QUALITY IMPROVEMENT REPORT

Improving MMR vaccination rates: herd immunity is a realistic goal

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Abstract

Problem As measles is a highly infectious disease, the United Kingdom recommendation is for at least 95% of children to receive a first vaccination with the measles, mumps, and rubella (MMR) vaccine before age 2 years and a booster before age 5 years to achieve herd immunity and prevent outbreaks. Reported vaccination rates for England have improved since a low level in 2003-4. Coverage for London is consistently lower than for England, however, and concerns have been expressed that there could be an epidemic of measles in the capital.

Design Observational time series study.

Setting London Borough of Tower Hamlets.

Key measurements for improvement Uptake rates for childhood vaccinations. The key target was to reach 95% coverage for the first MMR vaccine before age 2 years.

Strategies for change Financial support for the development of geographically based networks of general practices. Commissioning of care packages, incentivising delivery of high quality integrated care with network level vaccination targets of 95%. Innovative use of information technology to enable robust call and recall processes, active follow-up of defaulters, and increased knowledge about the demography of the children most difficult to reach.

Effects of change The development of networks of practices facilitated collaborative working among primary care clinicians and other stakeholders; peer review of achievements; and an element of healthy competition. Uptake improved for all childhood vaccinations, and to herd immunity levels for most. Uptake of the first MMR vaccine before age 2 years rose from 80% in September 2009 to 94% in March 2011.

Lessons learnt Achieving herd immunity for childhood vaccinations is an achievable target in an ethnically mixed, socially deprived inner city borough. The ability to identify characteristics of the difficult to reach groups, including significant differences in uptake across different ethnicities, will allow targeted interventions that may further improve overall coverage.

Vaccination programmes are cost effective and have been shown to reduce health inequality worldwide.[1] As measles is a highly contagious disease[2] it requires vaccination levels to be at least 95% to maintain herd immunity and prevent outbreaks.[3] These levels of vaccination will also be needed to achieve the World Health Organization's goal of elimination of measles worldwide.

The measles, mumps, and rubella (MMR) vaccine was introduced in the United Kingdom in 1988 and the booster dose was added to the programme in 1996.[4] Current recommendations are that every child should receive a first dose of MMR vaccine before the age of 2 years and a booster dose before the age of 5 years.[4]

Uptake for the first dose of MMR vaccine (MMR1) in England reached 92% in 1992, and stayed above 90% until 1998 when rates started falling, down to 79% by 2003.[5] The decline in uptake of the MMR vaccine is thought to be caused partly by safety concerns but also, ironically, by the success of vaccination programmes leading to the impression that these childhood diseases are mild and uncommon.[6] MMR vaccination uptake rates are now increasing in England. However, the effects of the vaccine scare in the UK that followed Andrew Wakefield and colleagues' now discredited 1998 article (which had raised the possibility of a link between MMR vaccine and autism) are still present over a decade later.[7]

Reported rates of uptake of all childhood vaccinations in London remain below those for England.[8] Ongoing low levels of MMR vaccination in London have raised concerns of the possibility of a serious outbreak of measles in the city.[9]

The year 2008 saw the highest number of recorded confirmed cases of measles (1370) in England and Wales since the introduction of disease monitoring in 1995.[10] Most of the cases were concentrated in London.[11] Between 2006 and 2008 the inner London borough of Tower Hamlets had the highest rates of confirmed measles,[12] with 24.6 cases per 100 000 (46 confirmed cases) compared with a national figure of 2 per 100 000.

The problem

The organisation and delivery of childhood immunisation programmes is complex, involving many parts of the healthcare system, including departments of public health, child health services, and information technology systems. Most of the programme in Tower Hamlets is delivered by primary healthcare staff in general practice settings.

A call and recall system improves vaccination rates.[13] Problems with child health information systems in recent years, including the inability to be able to operate a functional call and recall system in some areas, has been detrimental to the UK vaccination programme, especially in London.[14]

Tower Hamlets is one of the five most socially deprived areas in England. Its ethnicity is diverse, with more than

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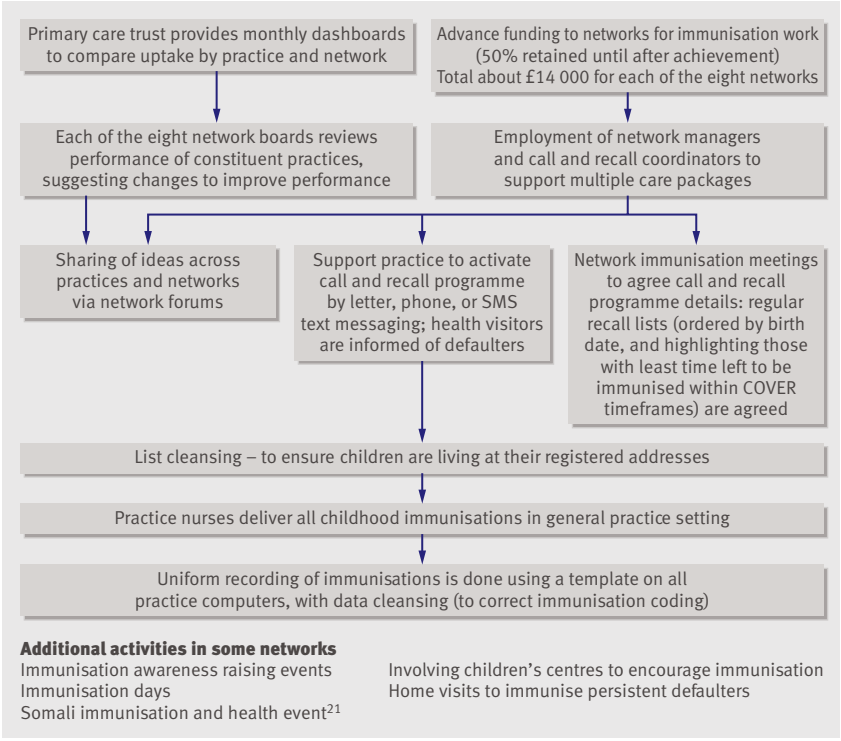

Fig 1 | Components of the immunisation intervention in Tower Hamlets: core components plus additional activities

half the population being non-white, and 30% of the whole population being of Bangladeshi origin.[15] Previous studies have suggested that both deprivation and large numbers of children from black and minority ethnic groups make achieving high rates of vaccination more challenging.[16] High growth rate and mobility of the population in London are also cited as contributory factors to low vaccination rates.[8]

The health gain from achieving high uptake levels for all childhood vaccinations is well recognised. Improving the rates of childhood vaccination has been a long term priority for NHS Tower Hamlets and recorded rates of immunisation were already higher than those for London as a whole. However, uptake of the MMR vaccine has remained below that of other childhood vaccinations. There was particular interest within the Department of Public Health in focusing on increasing MMR vaccination rates to 95% to prevent further outbreaks of measles in the borough.

Key measures for improvement

The target was borough-wide uptake rates of 95% for all childhood vaccinations. MMR vaccination was given high priority because of the potential risk of further measles outbreaks. The level of coverage with the MMR1 vaccine before 2 years of age was actively tracked and chosen as an early marker for the success of the intervention.

Process of gathering information

We used routinely collected data from the Health Protection Agency's COVER programme (Cover Of Vaccination Evaluated Rapidly) to assess trends in annual uptake rates of the MMR vaccine for London and England.[5]

We used COVER quarterly reports to monitor trends in rates of uptake before and after the intervention in Tower Hamlets, compared with London and England.[17] We used EMIS Web (www.emis-online.com/emis-web-for-gps) to collect immunisation data and other demographic data (age, sex, social deprivation, and ethnicity) from all the 36 general practice surgeries in Tower Hamlets for each child who had their second birthday during the period January to December 2010.

Analysis and interpretation

We used Stata version 10 (www.stata.com/stata10/) for all the data analysis. We used regression analysis to assess if there was significant change in uptake of the MMR1 vaccine before and after the intervention by comparing the slopes on the graphs of vaccination uptake by quarter.

The importance of recognising differences between population groups and of targeting the groups with more barriers to vaccination has been urged previously.[18] Using the high levels of ethnicity recording (97%) in the population of under 5s, we did an analysis using bivariate statistics to examine differences in MMR vaccine uptake by ethnic group.[19] We did logistic regression analysis to determine whether the likelihood of receiving the MMR1 vaccine differed by ethnic group after adjustment for sex and social deprivation (measured using individual level Townsend scores based on the 2001 census).

Strategy for change

NHS Tower Hamlets was part of a Department of Health Integrated Care Pilot Programme,[20] which promoted new ways of working together to achieve sustainable improvements in the quality of patient care. The programme has focused on the development of care packages. These are aimed at improving the management of long term conditions along with other priority areas, such as childhood immunisation, and has provided additional investment in primary care in Tower Hamlets, recognised as an under-resourced area of London.

Practices are incentivised to work in geographically based federated clusters, called networks, aligned with local authority boundaries. Each of the eight networks consists of four or five practices that work together towards achieving targets for newly commissioned network care packages. Funding for the employment of managers and coordinators has enabled networks to build an infrastructure to support collaboration between practices and with other local stakeholders, such as the local authority, children's centres, schools, and voluntary organisations.

Commissioning the immunisation care package required strong clinical and management engagement and leadership involving the director of public health, primary care trust managers, and clinical champions (including a public health nurse and a general practitioner clinical lead). These key individuals were part of a wider team promoting the importance of high levels of vaccination. Fig 1 illustrates the core and optional components of the intervention.

A small financial incentive for achieving herd immunity (95%) across all childhood immunisations was introduced for networks. This amounted to £112 000 (€130 400; $177 700) in total, split across eight networks with 50% paid in advance, and 50% dependent on performance. This was in addition to the existing funding through the

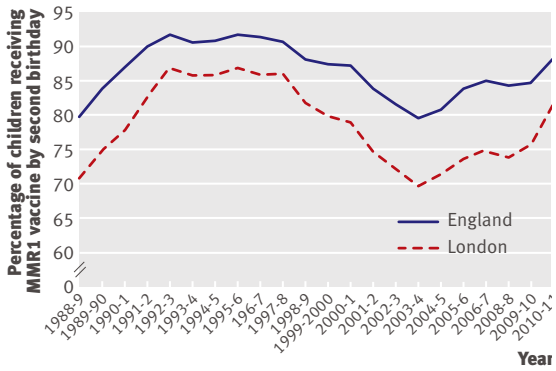

Fig 2 | Annual uptake of MMR1 for England and London 1988-2010 (note that the y axis effectively starts at 60). Data source: Health Protection Agency[5]

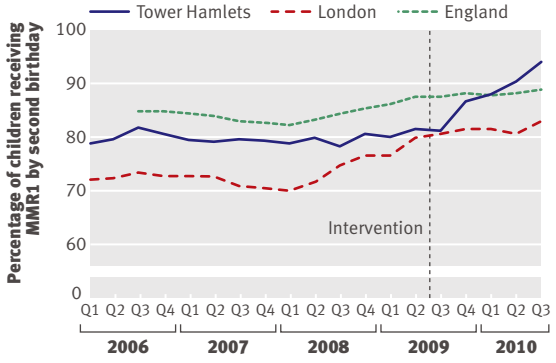

Fig 3 | Quarterly uptake (shown as Q1-4) of the MMR1 vaccine for Tower Hamlets 2006-10 compared with London and England (the number of children aged under 2 years in Tower Hamlets, December 2010, was 8188). Data source: Health Protection Agency's quarterly COVER data where Q1 is April-June (www.hpa.org.uk/Topics/InfectiousDiseases/InfectionsAZ/VaccineCoverageAndCOVER/EpidemiologicalData/VaccineCoverage DataTables/)

Directed Enhanced Service for childhood immunisation in England, which rewards at 70% uptake, but with a higher reward rate for 90%.

The 95% targets were for all childhood vaccines to be given within COVER timeframes, more challenging targets than those issued by the Directed Enhanced Service. For example, the MMR1 vaccine needs to be given before the age of 2 years to be counted in COVER, but the Directed Enhanced Service allows it to be given up to the third birthday. These differences were not previously well understood by practice staff. Multidisciplinary training was provided to meet this and other identified learning needs as part of the introduction to the new care package.

Robust information technology (IT) systems and good data quality formed a key part of the strategy. Coding of vaccination was standardised with the use of a template to aid data entry. With all practices using the medical software EMIS, Tower Hamlets has been an early adopter of EMIS Web. This allows centrally written searches to be used at the level of primary care trusts, networks, and general practices. Networks are able to run their own systematic call and recall programmes using centrally designed searches set for the UK immunisation programme and COVER timeframes. Defaulter lists can be produced regularly. Using EMIS Web for call and recall has removed the need to rely on child health IT systems that have not been fit for purpose in this respect.[14] Using credible data direct from practices to report local vaccination figures has been important for clinician engagement.

EMIS Web also enabled centralised monitoring of immunisation, with figures produced for networks on a monthly basis. Dashboards indicated how many more children needed to be immunised to reach 95%, often illustrating the small number of additional children needed to reach the target. Peer review of practice and network figures was encouraged, along with sharing ideas for reaching groups of defaulters. An element of healthy competition has developed. Support was offered to those practices and networks that seemed to be struggling.

An active patient management approach is encouraged, taking inspiration from the success of such an approach in the Heart of Birmingham Teaching Primary Care Trust.[22] This emphasises active follow-up and direct contact with defaulters, now made possible with accurate defaulter lists.

The first wave of the child health immunisation care package was introduced in September 2009 to three of the eight networks and subsequently rolled out to the other five from January 2010.

Effects of change

Rates of uptake for all childhood vaccination have increased, reaching over 95% for most childhood immunisations. Tower Hamlets now has the highest rate of all London boroughs for the MMR1 vaccination given before the age of 2 years, not quite at the target of 95% but achieving 94% in the third quarter of 2010-1.[17] Fig 2 illustrates the general trends in MMR1 vaccination rates from 1988 to 2010 for England and London.

Fig 3 shows that uptake of the MMR1 vaccination in Tower Hamlets was at a plateau of about 80% from 2006 to 2009 but has risen steeply since the start of the intervention. Although rates have also increased for London and England, there seems to have been a step change in Tower Hamlets' performance after the intervention, which was introduced just before the third quarter of 2009.

Regression analysis shows that before the intervention there was a non-significant decrease of 0.07% in uptake of the MMR1 vaccine per quarter in Tower Hamlets; after the intervention, the uptake increased by 1.86% every quarter. A comparison of the two slopes indicates that they are significantly different from each other ($P<0.001$, 95% confidence interval 1.47 to 2.24).

To explore the effect of ethnicity on immunisation, we calculated the absolute percentage of MMR1 vaccination for all children reaching their second birthday during the period January to December 2010. Fig 4 shows that the South Asian group had the highest proportion of children vaccinated within the COVER period (93.61%). Focus group work by Tower Hamlets Primary Care Trust before the intervention indicated concerns in the Somali community about the MMR vaccine.[23] Feedback from practices also suggested that Somali children were hard to reach. When Somali children were treated as a separate ethnic group, we found that only 56% of Somali children had been vaccinated within the COVER period.

We used odds ratios to determine whether the likelihood of receiving the MMR1 vaccine differed significantly by ethnic group (see the appendix). As the South Asian group is the

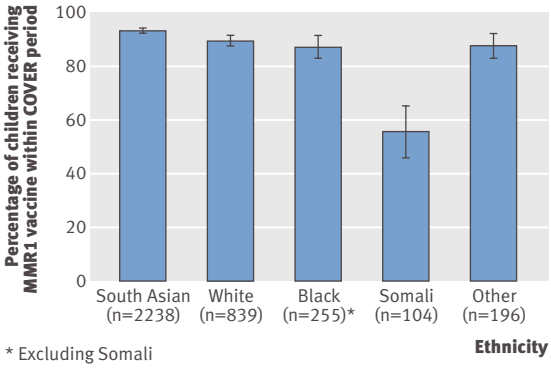

Fig 4 | Crude proportion of children receiving the MMR1 vaccine within the COVER period, by ethnicity

* Excluding Somali

largest, we used this as the reference category. After adjustment for sex, social deprivation, and clustering by practice, our analysis shows that the likelihood of having received the MMR1 vaccine by age 2 years is significantly lower for all ethnic groups than for South Asian children. The likelihood of MMR1 vaccination by age 2 years is 45% lower for white children (odds ratio 0.55, 95% confidence interval 0.43 to 0.72) and 76% lower for Black African and Caribbean children (including Somali) (0.24, 0.17 to 0.33). When Somali children were treated as a separate category, the likelihood of these children receiving the MMR1 vaccine by age 2 years was 92% lower than for South Asian groups (0.08, 0.06 to 0.12).

Lessons learnt

Herd immunity is an achievable goal for all childhood vaccinations including the MMR vaccine. High levels of vaccination are achievable in ethnically diverse, deprived, and mobile inner city populations.

The experience in Tower Hamlets contrasts with previously published work on vaccination uptake in black and minority ethnic groups and areas with high levels of deprivation.[16] The achievement of high levels of vaccination echoes the view of the Heart of Birmingham Teaching Primary Care Trust that good organisation is the key to success.[22]

Around the time of this intervention other initiatives in England were aiming to increase vaccination rates. A national MMR "catch-up campaign" was launched in 2008, and in 2009 the Health Protection Agency and the National Institute for Health and Clinical Excellence published guidance on ways to reduce differences in immunisation uptake.[9 24] However, the reported figures suggest a step change in Tower Hamlets over and above the upward trends for other areas over this period.

Identifying which element of this complex intervention made the difference is difficult. However, building from a practice-wide base of consistent coding, the introduction of systematic call and recall across the practice networks is likely to have been crucial. Individual practices may have been operating their own call and recall system before this intervention, but many were not.

The practice networks encouraged clinicians and network coordinators to share experiences and find solutions to cope with a high turnover of patients in a highly mobile population. Providing the networks with regular feedback on performance led to some healthy competition, with networks seeking to improve uptake in different ways. For example, in some networks, call and recall was at network level, in others it was at practice level. A range of methods to follow up defaulters was developed, such as telephone or text reminders, involving health visitors, children's centres, and schools. Some networks held immunisation events; some arranged home visits for the hard to reach.

THE EXPERIENCE OF ONE TOWER HAMLETS PRACTICE

Initially our practice was sceptical about improving our MMR immunisation rate from its regular 80% position. We already sent out monthly recall letters and worked with our health visitors. So what could we do differently?

The practice immunisation team (practice nurse, general practitioner, and administrator) met weekly with the network coordinator to really understand the COVER timeframe. Ordering children for recall by their birth date helped us understand the number of children we had to contact this week, this month, next month. All general practitioners helped to clean the practice list of families who had moved, checking with health visitors and schools if necessary. The practice administrator chivvied receptionists to send reminders (via phone or SMS texts) for all clinic appointments. Every person who failed to attend an appointment was contacted directly after the clinic by phone and given another appointment. We agreed that children could be vaccinated at any time, not just during baby clinic sessions.

After three months of agonised fumbling, and many tense meetings, the system clicked into place and results began to improve towards 95% for all immunisations. Now that the process is working smoothly, the vaccination system is no more costly to run than before, and brief fortnightly meetings maintain a light touch on a slick system.

For us the key to change was systematic support from the network with practice tailored recall lists, and a clean registered patient list. Alongside this was a laudable public health target and a small financial stimulus. We are confident this is an improvement we can maintain.

Sally Hull, general practitioner

Next steps

A national debate is needed to decide whether the Directed Enhanced Service for childhood immunisation in England should be brought in line with COVER's timeframes to ensure greater shared understanding of the data on immunisation uptake. It seems sensible for public health and primary care to be using the same variables to measure vaccination uptake rates.

Using ethnicity data to identify subgroups within the childhood population that may need further help with vaccination uptake illustrates the value of ethnicity recording at practice level.[19] In Tower Hamlets, focus group work with Somali parents suggests that fear of autism has played a part in their concerns over the safety of MMR vaccination.[21 23] Some evidence suggests an increased prevalence of autism in the Somali population,[25 26] and this may have heightened concerns. Clinicians within Tower Hamlets suggest that some Somali parents delay the MMR vaccination rather than decline altogether. Understanding the reasons for higher rates of vaccination in the South Asian population may provide further ideas for improving rates nationally.

How sustainable is the improved performance? The fact that this intervention was not a one-off, catch-up campaign, but rather a long term programme investing in primary care teams, infrastructure, collaborative working, and the embedding of systematic processes may mean that improvements will be sustainable. Ongoing monitoring suggests this is the case, and Tower Hamlets now has the highest rates of immunisation across the whole of London for all childhood immunisations, including MMR vaccination.[17]

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UNCERTAINTIES PAGE

How does the level of BCG vaccine protection against tuberculosis fall over time?

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WHO estimates that in 2009, 9.4 million people developed tuberculosis and 1.7 million died of the disease worldwide. [1] In the UK, incidence has risen over the past two decades; most cases are in vulnerable groups such as migrants, people who are homeless, or those with a history of imprisonment.[2] Bacillus Calmette Guérin (BCG) vaccine offers 70-80% efficacy against severe forms of tuberculosis in childhood, particularly meningitis in infancy.[3 4] When given later in life, efficacy against tuberculosis (which, in adults, commonly presents as pulmonary disease) varies in different regions of the world, for reasons that are not clearly understood.[3 5] The failure of BCG to protect adults in some populations—in particular in some studies in India[6]—has sometimes been wrongly generalised to suggest that BCG never protects against pulmonary disease. However, the Medical Research Council trial established that use of BCG in school age children in the UK was highly effective against tuberculosis (80%).[7]

On the basis of criteria from the International Union Against Tuberculosis and Lung Disease,[8] universal BCG vaccination of school children with a negative tuberculin skin test (aimed at preventing the peak of tuberculosis in young adults in the UK) was discontinued in 2005. Current policy recommends vaccination in infancy of children in high risk groups to prevent severe forms of childhood tuberculosis,[9 10] and this practice is cost effective.[4] Uncertainty remains, however, about how long the protection afforded by BCG vaccination lasts.[11] This uncertainty has implications for the cost effectiveness of vaccination at later ages and for the role of a new vaccine.

An intensive search is in progress for a new vaccine that would work under circumstances in which BCG does not, possibly used together with BCG, or as a booster after BCG, with 12 candidates currently being evaluated.[12] The process of development, testing, and delivery of a new vaccine requires a thorough understanding of the mechanism behind protection against tuberculosis, including reasons for variation in protection, duration of protection, and the magnitude of waning, and whether previous BCG vaccination might interfere with the action of a new vaccine.[13]

This is one of a series of occasional articles that highlight areas of practice where management lacks convincing supporting evidence. The series adviser is David Tovey, editor in chief, the Cochrane Library. This paper is based on a research priority identified and commissioned by the National Institute for Health Research's Health Technology Assessment programme on an important clinical uncertainty. To suggest a topic for this series, please email us at uncertainties@bmj.com

What is the evidence of uncertainty?

We searched Pubmed and Embase for articles and systematic reviews on the duration of protection by BCG. This analysis is limited to a selection of studies with relevance to UK policy based on a previous systematic review[11] and our knowledge of the general literature on BCG efficacy. The previous systematic review, which included nine randomised controlled trials of high quality, found no evidence of substantial protection against tuberculosis after 10 years from BCG vaccination.[13] Lack of evidence of protection, of course, is not the same as evidence of lack of protection. However, we note from recently published data the possibility of longer BCG protection: additional comprehensive follow-up of a trial in North American Indians found that protection against disease of about 50% was present 40-50 years after vaccination.[14] A cohort study in Brazil with good follow-up found efficacy of 48%, 15-20 years after neonatal BCG vaccination.[15] Other studies that were not included in the previous systematic review contained further relevant evidence. Of particular interest is a case-population study in the UK, in which information about BCG vaccination or absence of previous latent tuberculosis was available for people with tuberculosis and for the general population, allowing comparison of disease rates in a vaccinated and an unvaccinated uninfected cohort. This study showed 59% protection at 10-15 years after vaccination at school age.[16]

Is ongoing research likely to provide evidence?

A search of the Cochrane database and of clinical trials registers (WHO's international clinical trials registry platform, which includes several national databases, current controlled trials, and the UKCRN portfolio database) did not identify any ongoing or recently completed trials. A Cochrane systematic review entitled *Infant Bacillus Calmette-Guerin (BCG) Immunisation and Duration of Protection Against Tuberculosis* was registered in 2008, but we found no accompanying protocol or published review.

There are two ongoing projects commissioned by the National Institute for Health Research (Health Technology Assessment): a new systematic review of all trials and observational studies; and a series of case-control studies undertaken to estimate BCG protection against tuberculosis in the UK, up to 25 years after school age vaccination and up to 17 years after neonatal vaccination. Although case-control studies can be vulnerable to selection and information bias, this approach addresses the research question in the shortest possible time in countries with a low burden of tuberculosis.

RECOMMENDATION FOR FURTHER RESEARCH

Populations—Adults and children at risk of tuberculosis

Interventions—BCG vaccination

Comparisons—Vaccinated and unvaccinated individuals in a randomised controlled trial, but the sample size required would be too high given the relatively low incidence of TB in the UK; there are also ethical issues. Alternatively, cases of tuberculosis and controls in a case-control design. In high burden countries, a cohort design may be feasible (although there would be ethical issues) but would require a long period of follow-up, by which time a new vaccine might be available.

Outcome—Level of BCG protection against active tuberculosis with time since vaccination

What should we do in the light of uncertainty?

Clinicians should be aware of and support the current policy of infant BCG vaccination for those at higher risk.[10] The best estimate of duration of protection by BCG is currently about 10 years, with recent data suggesting that the vaccine may protect for longer, although the level of protection seems to fall with time. People vaccinated 10 years or more before coming into close contact with infectious tuberculosis might have no BCG derived protection against active disease. BCG does not protect when given to people who are already infected, and revaccination of individuals after initial vaccination does not seem to offer substantial additional protection.[17] We therefore do not recommend repeat vaccination, even in people travelling to countries with a high tuberculosis burden.

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