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Implementation and evaluation of a measles/rubella vaccination campaign in a campus university in the UK following an outbreak of rubella

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SUMMARY

An age shift in rubella infection to young adults has occurred in Scotland since the introduction of a first dose measles, mumps and rubella (MMR) vaccination in 1988 and a second dose measles/rubella (MR) vaccination in 1994/95. The Health Board was alerted to an outbreak of rubella at Stirling University by the notification of 6 cases amongst male students aged 18–28 years with dates of onset between 3 March and 21 March 1996. In response, a MR vaccination campaign was conducted to enhance population immunity to rubella within the university population and to reduce the likelihood of further cases. A total of 1795 students, staff and visitors were vaccinated. Vaccine coverage of 46% was estimated to be sufficient to boost rubella immunity in full time male students in university accommodation to 88·7–91·0%, just above the upper critical level of herd immunity for rubella of 85–88%. Students in colleges and universities in the UK will remain at increased risk of outbreaks of rubella and measles until the cohort who have received a two dose schedule of MR form the bulk of the college population. It may be prudent for tertiary education colleges and other institutions in the UK with young adults living in shared residential accommodation to offer MR vaccination to new entrants, targeting those who have not previously received the vaccine, between now and the year 2000.

INTRODUCTION

Following the introduction in Finland of the two dose measles, mumps and rubella (MMR) vaccination programme of children aged 14–18 months and 6 years in 1982 a shift in the age distribution of these diseases towards older age groups was described [1]. An age shift in rubella infection has also occurred in Scotland [2] since the introduction of the first dose MMR vaccination programme for children aged 12–18 months in 1988 and the second dose measles/rubella (MR) vaccination programme which started with the mass vaccination of school age children in 1994/5 followed by a routine second dose for all 4 year olds. Shifts in the age distribution of these diseases towards older teenagers and young adults has implications for young adults in tertiary education and other institutions (e.g. military establishments and young offenders units). In these institutions large numbers of susceptible individuals live in close proximity in halls of residence and other shared accommodation. Under these circumstances transmission of disease is more likely, which increases the probability that an outbreak will occur. Outbreaks of rubella [3] and measles [4, 5] on campus universities in

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the USA were widely reported during the 1980s and resulted in the introduction of state mandated prematriculation immunization requirements [6]. In the UK outbreaks of rubella in tertiary education and other similar institutions were reported during the first quarter of 1996 [7]. Evaluation of a vaccination programme targeted at groups at risk during a rubella outbreak in a tertiary education setting in the UK has not been previously described.

At the time of the campaign the most recent serosurveillance studies in England and Wales indicated that 16% of men aged 18–20 years old were susceptible to rubella [8] compared with 2% of nulliparous women and 1·2% of parous women [8, 9]. The differential has arisen because boys were not included in the schoolgirl rubella vaccination programme introduced in 1970 and this age cohort was too old for both the first dose MMR programme of 1–2 year olds introduced in 1988 and the MR campaign aimed at 5–18 year olds in schools in 1994/5. From week 5 of 1996 the Scottish Centre for Infection and Environmental Health (SCIEH) reported an unprecedented rise in the number of laboratory confirmed cases of rubella in Scotland [10]. During the first 14 weeks of 1996 there were 370 laboratory confirmed cases of rubella compared with 123 in the whole of 1995 and men aged 15–34 years accounted for 79% of these cases [10].

Although rubella infection in adults can be more severe than in children [11], the principal public health concern is to prevent transmission of rubella virus to susceptible women who are in the early stages of pregnancy. In the UK between 1991 and 1993 confirmed laboratory reports of rubella infection in pregnancy accounted for 19 per 1000 laboratory confirmed rubella cases, declining from 85 per 1000 between 1987 and 1989 [9]. Infection in the first trimester of pregnancy can have devastating effects on the fetus including intrauterine death, spontaneous abortion and congenital rubella syndrome [9]. Of 25 women in the UK identified with confirmed rubella infection in pregnancy in 1993 [9], 9 had been infected by another adult in the household indicating the importance of adult to adult transmission as a route of infection following the introduction of the MMR programme. Thirteen of the 25 presented during the first trimester and all elected for a termination of pregnancy.

The outbreak

Forth Valley Health Board (FVHB) was alerted to an outbreak at Stirling University by the statutory notification of six cases of rubella amongst male students aged 18–28 years. All had dates of onset between 3 March and 21 March 1996 and all lived in university accommodation (four on campus in different halls of residence, and two in residences off campus). Investigations did not reveal a suspected source for the index case of the outbreak in this mobile population. Five of the cases were subsequently confirmed serologically. A further case of rubella in a female student was notified during the first week of April although this case was not subsequently serologically confirmed. In total 13 cases of rubella in students at the university were notified to the Health Board between 1 March and 17 April 1996. Eleven were male and two were female, one of whom was a foreign student. Statutory disease notifications from doctors in the area indicated that there were no cases of rubella notified in the previous year.

The university had 5500 full time students (of whom 2500 lived in university accommodation on or off the main campus) and 1300 full time members of staff. Applying published serosurveillance data on rubella for England and Wales [8, 9] to the university population there were estimated to be 400 rubella susceptible men and 25–50 rubella susceptible women in the student population, so there was potential for a propagation of a large outbreak of rubella, especially amongst those living in university residences.

After consultation with the medical centre providing primary care to the majority of students at the university the Department of Public Health decided that prompt action should be taken to reduce the likelihood of a further extension of this outbreak. Stocks of MR vaccine surplus to the requirements of the 1994/5 schools campaign were available locally and as there was extensive data on the safety of this vaccine in children and teenagers [12, 13], this was the vaccine of choice. The use of a combined MR vaccine would also give protection against future outbreaks of measles, an additional health gain.

METHODS

The aim of the campaign was to enhance population immunity to rubella within the university population (especially those living in shared residences) to a point where further outbreaks of rubella would be unlikely. Specific objectives for the campaign included: (1) to decide which groups should be targeted; (2) to identify appropriate resources of the campaign; (3) to publicise the campaign amongst at risk groups; (4) to evaluate

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coverage of at risk groups; (5) to evaluate the success of the campaign using local surveillance data.

Target groups

A number of options were considered:

(1) *Targeting men only* would reach those at highest risk (male full-time students and staff in the at-risk age groups). Provided sufficient coverage was achieved non vaccinated individuals including non-immune women would be protected. However, as the vaccine of choice was the MR vaccine, if women were not offered vaccination they would be denied protection against measles.

(2) *Targeting all men, and only women who were rubella susceptible* (*identified from vaccination history*) would catch some but not all rubella non-immune women as a small minority of those vaccinated may not have developed protective antibodies [14]. Again, only half the population would be offered protection against measles. Identification of non-immune women by serology is recommended [15] but it is time consuming and would stretch local laboratory facilities and consume significant resources.

(3) *Targeting both men and women* would reach rubella susceptible men and women, and boost immunity in those women vaccinated previously. This approach would provide additional health gain as it would protect both sexes against future measles outbreaks, obviating the need for a second vaccination campaign should an outbreak of measles occur.

Option (3) was chosen. Those invited for immunization were full time male students and staff under 35 years and full time female students and staff under 40 years. Students living in university accommodation were the primary target group for the campaign. However, full-time students living off campus and staff were also invited. Students who had previously been given MR as part of the 1994/5 schools MR campaign were excluded.

Selecting males under 35 years was justified as 79% of confirmed rubella cases reported to SCIEH in the first quarter of 1996 were in this age range. Women under 40 years were selected to cover the group of child bearing age. Initially only academic staff were invited, although after consultation the invitation was later broadened to include all staff.

Resources

The University Principal and Academic Registrar agreed to the campaign and provided publicity and administrative support. An appropriate venue for the campaign was provided on the campus. Staff from the campus medical practice carried out the campaign and recruited extra nursing and clerical staff as needed. The Health Board funded additional staff sessions and equipment costs.

On the basis of the target population and experience from other recent mass vaccination programmes in schools (M. Jakobovic, County Durham Health Authority, personal communication), it was estimated that up to 200 people per hour could be accommodated by 6 teams of 3 staff responsible for the throughput of vaccinees. Each team of 3 consisted of an administrator who greeted the vaccinee, handed out consent forms and took personal details and 2 nurses or doctors who obtained consent from the vaccinee, gave the vaccination and supervised the recovery area. The final timetable comprised 6 evening sessions lasting 3 h each and a longer daytime weekend session lasting 6 h.

The local hospital pharmacy supplied the necessary equipment for the campaign on a daily basis, including cool boxes, anaphylaxis packs, needles, syringes, cotton wool, alcohol swabs and sharps bins. After discussion with the Scottish Office Department of Health the Health Board released existing stocks of MR vaccine left over from the 1994/5 schools MR campaign.

The vaccination sessions were widely publicized within the University. Notices and letters of invitation were distributed to every student in university accommodation, to each academic department and to the term time address of all students off campus. An e-mail message was sent round to everyone using the computing service. Posters were displayed on campus in public areas including the main library and the social areas of each hall of residence. The Students' Association was informed and asked to publicize the campaign. The University Radio Station broadcast details of the campaign and an interview with one of the general practitioners (GPs) from the campus practice. Other GPs in the locality outwith the campus practice received a briefing by fax about the campaign together with a timetable of vaccination sessions. A representative from Occupational Health was also briefed and provided useful feedback.

RESULTS OF THE CAMPAIGN

A total of 1795 students, staff and 'extras' (visitors, partners, spouses) were vaccinated during the campaign. The coverage achieved based on named

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Table 1. *Numbers of people who were vaccinated with MR and coverage by sex, Stirling University, Scotland, 1996**

Target group	Denominator population (based on university address lists)	Number vaccinated	% Coverage achieved
Full-time male students < 35 yr			
Living in university accommodation	1200	548	46
Not living in university accommodation	1020	190	19
All full-time male students < 35 yr	2220	738	33
Full-time male staff < 35 yr	278	19	7
Full-time female students < 40 yr			
Living in university accommodation	1335	578	43
Not living in university accommodation	1337	230	17
All full-time female students < 40 yr	2672	808	30
Full-time female staff < 40 yr	463	23	5

* Based on 1588 vaccinees who were on named denominator lists (excluding 207 'extras' who were not).

denominator lists of full time staff and students in university and other accommodation is shown in Table 1.

Coverage of 46% and 43% was achieved in male and female full-time students living in university accommodation respectively. Coverage was lower in students not living in university accommodation (19% in male students and 17% in female students) and very much lower in staff (7% in male staff and 5% in female staff). Overall coverage of the full-time student population was 33% in men and 30% in women.

Because of student mobility the named denominator lists were not entirely accurate. Of the 207 'extras', many were full-time students resident in university accommodation. Assuming these students had moved into rooms previously occupied by others who were named on the denominator lists, the addition of these vaccinees to the totals increased coverage of male students in university accommodation to 49% and of female students in university accommodation to 46·5%. The estimate of coverage in the total full-time student population increased to 37% in men and 33% in women. In addition, 11 people were vaccinated in the following week by the campus practice.

The predicted effects of the campaign on rubella immunity in the target groups are shown in Table 2. These results assume that 95% of those vaccinated develop protective levels of antibodies against rubella [14] and that the uptake of vaccine is distributed randomly amongst susceptible and immune individuals. The prevalence of antibodies to rubella in each of the groups before the campaign is unknown. Herd immunity levels of levels of 85–88% should be sufficient to prevent wild rubella virus transmission [16]. Since serosurveillance data indicated 16% of men aged 18–20 years old in England and Wales were susceptible to rubella [8] we estimated that pre-vaccination less than 85% of our male target population were immune to rubella.

Taking a low estimate that only 80% of male students were immune before the vaccination programme, MR coverage of 46% in male students in university accommodation with a protective efficacy of the vaccination of 95% [14] will have increased the herd immunity in this group to 88·7% (80% +

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Table 2. *Estimated herd immunity levels to rubella before and after the MR campaign, Stirling University, Scotland, 1996**

Target group	Estimated level of rubella immunity before campaign (%)	Estimated level of rubella immunity after campaign (%)	Level of immunity†
Full-time male students < 35 yr			
Living in university accommodation	80–84	88·7–91·0	A
Not living in university accommodation	80–84	83·6–86·9	B
All full-time male students < 35 yr	80–84	86·3–89·0	A
Full-time male staff < 35 yr	80–84	81·3–85·1	B
Full-time female students < 40 yr			
Living in university accommodation	98–99	98·8–99·4	C
Not living in university accommodation	98–99	98·3–99·2	C
All full-time female students < 40 yr	98–99	98·6–99·3	C
Full-time female staff < 40 yr	98–99	98·1–99·1	C

* Based on coverage calculated using named denominator lists (see Table 1) assuming 95% protective efficacy after vaccination [14].
† Level of immunity: A, now raised above critical level of herd immunity of 85–88%; B, lower estimate of herd immunity after campaign still less than 85%; C, already well above critical level of herd immunity.

(20% × 0·46 × 0·95)), considerably decreasing the likelihood of further outbreaks of rubella s the upper level of critical herd immunity has been achieved.

The estimated herd immunity levels to measles before and after the campaign is shown in Table 3. These results assume a vaccine protective efficacy of 90% [17] and that an upper estimate of 6% of young adults aged 17–24 years are susceptible to measles (N. Gay, PHLS Communicable Disease Surveillance Centre, personal communication). The majority of the cohort are immune through infection in childhood and childhood uptake of single measles vaccine. The estimated level of measles immunity after the campaign was 94·6–96·4% based on vaccine coverage of 44·4% in all full-time male and female students living in university accommodation.

The estimated additional costs of the campaign to the NHS, excluding the fixed costs of the campaign to all the agencies involved (e.g. the time taken for co-ordination and administration), amounted to £14650 or £8.12 per person vaccinated (Table 4).

After completion of the campaign ongoing surveillance of notifications and laboratory reports over the next 3 months revealed 3 confirmed cases of rubella in students, all of whom were male and 2 of whom lived in university accommodation.

DISCUSSION

Uptake of vaccination amongst the total student population initially appeared to be disappointingly low. Previously recognized reasons for low uptake of MMR include previous vaccination, concern about side effects, perceived lack of risk of disease because of previous clinical infection, absence, and refusal [18]. A vaccination programme against measles on a campus university in the USA following an outbreak of 16 cases achieved coverage of 67% (2060/3076) [3]. In the UK a catch up campaign using MMR in South Glamorgan secondary schools following a community outbreak of measles achieved coverage of 43% (7633/17595) [18].

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Table 3. *Estimated herd immunity levels to measles before and after the campaign, Stirling University, Scotland, 1996**

Target group	Estimated level of measles immunity before campaign (%)†	Estimated level of measles immunity after campaign (%)	Level of immunity‡
Full-time male students < 35 yr			
Living in university accommodation	91–94	94·7–96·5	A
Not living in university accommodation	91–94	92·5–95·0	B
All full-time male students < 35 yr	91–94	93·7–95·8	B
Full-time male staff < 35 yr	91–94	91·6–94·4	B
Full-time female students < 40 yr			
Living in university accommodation	91–94	94·5–96·3	A
Not living in university accommodation	91–94	92·4–94·9	B
All full-time female students < 40 yr	91–94	93·4–95·6	B
Full-time female staff < 40 yr	91–94	91·4–94·3	B
All full-time male and female students in university accommodation	91–94	94·6–96·4	A

* Based on coverage calculated using named denominator lists (see Table 1) and a protective efficacy of vaccination of 90% [17].
† Upper estimate based on personal communication N. Gay, PHLS Communicable Disease Surveillance Centre.
‡ Level of immunity: A, now raised above critical level of herd immunity of 93·5–96·0%; B, estimate of herd immunity after campaign between 93·5–96·0%.

However, further analysis of the coverage figures revealed wide variation between the target groups. The highest coverage was achieved in full-time male students in university accommodation, the group most at risk of an extension of the outbreak, followed by full time female students living in university accommodation. Vaccine coverage of 46% was estimated to be sufficient to boost rubella immunity in full-time male students in university accommodation to 88·7–91·0%. This is just above the upper critical level of herd immunity for rubella [14]. Vaccine coverage in all full-time male students of 33% was sufficient to improve estimated rubella immunity to 86·3–89·0%. The boost to herd immunity in the groups most at risk should be sufficient to protect others still at risk from rubella.

Amongst males and females living in university accommodation uptake of MR vaccination was sufficient to boost herd immunity to measles to an estimated 94·6–96·4%. It has been estimated that herd immunity levels of 93·5–96·0% are required to prevent wild virus transmission [19]. This critical level appears to have been achieved. Furthermore entrants to tertiary education from the academic year 1996/7 are increasingly likely to have had MR vaccination as part of the UK schools programme in 1994/5 resulting in maintenance or even an increase in the existing levels of herd immunity to rubella and measles at the university.

Should other institutions consider a similar intervention in the case of a rubella outbreak? This vaccination campaign was successful in raising the level of herd immunity in the groups most at risk of an outbreak to above the critical level. A further factor to

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Table 4. *Total costs of the MR campaign to the NHS, Stirling University, Scotland, 1996**

Item	Cost £
Costs funded by Health Board	
Staff overtime payments (health visitors/practice nurses/reception staff)	3909.25
Equipment from pharmacy	540
Postage (£0·25 × 1450)	362.50
Total	4811.75
Costs funded centrally	
Item of service fees (1805@£5.45) under Statement of Fees and Allowances payable to general medical practitioners in Scotland	9837.25
Total	9837.25
Total cost	14649.00†

* Excluding time taken to organize and co-ordinate the campaign and the cost of the MR vaccine which was provided from existing stocks.
† Equivalent to £8.12 per person vaccinated.

consider is cost. The estimated cost of the campaign excluding the time taken for co-ordination and administration by all the agencies involved was £14650 or £8.12 per person vaccinated. The cost of the campaign can be set against the estimated costs associated with congential rubella syndrome or a termination of pregnancy due to foetal abnormality, a risk associated with a large outbreak in this age group.

Should tertiary education and other institutions consider offering MR vaccination to all new entrants who missed the 1994/5 schools MR programme to reduce the likelihood of outbreaks of rubella and measles on campus over the next few years? Following the introduction of a two dose MMR schedule in Finland in 1982 periodic outbreaks of rubella, especially amongst teenage and young adult males, continued until 1991 [20]. The immunity gap in young adults was recognized and dealt with by a selective vaccination programme of military conscripts aged 18–29 years introduced in 1987 [20]. In the 1980s tertiary education colleges in many parts of the USA introduced state mandated prematriculation immunization requirements (PIRs) to reduce the likelihood of campus outbreaks of vaccine preventable diseases including rubella and measles [6]. Students had to present proof of immunity to vaccine preventable diseases as a prerequirement to matriculation. Colleges with state mandated PIRs were significantly less likely to report measles outbreaks compared with colleges without such a requirement (relative risk = 0·30, 95% confidence interval 0·11–0·86), indicating the effectiveness of PIRs in reducing the likelihood of measles outbreaks. However, unlike the USA, the UK has never had a policy of increasing uptake of vaccination by linking it with entry to school or university.

The cohort of schoolchildren who received MR in the UK schools mass vaccination programme in 1994 will be starting to enter higher education from 1996/7. However many may delay entry for a year and up to a third of students in tertiary education are mature students. It may be prudent for tertiary education colleges and other institutions in the UK with young adults living in shared residential accommodation to offer MR vaccination to new entrants who did not receive MR vaccination whilst at school. How long should this continue for? In the UK, in addition to outbreaks of rubella in institutions 4 clusters of between 2 and 11 cases of measles in 4 universities or colleges have been reported since the beginning of 1996 [21]. Experience in the USA indicates that students in colleges and universities will remain at increased risk of measles outbreaks as a result of imported measles until the cohort who have received a two dose schedule of MR form the bulk of the college population. The MMR was introduced in the UK in 1988 with a catch-up programme for those born between 1983 and 1988. Those born in 1983 will be starting to entering colleges and universities in the year 2000. The immunity gap to measles and rubella amongst students is likely to continue between now and then.

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