

Factors associated with uptake of measles, mumps, and rubella vaccine (MMR) and use of single antigen vaccines in a contemporary UK cohort: prospective cohort study

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ABSTRACT

Objectives To estimate uptake of the combined measles, mumps, and rubella vaccine (MMR) and single antigen vaccines and explore factors associated with uptake and reasons for not using MMR.

Design Nationally representative cohort study.

Setting Children born in the UK, 2000-2.

Participants 14 578 children for whom data on immunisation were available.

Main outcome measures Immunisation status at 3 years defined as "immunised with MMR," "immunised with at least one single antigen vaccine," and "unimmunised."

Results 88.6% (13 013) were immunised with MMR and 5.2% (634) had received at least one single antigen vaccine. Children were more likely to be unimmunised if they lived in a household with other children (risk ratio 1.74, 95% confidence interval 1.35 to 2.25, for those living with three or more) or a lone parent (1.31, 1.07 to 1.60) or if their mother was under 20 (1.41, 1.08 to 1.85) or over 34 at cohort child's birth (reaching 2.34, 1.20 to 3.23, for ≥ 40), more highly educated (1.41, 1.05 to 1.89, for a degree), not employed (1.43, 1.12 to 1.82), or self employed (1.71, 1.18 to 2.47). Use of single vaccines increased with household income (reaching 2.98, 2.05 to 4.32, for incomes of \geq £52 000 (€69 750, \$102 190)), maternal age (reaching 3.04, 2.05 to 4.50, for ≥ 40), and education (reaching 3.15, 1.78 to 5.58, for a degree). Children were less likely to have received single vaccines if they lived with other children (reaching 0.14, 0.07 to 0.29, for three or more), had mothers who were Indian (0.50, 0.25 to 0.99), Pakistani or Bangladeshi (0.13, 0.04 to 0.39), or black (0.31, 0.14 to 0.64), or aged under 25 (reaching 0.14, 0.05 to 0.36, for 14-19). Nearly three quarters (74.4%, 1110) of parents who did not immunise with MMR made a "conscious decision" not to immunise.

Conclusions Although MMR uptake in this cohort is high, a substantial proportion of children remain susceptible to avoidable infection, largely because parents consciously decide not to immunise. Social differentials in uptake could be used to inform targeted interventions to promote uptake.

INTRODUCTION

In 1995 uptake of MMR among 2 year olds living in the UK reached its peak at 92%.¹ After publication of research in 1998 that was widely interpreted as suggesting a link between the vaccine and autism and bowel disease,² uptake declined to a low of 79% in 2003.³ Current uptake, based on data from July-September 2007, is estimated to be 85%.⁴ Despite subsequent research showing no link between MMR and autism and bowel disorders,^{5,6} some parents have sought single vaccines for their children. There are no routine data on use of single antigen vaccines in the UK, and estimates derived from local level studies⁷⁻⁹ and a national survey of providers¹⁰ range from around 2% to 21%.

Before 1998, MMR uptake was lower among single parent families and larger families and in more socially deprived areas.¹¹⁻¹⁵ Since 1998, however, the decline in uptake has been faster in more affluent areas^{13,16} and slower in areas with less highly educated residents.^{13,17}

We estimated MMR coverage and the uptake of single vaccines across the UK and explored risk factors, as well as parents' reasons, for not accepting MMR, differentiating between parents who did not immunise their child against measles, mumps, and rubella at all and those who chose to use single vaccines.

METHODS

Participants

We examined data from the millennium cohort study, a longitudinal study of children born in the UK from September 2000 to January 2002. The sample was taken from a random sample of electoral wards that were disproportionately stratified to ensure an adequate representation of all four UK countries, deprived areas, and areas with high proportions of families from ethnic minorities.¹⁸ The first contact with the cohort was when the children were aged about 9 months, when information was collected on 72% of those approached, giving 18 819 babies. The second sweep of data collection took place when children were about 3 years old. Of the original 18 296 singleton babies, 80% (14 630) participated in the second sweep. Trained researchers interviewed the main care giver. At three

years, researchers determined MMR uptake and parents' reasons for not opting for MMR.

Our analysis included 14 578 children at age 3 for whom information was available on MMR uptake (99.6% of the 14 630 included in the second sweep).

Analysis

We calculated the uptake of MMR for the UK overall. We looked at the combinations of single antigen vaccines used in those children immunised with at least

one antigen. We used forward stepwise regression analysis to identify socioeconomic and cultural characteristics associated with vaccination uptake in two independent models: the first examining the risk of being unimmunised against measles, mumps, and rubella (compared with MMR) and the second the risk of being immunised with at least one single antigen vaccine (compared with MMR). We used backwards stepwise regression to check the validity of the models and ran sensitivity analyses. We reported parents' reasons for not having their child immunised with MMR. Survey weights were used to take account of the sample design and non-response at the first and second sweeps.

Table 1 | Adjusted risk ratios for children being unimmunised against measles, mumps, and rubella by age 3*

Social characteristics†	%‡ (No)	Adjusted risk ratios‡ for being unimmunised against MMR	P value
Country:			
England	57 (8595)	1	0.001
Wales	16 (2125)	1.24 (0.99 to 1.54)	
Scotland	14 (1716)	0.88 (0.68 to 1.15)	
N Ireland	13 (1390)	0.60 (0.43 to 0.84)	
No of children in household:			
1	41 (5587)	1	0.001
2-3	52 (7121)	1.18 (1.02 to 1.38)	
≥4	7 (1118)	1.74 (1.35 to 2.25)	
Maternal age at cohort birth:			
14-19	8 (1101)	1.41 (1.08 to 1.85)	<0.001
20-24	17 (2544)	1.07 (0.86 to 1.31)	
25-29	28 (3874)	1	
30-34	30 (4175)	1.11 (0.91 to 1.34)	
35-39	15 (1991)	1.60 (1.32 to 1.95)	
≥40	2 (293)	2.34 (1.70 to 3.23)	
Single parent:			
No	85 (11 678)	1	<0.001
Yes	15 (2148)	1.31 (1.07 to 1.60)	
Mother's employment status:			
Full time	11 (1643)	1	<0.001
Part time	31 (4033)	1.07 (0.82 to 1.39)	
Not employed	49 (6933)	1.43 (1.12 to 1.82)	
Self employed	3 (432)	1.71 (1.18 to 2.47)	
On leave	5 (664)	0.94 (0.61 to 1.45)	
Full time student	1 (121)	1.85 (0.98 to 3.47)	
Maternal education:			
None	16 (2477)	1	0.01
Other	2 (361)	1.06 (0.68 to 1.66)	
GCSE grades D-G	11 (1502)	0.81 (0.62 to 1.06)	
O level/GCSE grades A*-C	35 (4664)	0.98 (0.81 to 1.19)	
A/AS level	9 (1323)	1.35 (1.01 to 1.80)	
Diploma	9 (1222)	1.15 (0.87 to 1.54)	
Degree	17 (2277)	1.41 (1.05 to 1.89)	
Ever smoked in pregnancy:			
No	65 (9004)	1	0.02
Yes	35 (4822)	1.22 (1.04 to 1.43)	
Sex of child:			
Male	51 (7016)	1	0.005
Female	49 (6810)	0.84 (0.75 to 0.95)	

*Total No of observations=13 826; data missing for 18 for maternal age, 40 for mother's employment status, 50 for educational qualification, 60 for ever smoked during pregnancy.

†Variables not significantly adding to model and therefore omitted: household income, household language.

‡Percentages and risk ratios calculated with sample and non-response weights.

RESULTS

Of the total cohort, 88.6% (87.5% to 89.7%, n=13 013) had been immunised with MMR by age 3, 5.2% (4.6% to 5.9%, n=634) had received at least one of the single antigen vaccines, and 6.1% (5.5% to 6.9%, n=931) were unimmunised.

Of the 634 children who received at least one single antigen vaccine, 52% (47.1% to 56.6%, n=335) had received all three and 37% (31.8% to 42.1%, n=227) had received measles and rubella. Some 7.4% (5.6% to 9.8%, n=48) of children had received only one of the vaccines, of which measles was the most common and mumps the least.

Table 1 shows risk ratios for children being unimmunised, adjusted for all other characteristics that significantly added to the model. Children were significantly less likely to be unimmunised if they lived in Northern Ireland. They were more likely to be unimmunised if they lived in families with other children, if their mother was over 34 or under 20 when she gave birth to the cohort child, or if they lived in a single parent household. Children were also at increased risk of being unimmunised if their mother was not employed or was self employed, if her highest educational qualifications were AS/A level or above, or if she had ever smoked during pregnancy. Girls were significantly less likely to be unimmunised than boys.

Table 2 shows risk ratios for children receiving at least one of the single antigen vaccines, adjusted for all other characteristics in the model. Children were less likely to have received single antigen vaccines if they lived in Wales, Scotland, or Northern Ireland or in families with other children. Use of single antigen vaccine increased with maternal age at birth of the cohort child and also with household income. Mothers who were not employed or educated to GCSE level or above were also more likely to use single antigen vaccines. Children were less likely to have received single antigen vaccines if their mother was Pakistani or Bangladeshi, Indian, or black.

Sensitivity analyses were conducted, and the size of the associations changed little. Of the parents whose children were unimmunised or who received single antigen vaccines, 74.4% (71.3% to 77.0%, n=1 110) made a "conscious decision" not to have their child immunised with MMR. Of all the reasons given by parents that fell into the "conscious decision" category, the most

Table 2 | Adjusted risk ratios for children being immunised with at least one single antigen vaccine by age 3*

Social characteristics†	%‡ (No)	Adjusted risk ratios‡ for being immunised with at least one single antigen vaccines	P value
Country:			
England	59 (7817)	1	
Wales	16 (1931)	0.65 (0.51 to 0.84)	<0.001
Scotland	13 (1537)	0.45 (0.34 to 0.59)	
N Ireland	12 (1208)	0.33 (0.22 to 0.50)	
No of children in household:			
1	43 (5298)	1	
2-3	51 (6306)	0.31 (0.26 to 0.38)	<0.001
≥4	6 (889)	0.14 (0.07 to 0.29)	
Maternal age at cohort birth (years):			
14-19	7 (1021)	0.14 (0.05 to 0.36)	<0.001
20-24	17 (2431)	0.63 (0.45 to 0.87)	
25-29	28 (3826)	1	
30-34	31 (4186)	1.36 (1.11 to 1.66)	
35-39	15 (1933)	1.40 (1.10 to 1.77)	
≥40	2 (284)	3.04 (2.05 to 4.50)	
Household income (£):			
<10 400	22 (3068)	1	<0.001
10 400-20 800	32 (4118)	1.20 (0.86 to 1.69)	
20 800-31 200	22 (2639)	1.88 (1.33 to 2.66)	
31 200-52 000	17 (1974)	2.05 (1.42 to 2.95)	
≥52 000	7 (694)	2.98 (2.05 to 4.32)	
Mother's employment status:			
Full time	11 (1580)	1	0.003
Part time	32 (3773)	1.23 (0.96 to 1.59)	
Not employed	48 (6067)	1.60 (1.26 to 2.04)	
Self employed	3 (360)	1.46 (0.97 to 2.18)	
On leave	5 (614)	1.16 (0.78 to 1.72)	
Full time student	1 (99)	0.47 (0.07 to 3.24)	
Maternal education:			
None	15 (2043)	1	<0.001
Other	2 (293)	1.76 (0.66 to 4.66)	
GCSE grades D-G	11 (1343)	1.48 (0.74 to 2.97)	
O level/GCSE A*-C	35 (4258)	2.66 (1.52 to 4.66)	
A/AS level	10 (1230)	3.37 (1.85 to 6.13)	
Diploma	10 (1161)	3.31 (1.92 to 5.69)	
Degree	18 (2165)	3.15 (1.78 to 5.58)	
Mother's ethnicity:			
White	90 (10 847)	1	<0.001
Mixed	1 (109)	1.94 (0.85 to 4.41)	
Indian	2 (302)	0.50 (0.25 to 0.99)	
Pakistani or Bangladeshi	4 (695)	0.13 (0.04 to 0.39)	
Black or black British	3 (343)	0.31 (0.14 to 0.64)	
Other	1 (197)	0.56 (0.23 to 1.36)	

*Total No of observations=12 493; data missing for 18 for maternal age, 1095 for household income, 40 for mother's employment status, 31 for educational qualification, 30 for ethnicity.
 †Variables not significantly adding to the model and therefore omitted: maternal age at first live birth, ward type, interview language, household language, lone parenthood, sex of the child, ever smoked in pregnancy.
 ‡Percentages and risk ratios calculated with sample and non-response weights.

common were being too scared or thinking the vaccine was too dangerous (24.1%, 21.2% to 27.2%, n=277), not wanting to their child to receive MMR (18.6%, 16.1% to 21.3%, n=211), fears over possible links with autism (14.1%, 12.1% to 16.4%, n=168), and negative media

attention (9.5%, 7.4% to 12.0%, n=105). Around 12% reported medical reasons, such as “the child had a cold at time of appointment” and a further 3% practical reasons, for example “missing an appointment.”

DISCUSSION

In this large cohort study we found that around 88.6% of children were immunised with MMR, 5.2% had received one or more of the single antigen vaccines, and 6.1% were unimmunised. Parents often made a conscious decision not to immunise.

Strengths and limitations

The data collected in the millennium cohort study allowed us to differentiate between children who had been immunised with at least one of the single antigen vaccines and those who remained unimmunised. The large sample size, and the oversampling of ethnic minorities and people living in disadvantaged areas enabled precise estimation of vaccine uptake across the UK and its variation in different socioeconomic, cultural, demographic, and ethnic groups. The non-response weights were not able to fully take into account the fact that children in the second sweep were more likely to have been immunised with primary vaccinations (96%, ascertained at the first sweep) than those who were not included (93%). Therefore it is possible that our estimates of MMR uptake are slightly inflated.

Immunisation status was based on maternal report. There is, however, no agreed standard for reporting immunisation status, and parents reporting non-uptake of MMR in the cohort study would probably accurately recall this information as for most their decision was made consciously and in the case of those deciding to use single antigen vaccines one that required special arrangements. We were unable to take into account the timing of vaccination.

Our findings relate to children who were born in 2000-2. From 1998 considerable media attention was given to the safety of MMR vaccine with a peak of negative coverage around the time when cohort parents were likely to be making decisions about their child's vaccinations. It is therefore possible that our results are unique to this cohort.¹⁹

Comparison with other findings

We found the reported uptake of MMR at 3 years to be higher than that in published routine statistics for a similar UK birth cohort at 2 years (80.7%).²⁰ This may be because of under-reporting, which is known to occur in routine data, or selection or recall bias in the cohort study.

There are no routine data on use of single antigen vaccine and only a limited number of small studies with which to compare our findings. One study estimated uptake of single vaccines in England and Wales based on the number of applications for importation and the number of vaccines actually administered by a proportion of providers.¹⁰ It calculated that 1.7-5.6% of children born in 2001 and 2.1-5.6% of children born in 2002 would have received the single measles

WHAT IS ALREADY KNOWN ON THIS TOPIC

In the UK, MMR uptake has declined and its social patterning is changing
 There is no comparable information on the use of single antigen vaccines
 Current estimated coverage of 85% is below the level required for herd immunity

WHAT THIS STUDY ADDS

Many parents make a conscious decision not to have their child immunised with MMR, with a substantial proportion opting to use single antigen vaccines
 Socioeconomic and cultural patterns in uptake differ for parents choosing the single antigen vaccines and those not immunising at all
 Interventions to improve uptake should be designed to meet the needs of different groups

vaccine. For the mumps vaccine estimates were 0.3-4.0% and 0.02-4.0%, respectively.

Previous research has shown that single parenthood, area deprivation, and high birth order and family size are associated with lower uptake of MMR.¹¹⁻¹⁴ Our study also found that children who remained unimmunised were more likely to live in a household with greater numbers of children or be living with a single parent. Type of ward (disadvantaged, advantaged, or ethnic) was not significantly associated with uptake. This categorisation, however, is not directly comparable with measures of area deprivation and we were able to take into account individual and household level socioeconomic measures. The adjusted associations of individual and household characteristics with use of single antigen vaccines have not previously been reported.

In previous research, fears over safety, negative publicity, the belief that the risk of side effects outweighs the risk of contracting the disease, and mistrust in professional and government advice were given as reasons by parents choosing not to immunise their child with MMR.^{8,17} Our findings are consistent with these for parents who chose to use single antigen vaccines as well as for those who chose not to have their child immunised at all.

Implications for policy, practice, and research

We estimate that 88.6% of children born in 2000-2 had received MMR by the age of 3 and a further 2.7% had received all three of the single antigen vaccines. Although coverage is relatively high, it remains lower than the estimated level required to ensure herd immunity (over 95%). We know little about the nature and handling and therefore effectiveness of the unlicensed single antigen vaccines. Furthermore, because of the intervals between doses of single antigen vaccines, children are left unprotected for a longer period of time than if they had received MMR. As our data show, a significant proportion of children whose parents choose single vaccines do not receive all three antigens (48%).

We have shown social inequalities in uptake of different vaccines and suggest that a range of interventions might be required to address these inequalities and therefore increase uptake. For most parents who declined MMR it was a conscious decision and it is therefore important to ensure access to evidence based

information about MMR vaccine, tailored to respond to particular concerns, questions, and beliefs of different groups.

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Competing interests: HB and DE have been reimbursed in the past (not in the past five years) by several vaccine manufacturers, for attending and speaking at conferences and conducting research. DE has also provided expert reports for potential litigants in court cases involving vaccines.

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