Sandford, Helena and Tata, Laila J. and Browne, Ivan and Pritchard, Catherine (2015) Is there an association between the coverage of immunisation boosters by the age of 5 and deprivation?: an ecological study. Vaccine, 33 (9). pp. 1218-1222. ISSN 0264-410X

Is there an association between the coverage of immunisation boosters by the age of 5 and deprivation? An ecological study

Helena Sandford[1]; Laila J Tata[1]; Ivan Browne[2]; Catherine Pritchard[1]

Helena Sandford# (mzyhs1@nottingham.ac.uk); Dr Laila J Tata (laila.tata@nottingham.ac.uk) and Dr Catherine Pritchard (Catherine.pritchard@nottingham.ac.uk)

[1]Division of Epidemiology and Public Health

University of Nottingham

Clinical Sciences Building Phase 2

City Hospital

Hucknall Road

Nottingham

NG5 1PB

[2]Ivan. Browne@leicester.gov.uk

Leicester City Council

Public Health Directorate

New Walk Centre

Leicester

LE1 6ZG

#= corresponding author

The authors have no conflicts of interest.

Manuscript word count =3095 (inclusive of abstract)

Abstract word count = 310

Abstract

Objective: To determine whether there was an association between the coverage of booster immunisation of Diphtheria, Tetanus, acellular Pertussis and Polio (DTaP/IPV) and second Measles, Mumps and Rubella (MMR) dose by age 5 in accordance with the English national immunisation schedule by area-level socioeconomic deprivation and whether this changed between 2007/08-2010/11.

Design: Ecological study.

Data: Routinely collected national Cover of Vaccination Evaluated Rapidly data on immunisation coverage for DTaP/IPV booster and second MMR dose by age 5 and the Index of Multiple Deprivation (IMD).

Setting: Primary Care Trust (PCT) areas in England between 2007/08-2010/11.

Outcome measures: Population coverage (%) of DTaP/IPV booster and second MMR immunisation by age 5.

Results: Over the 4 years among the 9,457,600 children there was an increase in the mean proportion of children being immunised for DTaP/IPV booster and second MMR across England, increasing from 79% (standard deviation (SD12%)) to 86% (SD8%) for DTaP/IPV and 75% (SD10%) to 84% (SD6%) for second MMR between 2007/08-2010/11. In 2007/08 the area with lowest DTaP/IPV booster coverage was 31% compared to 54.4% in 2010/11 and for the second MMR in 2007/08 was 39% compared to 64.8% in 2010/11. A weak negative correlation was observed between average IMD score and immunisation coverage for the DTaP/IPV booster which reduced but remained statistically significant over the study period ($r=-0.298$, $p<0.001$ in 2007/08 and $r=-0.179$, $p=0.028$ in 2010/11). This was similar for the second MMR in 2007/08 ($r=-0.225$, $p=0.008$) and 2008/09 ($r=-0.216$, $p=0.008$) but there was no statistically significant correlation in 2009/10 ($r=-0.108$, $p=0.186$) or 2010/11 ($r=-0.078$, $p=0.343$).

Conclusion: Lower immunisation coverage of DTaP/IPV booster and second MMR dose was associated with higher area-level socioeconomic deprivation, although this inequality reduced between 2007/08-2010/11 as proportions of children being immunised increased at PCT level, particularly for the most deprived areas. However, coverage is still below the World Health Organisation recommended 95% threshold for Europe.

Key words

Immunisation; England; Index of Multiple Deprivation; ecological study; children[1]

[1] Abbreviations used: COVER Cover Of Vaccination Evaluated Rapidly, IMD Index of Multiple Deprivation; NICE National Institute for Health and Clinical Excellence, PCTs Primary Care Trusts

Introduction

A recent upsurge in measles in England has reignited the debate about the need for robust delivery and coverage of childhood immunisation in order to achieve the World Health Organisation (WHO) Global vaccine action plan of ≥80% coverage in each district[1] and the 95% coverage recommendation for European countries[2] in order to maintain herd immunity [1, 3, 4]. Childhood immunisations are freely available and the immunisation schedule in England incorporates boosters provided between the ages of 3 years and 4 months to 5 years for diphtheria, tetanus, acellular pertussis, polio (DTaP/IPV booster) and the second dose of measles, mumps and rubella (MMR).

Coverage of booster immunisations has steadily increased for DTaP/IPV from 78.6% in 2007/08 to 87.4% in 2011/12 and second MMR from 74.6% in 2007/08 to 86.0% in 2011/12 [5]. However, evidence indicates that there remains significant variation in geographical coverage, particularly in large conurbations [6]. Several studies have shown a link between low coverage of childhood immunisations and increasing deprivation [7-19]. It has been postulated that children living in areas of high deprivation are less likely to be immunised due to the high degree of transience within such communities, higher proportions of ethnic minorities, incomplete or absent primary immunisations, poorer access to services, higher number of families with multiple children, single parent households and very young or old mothers [19-21]. However, the evidence related to different immunisations is inconsistent. Studies of coverage of HPV immunisation [22] and MMR at age 2 [23] were not associated with deprivation. The MMR at age 2 study utilised the Index of Multiple Deprivation (IMD) and found no association with IMD nor with the area percentage of the non-white population, however, it had a strong negative association with two IMD domains that quantify barriers to adequate housing (affordability and overcrowding) and local services (road distance to services) [23].

As the DTaP/IPV booster and second MMR are provided prior to children entering the education system this is a key transition point where herd immunity is of paramount importance. Therefore, we assessed whether there was an association between the coverage of childhood booster immunisations and socioeconomic deprivation in England and whether this changed over time.

Methods

Study design and data sources

We conducted an ecological study using aggregate data for the whole population of England available at the level of Primary Care Trust (PCT). Up until March 31st 2013 PCTs were the principal commissioning bodies for the country's National Health Service (NHS), which provides universal health care free at the point of access. We used Cover of Vaccination Evaluated Rapidly (COVER) data on immunisations and IMD data on area-level socioeconomic deprivation which are freely available online, so no formal ethical approval was required. The COVER scheme was first trialled in 1987 and by 1989 most areas in England were participating [24]. These data are collated quarterly and we accessed them via the Health and Social Care Information Centre of the NHS website (http://www.hscic.gov.uk/searchcatalogue?productid=9990&q=immunisation&sort=Relevance&size=10&page=1#top). COVER data are available for the British financial year which runs from April 1st to March 31st in the subsequent year and are thus presented as 2007/08 to 2010/11 at PCT level. The study population was all 5 year old children in England whose immunisation statistics were available as percentages of coverage for the population of children covered by each PCT with the DTaP/IPV booster and second MMR as the outcome measures. In 2008/09 to 2010/11 all PCTs achieved COVER data validation criteria and in 2007/08 141 PCTs achieved this. The number of PCTs changed from 152 in 2007-2009 to 151 in 2010 due to a boundary change on 1st April 2010 with the merger of North Hertfordshire with West Hertfordshire to form Hertfordshire.

Socioeconomic deprivation data were accessed from the English IMD PCT summaries for 2007 http://www.communities.gov.uk/documents/communities/zip/indices2007.zip [25] and 2010 https://www.gov.uk/government/publications/english-indices-of-deprivation-2010 [26] . IMD are 3-yearly statistical indices that provide a ranking of areas across England by their level of socioeconomic deprivation based on 7 domains: income, education, employment, health, barriers to housing and local services, environment and crime. Each domain score is ranked and exponentially transformed. Individual domain scores are available; however, a single population-weighted average score is also generated, allowing comparison between areas based on their relative levels of deprivation. We used the IMD average scores available at PCT level as a measure of overall deprivation; IMD scores for 2007 were used to represent deprivation for the 2007/08-2009/10 COVER data and the 2010 scores were used to represent deprivation for 2010/11 COVER data.

Statistical analysis

All downloaded data that were available in Excel spreadsheets were imported to and analysed using *Stata v.11* software. We first examined the size of the child population annually and the ranking of PCTs by IMD to assess whether there had been substantial socio-demographic changes over the study period. Over the 4 year period IMD average scores were plotted and were found to be fairly normally distributed. We assessed whether using different average IMD scores from the 2 time points of IMD collection (2007 and 2010) resulted in substantial changes in the relative socioeconomic position of PCT areas by assessing the 10 most and 10 least deprived PCT areas.

The percentage coverage of DTaP/IPV and second dose of MMR across PCTs was assessed for normal distribution and were found to be not normally distributed. We created scatter plots of the average IMD score against percentage coverage of the DTaP/IPV and second MMR separately to assess whether there was a linear relationship between the exposure and outcomes. Pearson's correlation coefficients were used to assess correlations between deprivation and the percentage coverage of each immunisation for each financial year across the study period. Finally, for each immunisation we assessed the number of PCTs that achieved district level immunisation coverage targets of >80% and >95% set by the WHO[1, 2] and whether this had changed over the study period.

Results

Population socio-demographics

We included data from all children with available COVER and IMD data aged 5 in England over the 4-year study period. As shown in table 1, the number of PCTs achieving validation criteria for COVER data increased from 141 in 2007/08 to all PCTs achieving the criteria from 2008/09 onwards. The population of children aged 5 in England changed from 2,365,400 in 2007/08 to 2,363,800 in 2010/11. In 2010/11, Hampshire PCT had the largest number of children in this age range (n=14,800) and Hartlepool had the lowest (n=1,200). When we used the 2010 IMD scores instead of 2007 IMD scores only one PCT moved out of the 10 most deprived areas, whereas, there were 3 changes in 10 least deprived PCTs. For both time periods Surrey was the least deprived and Heart of Birmingham was the most deprived. IMD average scores ranged from 8.1 (least deprived) to 48.3 (most deprived) with a mean value of 23.7 and median value of 23.6.

Table 1.

Table 2 shows that between 2007/08-2010/11 there was an increase in the mean coverage of immunisations in PCTs in England; the DTaP/IPV booster by 6.7% and second MMR dose by 9.1%. Variation of coverage across PCTs indicated by the standard deviations (Table 2) reduced for both immunisations over this period. There was also a reduction in the range of coverage for DTaP/IPV from 31.0%-94.0% (2007/08) to 54.4%-96.7% (2010/11) and for MMR from 39.0%-89.0% (2007/08) to 64.8%-95.1% (2010/11) which shows that the overall increased immunisation coverage was mainly achieved by an increase in areas with previously low coverage rates. This can also be seen in Figures 1-2: scatter plots plotting PCTs annually by their IMD average scores and their vaccination coverage for DTaP/IPV (figure 1) and MMR (figure 2). They show that whilst most PCTs across all levels of deprivation had quite high booster coverage, there were some PCTs with particularly low coverage and these were more likely to have high IMD scores. This appeared to be more so for

DTaP/IPV than for MMR and figures 1-2 also show the reduced variation in immunisation coverage between 2007/8 and the 2010/11 period which was mostly due to increasing coverage in those with initially low coverage rather than increases in PCTs with initially high coverage.

Table 2.

Figure 1.

Figure 2.

Table 3 shows correlation coefficients for the association of PCTs IMD scores and immunisation coverage. With increasing average IMD score there were weak negative correlations with PCTs coverage of both DTaP/IPV and second MMR, which were statistically significant across all years for DTaP/IPV boosters and in 2007/08 and 2008/09, but not the later years, for second MMR. The weak correlation between higher deprivation and lower coverage did decrease for both immunisations over the study period.

Table 3.

Table 4 show the number of PCTs across the study period that achieved 95% and 80% coverage WHO targets. Over the 4 year period the number of PCTs achieving ≥80% coverage substantially increased however the percentage reaching ≥95% has remained below 4% for DTaP/IPV and below 1% for MMR.

Table 4.

Discussion

Results from this ecological study demonstrate a weak statistically significant association between coverage of the DTaP/IPV booster at age 5 and deprivation over the 4 year period. Coverage for second MMR also demonstrated a weak negative correlation with deprivation however, this was only statistically significant for the periods 2007/08 and 2008/09. Over the time period there was an increase in coverage and a reduction in variation of coverage of DTaP/IPV and second MMR immunisations across PCTs in England. The reduction in variation of coverage in 2007/08, the lowest being 31% for DTaP/IPV and 39% for MMR and thereafter in 2010/11 being 54.4% and 64.8% respectively was particularly important as areas with low booster coverage were areas that were more deprived. Therefore, this study demonstrates that in a 4 year period areas with traditionally low immunisation coverage can improve.

The strengths of this study are that a large validated national immunisation dataset was used along with nationally derived deprivation indices. The immunisation coverage and denominator data for COVER data are validated both at local and national level. Validation criteria are utilised to ensure that the number of children immunised reflects both those children registered with general practice and those who are the responsibility of the PCT [27], therefore ensuring that information is complete. These immunisations have also been incorporated into contractual targets and therefore, active tracking of immunisation status via PCTs also supports the accuracy of these data systems. To date most research has primarily focused on primary immunisations and therefore this study provides insight into the association between coverage of boosters by the age of 5 and deprivation. As this is an ecological study we must acknowledge limitations of this method. We did not have measurements of socioeconomic deprivation for individual children nor did we know their individual vaccine coverage, so we cannot make any conclusions as to how children's or families' socioeconomic circumstances may directly affect their vaccine coverage. Furthermore, within PCTs there can be considerable variation in deprivation between smaller constituent areas, so even at an ecological level our use of PCTs' average IMD may have underestimated the association between deprivation and low immunisation coverage. This was a necessity however, as vaccination coverage data is available only at PCT level and this enabled us to assess the COVER recorded aged 5 population of England. That we have shown a persistence of socioeconomic inequality in immunisation coverage at a national level is important for the organisation of these public services. Changes in the ranking of PCTs in the IMD may have also impacted on our results as only 66% of areas remained within the same deciles of IMD in 2010/11 as in 2007/08 [28]; as this minor re-classification will be for reasons other than our outcome, if anything this will have led us to underestimate the association between deprivation and low immunisation coverage.

Whilst the coverage data are not normally distributed, we decided to use the mean coverage rather than median coverage as the figures were only slightly different (the median coverage was between 0.6-4% higher than the mean coverage). Mean figures are standardly reported in populations so we wanted to ensure that this was comparable in the context of other research which may also interpret data that is not normally distributed.

Whilst our study shows improved coverage of DTaP/IPV and second MMR at age 5 in England we have yet to achieve targets set by the World Health Organisation in every geographical district with 4 doses of DTaP/IPV and the second dose of MMR [1, 2] to support the achievement of herd immunity. By 2010/11 for DTaP/IPV booster 82.8% and for second MMR 81.5% of PCTs were achieving coverage of ≥80%. Our study ascertained that by 2010/11 the European WHO recommended threshold of 95% coverage for childhood immunisations was achieved by only 2.7% of PCTs for the DTaP/IPV booster and 0.7% of PCTs achieved this for MMR. Therefore, the majority of areas still fell well below the WHO European recommended targets. In comparison coverage of primary immunisations in 2011/12 in England was higher and almost achieved targets for DTaP/IPV at 94.7% and MMR 91.2% [5] therefore we hypothesise that greater emphasis needs to be placed on clear and consistent messaging about the need for completion of booster immunisations. Whilst there have been, now discredited, concerns over the safety of the MMR immunisation a survey of mothers in Birmingham indicated that they question the importance of the second dose of MMR[29] which may also impact on coverage. Booster doses may also be missed by particular vulnerable groups such as children in care, children with disabilities, some minority groups and non-English speakers [30].

Whilst an association between deprivation and MMR at age 2 [23]and HPV [22] immunisations were not found, other studies on immunisation coverage have been linked to deprivation in both England and New Zealand (2006) demonstrating higher coverage in more affluent populations [9, 17, 31, 32]. However, there are some notable differences between these studies and our own. Whilst the studies in England used national coverage data the time periods included when the controversy surrounding the safety of MMR was at its height in England and therefore may have affected the results. The study in New Zealand accessed coverage data for children up to 23 months old via an audit of primary care notes for an area that only covered 50% of the population and was dependant on practice agreement to the audit, which may have resulted in information bias. None of these studies assessed booster immunisations prior to entering school and therefore, our research contributes to the understanding of these immunisations. Overall we found an increase in the coverage of immunisation boosters over the 4 year period and the association between immunisation coverage and deprivation was less pronounced in the latter period of the study this is in contrast to the studies carried out prior to this one.

In accordance with the World Health Organisation Global Vaccine Action Plan the Department of Health in England has adopted policies to improve immunisation coverage. Our findings have demonstrated that over the 4 year period there has been an improvement in the numbers of PCTs reporting validated results into the COVER system and this improvement in reporting provides an increasingly accurate picture of immunisation delivery. Policies have also included contractual targets with primary care for the achievement of specified immunisation performance levels as an incentive to reduce health inequalities. Whilst targets can be criticised this study indicates that they may have had a beneficial effect in increasing coverage over time. This has been supported by increased efforts of primary care to support the delivery of booster immunisation services along with active management and follow up of the children in accordance with national guidance[30] which may explain the increase in coverage. Therefore, an integrated approach to immunisation delivery that incorporates the systematic improvement of data management, along with comprehensive and adaptable service delivery of immunisation schedules may support the reduction of inequalities.

Conclusion

Overall we found a weak negative correlation between PCTs' IMD average score and booster immunisation coverage for DTaP/IPV and the second dose of MMR, reflecting that higher area-level deprivation is associated with lower coverage. It is important to note that whilst this inequality reduced between 2007/8 and 2010/11 for both immunisations, it still persisted for DTaP/IPV in 2010/11. This improvement in coverage is indicative of the value of clear immunisation policies in supporting the reduction of health inequalities. Nevertheless, many PCTs were still not achieving targets set out the WHO so much more support is needed to improve coverage of booster immunisations.

References

1. World Health Organisation, *Global Vaccine Action Plan 2011-2020*. 2013, World Health Organisation: Geneva.
2. World Health Organisation, *The guide to tailoring immunization programmes. Increasing coverage of infant and child vaccinatio in the WHO region.* 2013, WHO Regional office for Europe: Copenhagan.
3. Centre for Public Health. *Health Protection- Childhood Immunisation.* 2012 [cited 2012 9 November 2012]; Available from: http://www.cph.org.uk/showPublications.aspx?pubid=263.
4. Department of Health, *The operating framework 2009-10 for the NHS in England.*, Department of Health, Editor. 2008, Department of Health,: London.
5. The Health and Social Care Information Centre, *NHS Immunisation Statistics England 2011-12*

2012.
6. Samad, L., et al., *Incomplete immunisation uptake in infancy: maternal reasons.* Vaccine, 2006. **24**(47-48): p. 6823-9.
7. Lynch, M., *Effect of practice and patient population characteristics on the uptake of childhood immunizations.* British Journal of General Practice, 1995. **45**(393): p. 205-208.
8. Fleming, D.M. and J.R.H. Charlton, *Morbidity and healthcare utilisation of children in households with one adult: comparative observational study.* British Medical Journal, 1998. **316**(7144).
9. Middleton, E. and D. Baker, *Comparison of social distribution of immunisation with measles, mumps, and rubella vaccine, England, 1991-2001.* British Medical Journal, 2003. **326**(7394): p. 854.
10. Wright, J.A. and C. Polack, *Understanding variation in measles-mumps-rubella immunization coverage-a population-based study.* European Journal of Public Health, 2006. **16**(2): p. 137-142.
11. Friederichs, V., J.C. Cameron, and C. Robertson, *Impact of adverse publicity on MMR vaccine uptake: a population based analysis of vaccine uptake records for one million children, born 1987-2004.* Archives of Disease in Childhood, 2006. **91**(6).
12. Coupland, C., et al., *Inequalities in uptake of influenza vaccine by deprivation and risk group: Time trends analysis.* Vaccine, 2007. **25**(42).
13. Grant, C.C., et al., *Factors associated with immunisation coverage and timeliness in New Zealand.* British Journal of General Practice, 2010. **60**(572): p. 180-186.
14. Kumar, V.M. and D.K. Whynes, *Explaining variation in the uptake of HPV vaccination in England.* Bmc Public Health, 2011. **11**.
15. Baker, D., A. Garrow, and C. Shiels, *Inequalities in immunisation and breast feeding in an ethnically diverse urban area: cross-sectional study in Manchester, UK.* Journal of Epidemiology and Community Health, 2011. **65**(4).
16. Clark, A. and R. Marshall, *Measles, mumps, and rubella vaccine coverage in 2 year old children in East Lancashire--better than it looks.* Communicable disease and public health / PHLS, 1999. **2**(1).
17. Grant, C.C., et al., *Primary care practice and health professional determinants of immunisation coverage.* Journal of Paediatrics and Child Health, 2011. **47**(8).
18. Lancashire University. *Deprivation is a key factor in why young children do not receive all their vaccinations.* August 2011. 2 August 2012]; Available from: http://news.lancs.ac.uk/Web/News/Pages/Deprivation-is-a-key-factor-in-why-young-children-do-not-receive-all-their-vaccinations.aspx.

19. Pearson, M., et al., *Primary immunizations in Liverpool. Is there a gap between consent and completion?* Archives of Disease in Childhood, 1993. **69**(1): p. 115-119.
20. Li, J. and B. Taylor, *Factors affecting uptake of measles, mumps and rubella immunization.* British Medical Journal, 1993. **307**(6897): p. 168-171.
21. Fleming, D.M. and J.R.H. Charlton, *Morbidity and healthcare utilisation of children in households with one adult: comparative observational study.* British Medical Journal, 1998. **316**(7144): p. 1572-1576.
22. Fisher, H., et al., *Examining inequalitiesin the uptake of the school based HPV vaccination programme in England: a retrospective cohort study.* Journal of Public Health, 2014. **36**(1): p. 36-45.
23. Lamden, K.H. and I. Gemmell, *General practice factors and MMR vaccine uptake: structure, process and demography.* Journal of Public Health, 2008. **30**(3): p. 251-257.
24. Health Protection Agency. *Vaccine Coverage and COVER.* 2012. 6 November 2012]; Available from: http://www.hpa.org.uk/Topics/InfectiousDiseases/InfectionsAZ/VaccineCoverageAndCOVER/GeneralInformation/.
25. Department for Communities and Local Government. *Indicies of deprivation 2007*. 2007; Available from: http://www.communities.gov.uk/documents/communities/zip/indices2007.zip.
26. Department for Communities and Local Government, *English Indicies of Deprivation 2010: PCT summaries*. 2011: England.
27. NHS England, *Data flows for direct commissioning child immunisations (COVER) Unify collections: Guidance v.1.3*, N.H.S. England., Editor. 2014.
28. Department for Communities and Local Government. *The English Indicies of Deprivation 2010*. 2011 [cited 2013 20th May 2013]; Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/6871/1871208.pdf.
29. Pareek, M. and H.M. Pattison, *The two-dose measles, mumps, and rubella (MMR) immunisation schedule: factors affecting maternal intention to vaccinate.* British Journal of General Practice, 2000. **50**(461): p. 969-71.
30. National Institute for Health and Clinical Excellence, *Reducing differences in the uptake of immunisations. Public health guidance 21.*, NICE, Editor. 2009, NICE: Manchester.
31. Kumar, V. and D. Whynes *Explaining variation in the uptake of HPV vaccination in England*. BMC Public Health, 2011. **11**, 172 DOI: http://dx.doi.org/10.1186/1471-2458-11-172.
32. Wright, J.A. and C. Polack, *Understanding variation in measles-mumps-rubella immunization coverage--a population-based study.* European Journal of Public Health, 2006. **16**(2): p. 137-42.