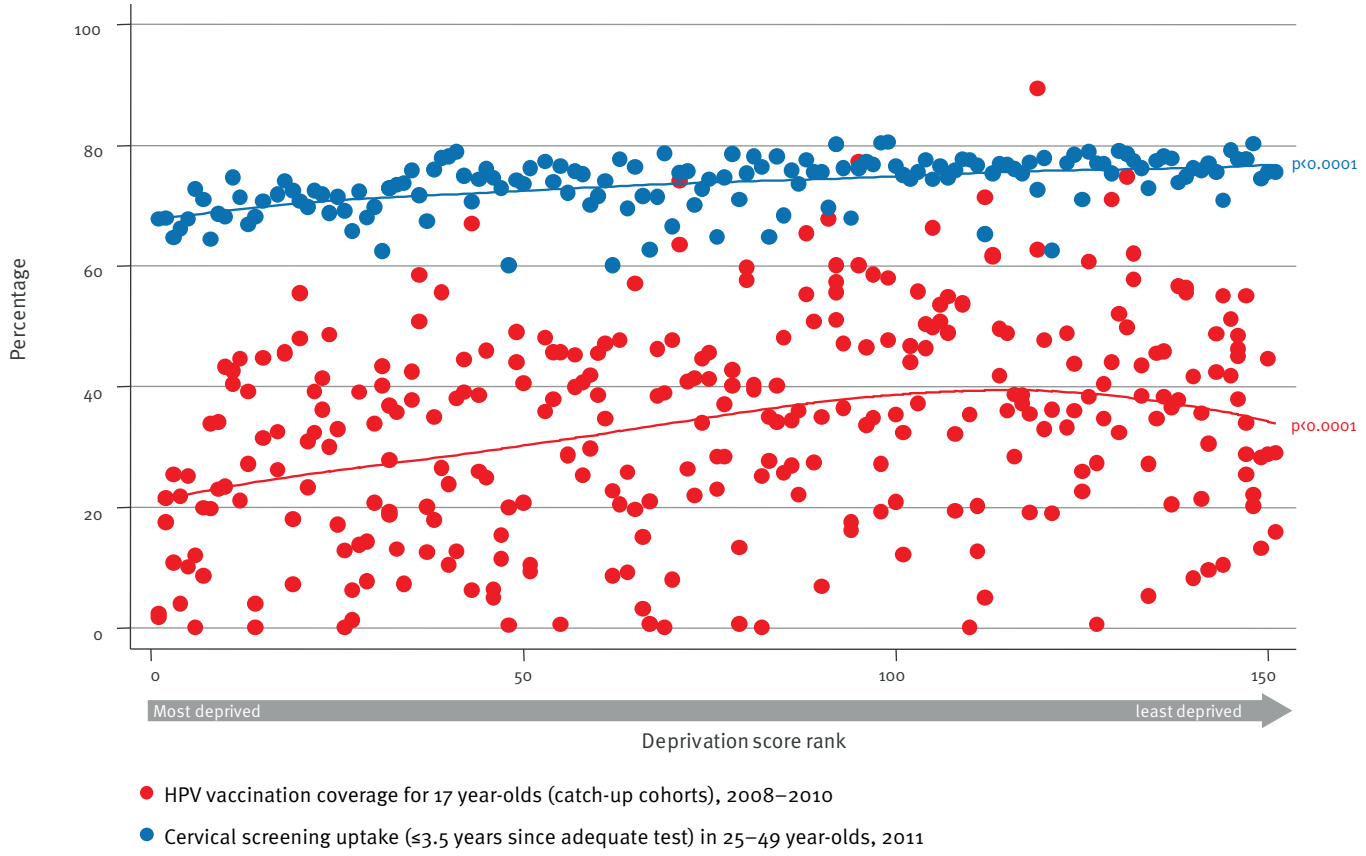
Results

For the routine cohorts, the Spearman's rank correlation coefficient between three-dose HPV immunisation coverage and rank of average IMD by PCT was 0.3094 (p=0.12) (Figure 1), showing that there was no significant correlation between PCT-level HPV immunisation coverage and deprivation. Whilst the HPV immunisation coverage was lowest in the lowest quintile of rank average IMD score, there was no trend towards increasing coverage across the quintiles (Table).

For the catch-up cohorts containing the girls still in compulsory full time education, there was also no significant correlation between HPV immunisation and IMD (Spearman's rank=0.1002, p=0.09) (Figure 1), nor trend by quintile. However, coverage was highest in the two quintiles comprising the least deprived areas (Table). For girls eligible for immunisation at age

Figure 2

Area-level cervical screening uptake (women aged 25–49 years) in 2011 and human papillomavirus (HPV) immunisation coverage (girls aged 17 years) in 2008–2010, by deprivation score rank, England



P-values calculated using the Spearman's correlation coefficient.

16 and over, there was a significant relationship with area-level deprivation (Figure 1, Table), whereby the more deprived areas had lower HPV vaccination coverage (Spearman's rank<0.0001, p<0.0001, p value for trend across quintiles <0.001). In this group there was an increase of vaccination coverage of 57% comparing the most deprived quintile to the least deprived quintile (compared to 5% increase for the younger cohorts).

Figure 2 shows the HPV immunisation coverage for the older catch-up girls (17 years) alongside cervical screening uptake. Cervical screening uptake, as measured by women aged 25 to 49 years with an adequate smear recorded in the last 3.5 years, showed a negative association with rank average IMD score (Spearman's rank=0.5636, p<0.0001, p value for trend across quintiles <0.001) as seen for the older catch-up cohorts for HPV immunisation.

Discussion

Published PCT level data for the first three years of the National HPV immunisation programme in England show little evidence of inequality in three-dose coverage among 12-year-old girls offered routine immunisation, by deprivation of the local area (least deprived quintile of PCTs 81% vs most deprived quintile 77%). Among girls who were aged 16 years and over when offered catch-up HPV immunisation, however, there appears to be a negative association between coverage and deprivation (least deprived quintile of PCTs 42% vs most deprived quintile 27%). The age group in between, who were offered catch-up immunisation under 16 years, is more similar to the younger girls, with only the slightest non-significant difference between least deprived and most deprived quintiles (72% vs 68%). Uptake of cervical screening amongst 25 to 49 year-old women is significantly associated with deprivation at the PCT level. These analyses suggest that inequality in cervical cancer control will be reduced by the routine HPV Immunisation Programme in England, in due course, in contrast to that reported by Bach et al. for the US [7].

There are important limitations to using area-level deprivation measures for studying the association of deprivation and health. The deprivation score for an area will not apply to all of its residents: nor does HPV immunisation coverage or cervical screening uptake. Not every person in a highly deprived area will themselves be deprived. Equally, there will be some

deprived people living in the least deprived areas. The probability of receiving HPV immunisation may be associated with deprivation at the individual level within each PCT, but be undetected as an association at the PCT level. Therefore, whilst our findings are reassuring they do not prove HPV immunisation is being delivered equitably and further analysis of individual-level factors are needed. Nevertheless, area-level inequalities are important in themselves, to the extent that sexual mixing is restrained by area, as the risk of exposure to infection for a given sexual behaviour (dependent in large part on coverage within the sexual network) can modify the risk experienced by any unvaccinated individuals [14].

Other factors not necessarily associated with deprivation may be associated with vaccine coverage and with risk factors for cervical cancer, e.g. religion, education levels and sexual behaviour. A study of young women attending genitourinary medicine clinics in Manchester has shown that unvaccinated girls more often tested positive for chlamydia, had higher alcohol consumption, and were more frequent smokers than vaccinated girls, suggesting that failure to participate in the HPV immunisation programme was a marker for high risk sexual behaviour [15].

The coverage data we used represented all areas of England and was subject to quality checks [1], however, it is likely that not all locally recorded mop-up immunisation was incorporated. It is also possible that data recording was less complete for older girls, who are more likely to have been vaccinated by GPs, and to have moved area during their immunisation schedule. The association we observed for the older catch-up girls could be due either to lower uptake of immunisation or to less complete recording of vaccinations in more deprived areas, or a combination of both.

Hibbitts et al. compared HPV prevalence by social deprivation score amongst women attending for routine cervical screening in South Wales. Although the prevalence of high-risk HPV was highest in the 10% most deprived areas this was not significantly different to other areas [16]. However, pooled analyses have shown an increased risk of cervical cancer associated with lower social deprivation [17]. In our analysis, a negative association between deprivation and HPV immunisation coverage developed with increasing age at immunisation, and became significant around age 16 years, the age when compulsory full-time education ends in England. How much this is due to reduced accessibility when not invited to school-based immunisation sessions (i.e. weakness in delivery systems), or to other factors, such as increased opting out (i.e. behavioural factors) at older ages, is not clear from these data.

Other UK studies have also indicated a negative association between HPV vaccination uptake and deprivation. A study in Manchester, conducted prior to the national programme and therefore possibly affected by different participation biases, found HPV vaccination uptake was significantly lower in more deprived areas [18]. In Wales, individual-level analyses have shown three-dose coverage to decrease with increasing IMD score for area of residence within the catch-up cohorts [19]. Scotland has also showed evidence of decreasing uptake with deprivation in school leavers [20].

The potential effect of unequal coverage by deprivation – if confirmed in the older catch-up cohorts at the individual level – on the aims of the English immunisation programme needs to be explored further. Mathematical modelling of the expected impact of HPV immunisation has assumed, for sake of simplicity and for want of evidence for other assumptions, that coverage is independent of risk factors for HPV infection and of screening uptake, and therefore of risk of cervical cancer [21]. The effectiveness of the HPV immunisation programme within the older catch-up cohorts may, therefore, be lower than expected from mathematical models to date, and lower than will follow for the younger catch-up cohorts and for the routine cohorts. Hopefully, given the high levels of coverage achieved overall, the absolute risk to unvaccinated girls will be substantially reduced by indirect protection conferred through herd-immunity. However, herd-immunity will always be less protective than direct immunity and if lower coverage associates with higher risk of HPV infection and, in due course, with lower cervical screening uptake then the relative risk of cervical cancer associated with deprivation may increase, albeit briefly, before it decreases.

Conclusion

School-based delivery of HPV immunisation at a young age appears to be successful at achieving high and equitable coverage, and should, in due course, reduce inequalities in cervical cancer control in England. Variations in deprivation, and risk behaviours, at individual level may be important and need further study in England. The trend towards lower coverage in deprived areas amongst the older catch-up cohorts indicates a danger – if all else remains equal – of lower programme-effectiveness in the catch-up years than otherwise expected and of increasing the relative risk of cervical cancer in the most deprived compared to the least deprived areas of England for these birth cohorts, despite a reduced absolute risk for all women.

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