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**Effectiveness of interventions
to improve the uptake of immunisation
in primary care, with specific focus on
Mumps, Measles and Rubella (MMR)**

Dr Jane Morrell, Dr Serena McCluskey, Steve Lui,
and Professor Annie Topping

June 2009

EXECUTIVE SUMMARY

Background

There has been a decade of MMR vaccine uptake which is below the threshold for herd immunity for measles and large numbers of children are unprotected. The number of measles cases in England is now rising (DH, 2008). The Department of Health has issued a letter about the urgent action needed to reduce the risk of a measles epidemic. PCTs are following DH guidance in conducting MMR catch up programmes to increase uptake to 95% to gain herd immunity for the population, as well as increasing the overall immunisation coverage.

Objectives

We carried out a rapid review of published studies to assess the evidence of the effectiveness of interventions to promote uptake of immunisation, with a particular emphasis on MMR. We also included studies which assessed healthcare professionals' issues relating to immunisation and studies which examined parents' concerns and issues that influenced decision making associated with vaccination.

Search Strategy

We searched electronic databases MEDLINE (1966 – 2009), CINAHL (1982 – 2009), DARE, EMBASE (1980 – 2009), NHS EED, CENTRAL, HTA, and the CRDS, PsycINFO (1985 – 2009). Results from reviews, published papers, and citations were used.

Selection criteria

Eligible studies were randomised trials, economic evaluations, ecological studies, surveys, interviews and focus groups, published by 2009.

Data collection and analysis

We identified 1313 articles possibly satisfying our search criteria and included 80 in the review.

Main results

This review has identified from published research, associations with groups where coverage for MMR is likely to be lower, children are more likely to be partially

immunised, have a delay in immunisation, receive a single vaccine or are unlikely to immunise at all. The review has also identified interventions which may be effective in a primary care context, as well as some interventions which are likely to be ineffective. The review has identified some of the concerns and problems among primary care practitioners, specifically GPs, health visitors and practice nurses. Furthermore, the review has found information about why parents have concerns about immunising their infants and some of the reasons they choose not to immunise.

Conclusions

Strategies can be introduced in primary care to increase the uptake of immunisation, particularly MMR. These include training, audit and feedback for health care professionals and reminder systems for parents.

Recommendations

Our recommendations are therefore as follows:

1. Education for health care professionals should be a priority to address parental concerns,
2. Practices should use a strategic approach to maximise uptake of immunisations,
3. Practices should accurately record immunisation uptake, including single antigens, and use computers for identifying parents who need to be reminded,
4. Practice should use a postal reminder, followed by a telephone call to parents,
5. Practices should perform regular audit with feedback to all health care professionals involved in immunisations,
6. Practices should consider collaborating with schools to plan 'mop-up' vaccination days.
7. Practices should consider initiating interventions with regard to looked after children and refugees and immigrants.

We strongly recommend that interventions which are newly introduced should be evaluated, ideally using a mixed methods approach, with a randomised controlled trial and qualitative evaluation, to capture evidence of an uptake of immunisation along with the perspectives of parents and health care practitioners.

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BACKGROUND

Vaccines work by stimulating the immune system to develop antibodies to combat infections, without the recipient suffering from the disease itself. The aim of vaccination is to offer protection to the recipient, who therefore becomes less likely to infect others, reducing the risk to others who have not been vaccinated.

This concept of population or herd immunity means that if there is a high level of immunity because a large enough number of a given population have been immunised, the remaining unimmunised members of the population will receive some protection from infection. This is because the antibodies in the immunised individuals will inactivate the virus and prevent it from being passed on to unimmunised people. The levels of uptake required for herd immunity varies for different diseases and depends on how contagious the disease is and on the conditions which allow it to spread. For a disease which is highly contagious and where the average age of infection is younger, the higher the proportion of people required to be immune, before the non-immune people can be protected by herd immunity. It is possible to calculate the proportion of people who should be vaccinated to prevent the disease from spreading. For example, the herd immunity threshold for measles is 92% - 95%, for rubella is 83% - 90%, and for polio is 80% - 86% (WHO, 2009). In this way people who cannot be immunised, because they are immunocompromised, for example due to cancer treatment, organ transplantation or have a weak immune system, also receive some benefit (Salisbury et al, 2006).

Where there are high levels of population immunity from high coverage, diseases such as diphtheria can be eliminated, so long as high vaccination coverage is maintained. In 1980 because of vaccination, smallpox was declared eradicated. In a similar way the World Health Organization is aiming to eradicate poliomyelitis.

In 1940, before the introduction of vaccination programmes: 409,281 children contacted measles, 53,607 contacted whooping cough, and 46,281 contacted diphtheria. In 1989, there were 24,570 cases of rubella, and 20,713 cases of mumps (Yarwood et al, 2005).

The UK immunisation programme

The overall aim of the routine childhood immunisation programme is to achieve and maintain high vaccination coverage to protect all children against the following preventable childhood infections: Diphtheria, tetanus, pertussis (whooping cough), Haemophilus influenzae type b, polio, meningococcal serogroup C, measles, mumps, rubella and pneumococcal.

In England there have been a series of changes to the immunisation programme. MMR vaccine was introduced in 1988, Hib was introduced in 1992, combined DTP-Hib in 1996, MenC in 1999, and DtaP pre-school booster was introduced in 2001. Two doses of the MMR vaccine are recommended to ensure immunity, as about 15% of vaccinated children fail to develop immunity from the first dose (WHO, 2008).

The schedule for routine childhood immunisations in the UK is shown in Table 1.

Table 1: Schedule for the routine childhood immunisation programme 2009
(Source: NHS Immunisation Service, 2009)

When to immunise	Diseases protected against	Vaccine given
Two months old	Diphtheria, tetanus, pertussis (whooping cough), polio and Haemophilus influenzae type b (Hib) Pneumococcal infection	DTaP/IPV/Hib + Pneumococcal conjugate vaccine, (PCV)
Three months old	Diphtheria, tetanus, pertussis, polio and Haemophilus influenzae type b (Hib) Meningitis C	DTaP/IPV/Hib + MenC
Four months old	Diphtheria, tetanus, pertussis, polio and Haemophilus influenzae type b (Hib) Meningitis C Pneumococcal infection	DTaP/IPV/Hib + MenC + PCV
Around 12 months	Haemophilus influenza type b (Hib) Meningitis C	Hib/MenC
Around 13 months old	Measles, mumps and rubella Pneumococcal infection	MMR + PCV
Three years and four months or soon after	Diphtheria, tetanus, pertussis and polio Measles, mumps and rubella	DTaP/IPV or dTaP/IPV +MMR
Girls aged 12 to 13 years	Cervical cancer caused by human papillomavirus types 16 and 18.	HPV
13 to 18 years old	Diphtheria, tetanus, polio	Td/IPV

Uptake of first immunisation

Vaccine uptake is generally high for first immunisation. Table 2 shows the variation in uptake of first immunisation by PCT in Yorkshire and The Humber, compared with the whole of England 2008.

Table 2: Percentage of children immunised by their 1st birthday, by Government Office Region and PCT, October - December 2008 (Source: Health Protection Agency, 2009)

Government Office Region and PCT	Number of children	DTaP/IPV /Hib %	MenC2 %	PCV2 %
Sheffield PCT	1699	90.1	89.4	88.9
Leeds PCT	2256	91.7	91.3	91.1
Doncaster PCT	965	92.7	92.5	93.0
North Yorkshire & York PCT	1694	93.2	92.6	91.1
Yorkshire & the Humber	15957	93.4	93.0	92.7
Bradford & Airedale PCT	2121	93.7	92.7	92.5
Rotherham PCT	786	93.8	93.4	93.5
Kirklees PCT	1391	93.9	94.1	94.0
Hull PCT	914	94.0	93.5	94.1
Calderdale PCT	679	94.0	94.0	94.1
North Lincolnshire PCT	467	94.0	94.4	94.0
Wakefield District PCT	1012	94.4	94.0	93.7
North East Lincolnshire PCT	501	94.6	94.8	94.6
Barnsley PCT	715	96.8	96.8	96.8
East Riding of Yorkshire PCT	757	97.6	97.4	97.4
England	164228	91.6	91.0	91.1

Measles

Measles is one of the most highly communicable infectious diseases and one death will occur in every 5000 cases in the UK (Salisbury et al, 2006). About 100 deaths per year occurred before 1968 when the measles vaccine was introduced (Salisbury et al, 2006). Measles results in otitis media in 7-9% cases, pneumonia in up to 6% of cases, diarrhoea in 8%, and convulsions in <1% of cases (Salisbury et al, 2006). Encephalitis is a less frequently occurring complication. Children less than one year and teenagers and adults are more likely to die from measles than children aged one to nine years. Children who are more poorly nourished, chronically ill or immunosuppressed are also more likely to suffer a fatal measles infection.

The WHO and UNICEF are collaborating to reduce global measles deaths by 90% by 2010. The strategy includes:

1. Strong routine immunization: for children by their first birthday.
2. A 'second opportunity' for measles immunization through mass vaccination campaigns, to ensure that all children receive at least one dose.
3. Effective surveillance in all countries to quickly recognize and respond to measles outbreaks.
4. Better treatment of measles cases, to include vitamin A supplements, antibiotics if needed, and supportive care that prevents complications.

Uptake of MMR

Until the late 1980's coverage remained low so measles continued to be a major cause of morbidity and mortality, until the measles, mumps and rubella vaccine was introduced in 1988. In the early 1990's coverage levels of 90% or more were associated with very low levels of notification of measles (Salisbury et al, 2006). In the UK in 1994-1995, a mass immunisation campaign with a measles and rubella vaccine (MR) was aimed at children aged 5-16 years. Immunisation uptake for MMR peaked in 1995 at 92% for two-year olds (Pearce et al, 2008).

In 1998 a paper was published by Wakefield and others in the Lancet proposing a link between MMR and Crohn's disease, and then there was a purported increased risk of autism in children vaccinated with MMR compared with unvaccinated children. A retraction of the interpretation of the data was published in The Lancet in 2004. A

systematic review of 31 articles has concluded that exposure to MMR was unlikely to be associated with Crohn's disease, ulcerative colitis, autism or aseptic meningitis (Jefferson et al, 2003; Demicheli et al, 2005). The DH now says there now overwhelming evidence that MMR is not associated with autism (DH, 2009).

The media were found to have a powerful effect and parents were strongly influenced by the perceived risk that a vaccine carries (Yarwood et al, 2005). An association with the adverse effects of a local evening newspaper campaign which began in July 1997 in Wales, was observed when the uptake of MMR declined in the distribution area of the newspaper by 13.6% (95% CI, -16.2% to -10.9%) compared with the rest of Wales, which saw a 2.4% reduction in uptake (95% CI, -5.5% to -1.4%) (Mason & Donnelly, 2000).

Uptake of MMR fell by 10% from 92% in England in 1995/6 to 82% in 2002/3, which is below the herd immunity threshold for measles (92% - 95%) with regional variations, for example, 58% in Kensington and Chelsea and 92% in West Cumbria (POST, 2004). Between January and March 2008, in the UK, MMR uptake for children reaching 24 months of age was 84.1% vaccine coverage (HPA, 2008).

Measles epidemics arise from a combination of factors, such as the age structure of a population, social and spatial arrangement and the season of transmission. A most important predictive factor is the reproductive number, which is proportional to the fraction of the population that is not immunised and depends on the average size of outbreaks. As the reproductive number approaches 1, this indicates that a large measles outbreak is increasingly likely (Jansen 2003). The estimated reproductive number was 0.47 for 1995 – 1998 and was 0.82 for 1999 – 2002 (Jansen 2003). As the proportion of unvaccinated individuals increases, a further increase in the reproductive number will possibly lead to endemic measles and the concomitant mortality (Jansen 2003). In this way parents increase the risk of exposure to measles by choosing not to have their infants immunised (Jansen 2003). There have been local outbreaks of measles where MMR uptake is low (POST, 2004).

Before 1998, MMR uptake was lower among children born to single parents, and those in larger families in more deprived socially areas (Pearce et al, 2008). Since 1998, uptake has declined among more affluent areas (Pearce et al, 2008).

Some parents have chosen to use single vaccines for measles, mumps or rubella or use no vaccine at all (Wright et al, 2005). These separate vaccines are not available through the NHS and their uptake through the private sector is not recorded in routinely collected statistics (Wright et al, 2005). At least 5.2% of three year old children in the Millennium Cohort study had received at least one of the single antigen vaccines (Pearce et al, 2009) whilst 17.5% of all mothers in a study in Brighton reported that they had chosen single mumps measles and rubella antigen vaccines, available privately or from overseas (Cassell, 2006). Children in England would require 21 single antigen injections rather than seven combined injections by the age of 15 months (Tickner, 2006). Only a quarter of children might receive all three measles, mumps and rubella vaccines (Casiday, 2006) indicating that the combined administration schedule might prove more efficient, easier to remember and less distressing for infants and their mothers (Tickner, 2006).

Measles outbreaks

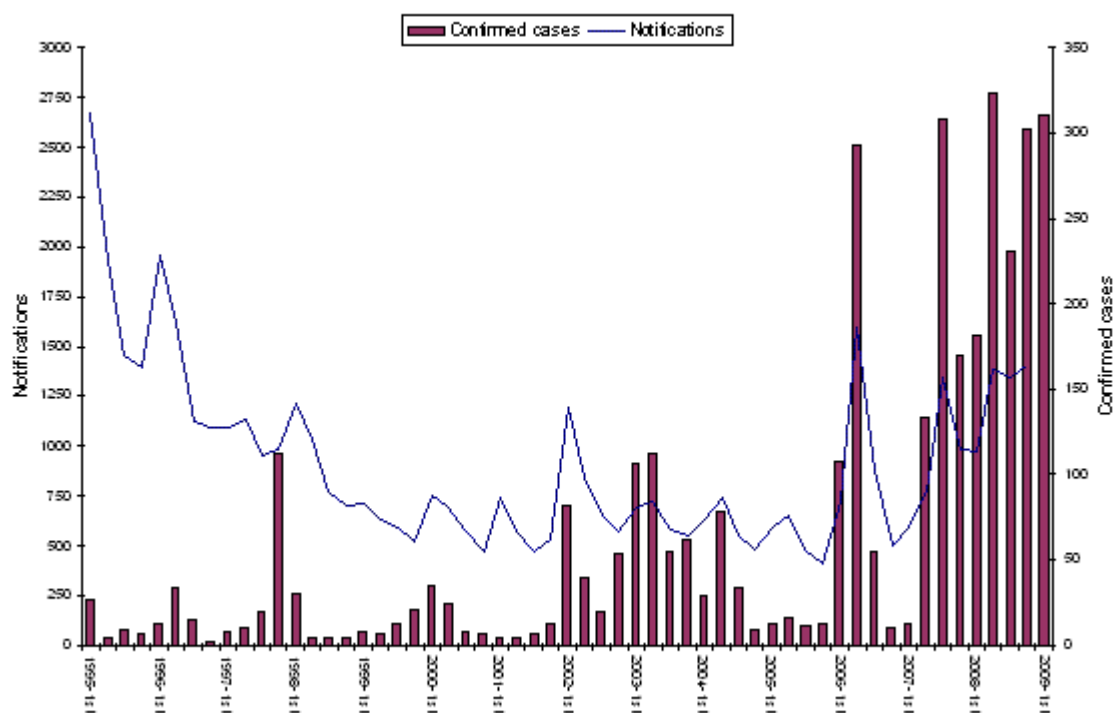
The impact of disproportionate adverse publicity on the uptake of the MMR vaccination programme has been well described (Ramsay et al, 2002) and the drop in the uptake of vaccine has been associated with a number of measles outbreaks in England and Wales since 1998 (Jansen 2003). In the North East of England up to May 2009, 53 cases of measles had been confirmed and more than 100 suspected cases were being investigated. This number is greater than the total number of cases reported for the whole of the previous year in the North East (HPA, 2009). Table 3 shows the number of confirmed cases of measles in England and Wales in 2008 and Figure 1 illustrates graphically the increase in the number of cases over time from 1995.

Table 3: Confirmed cases of measles by region, 2008 (Source: Health Protection Agency, 2009)

Age group	NE	NW	Y&H	EM	WM	EE	Lon	SE	SW	W	NK	Total
< 1y	2	10	3	4	8	7	59	16	3	0	0	112
1-4y	4	59	20	17	25	18	154	29	12	7	0	345
5-9y	2	46	13	8	30	18	140	32	7	8	0	304
10-14y	7	32	6	3	17	19	124	19	5	11	0	243
15-19y	1	9	1	8	9	14	74	9	6	6	0	137
20-24y	0	8	0	3	4	6	48	4	0	4	1	78
25-29y	1	5	2	3	7	2	21	4	2	1	0	48
30-34y	0	5	3	1	5	6	21	7	2	2	0	52
>=35y	0	5	2	1	8	0	23	8	4	0	0	51
Total	17	179	50	48	113	90	664	128	41	39	1	1370

Note: Lon=London, Y&H=Yorkshire & Humberside, EE=East of England EM=East Midlands, WM=West Midlands, W=Wales.

Figure 1: Notifications (confirmed cases) 1995-2009 by quarter (Health protection Agency, 2009)



For the Yorkshire and Humberside region, in 2008 cases of measles comprised 3.6% of all cases in England and Wales. In the first quarter of 2009, the 15 cases confirmed in Yorkshire and Humberside comprised 4.3% of all confirmed measles cases in England and Wales.

Table 4: Number of laboratory confirmed measles cases by age group and regional health authorities with onset dates in January to March 2009: England and Wales (Source: HPA, 2009)

Age group	NE	NW	Y&H	EM	WM	EE	Lon	SE	SW	W	NK	Total
< 1y	0	9	0	1	7	0	6	5	0	0	0	28
1-4y	0	12	2	6	11	9	23	29	4	3	0	99
5-9y	1	2	5	1	11	0	26	31	1	7	0	85
10-14y	0	5	5	0	7	1	22	23	1	5	0	69
15-19y	0	4	1	0	4	0	10	11	0	3	0	33
20-24y	0	3	0	0	2	0	2	6	0	0	0	13
25-29y	0	1	0	1	1	1	1	1	0	0	0	6
30-34y	0	0	1	0	2	2	4	1	0	0	0	10
>=35y	0	2	1	1	0	0	2	2	1	0	0	9
Total	1	38	15	10	45	13	96	109	7	18	0	352

Note: Lon=London, Y&H=Yorkshire & Humberside, EE=East of England EM=East Midlands, WM=West Midlands, W=Wales.

As well as an increase in the number of confirmed cases of measles, Table 5 illustrates the increase in the number of confirmed cases of mumps in England and Wales.

Table 5: All laboratory confirmed cases of measles, mumps & rubella, England and Wales, 1996 - 2008 (Source: HPA, 2009)

Year	Measles	Mumps	Rubella
1996	112	94	3922
1997	177	182	117
1998	56	121	119
1999	92	373	162
2000	100	730	62
2001	70	784	45
2002	319	500	64
2003	437	1541	16
2004	188	8129	14
2005	78	43378	29
2006	740	4420	34
2007	990	1476	35
2008	1370	2440	27

Mothers' attitudes

A series of surveys began in 1991 to track mothers' knowledge, attitudes and experiences of immunisation (Yarwood et al, 2005; Smith et al, 2007) as well as measure their recall and interpretation of advertising and immunisation materials. These surveys have captured the evolving attitudes since the height of the MMR controversy and found that the MMR vaccine remains the main vaccination issue for parents, but the proportion of parents who believe the MMR risk is greater than the disease has fallen from 24% in 2002 to 14% in 2006 (Smith et al, 2007). Also the proportion who have said the MMR was completely safe has risen from 60% in 2002 to 74% in 2006 (Smith et al, 2007). However, the proportion of parents who reject MMR has remained stable at 6%.

Suboptimal uptake is not exclusive to MMR as a substantial proportion of children also miss their primary DTP vaccination (Ticknet et al, 2006) or do not complete the full course.

SUMMARY

There has been a decade of MMR vaccine uptake which is below the threshold for herd immunity for measles and large numbers of children are unprotected. The number of measles cases in England is now rising (DH, 2008). The Department of Health has issued a letter about the urgent action needed to reduce the risk of a measles epidemic (DH, 2008) and PCTs are following DH guidance in conducting a MMR catch up programme (DH, 2008), seeking to increase MMR uptake to 95% to gain herd immunity for the population, as well as increasing the overall immunisation coverage.

AIM AND OBJECTIVES

The primary aim of this rapid review was to undertake a comprehensive literature review of interventions aimed at improving immunisation uptake, with a focus on MMR, followed by evidence based recommendations on how to improve MMR uptake.

In addition to the main study aim, our objectives were to answer the following questions:

What are the main issues for health care professionals in maximising immunisation uptake?

What are the conditions associated with low uptake of immunisations?

What do parents think about having their children immunised and what do they consider are the main barriers to having their infant immunised with MMR?

METHOD

Our broad search aimed to identify all studies relevant to the study main aim and objectives.

Types of studies

We included comparative prospective and retrospective studies, economic evaluations, surveys, and qualitative studies.

Participants

Health care professionals or parents were included in the studies.

Types of intervention

We included reviews of office-based interventions and client-oriented interventions intended to maximise the uptake of recommended immunisations. We also included studies of interventions in schools and hospitals.

Types of outcome measures

Immunisations uptake and seroprevalence.

Search methods for identification of studies

We searched the Cochrane Central Register of Controlled Trials (CENTRAL) and MEDLINE to identify randomised controlled trials. The search terms were adapted and used in the other electronic databases: CINAHL, DARE, Embase, PsycLIT, NHS EED, HTA, the Cochrane Controlled Trials Register and the Cochrane Database of Systematic Reviews. Results from reviews, published papers, and citations were used to perform citation searches of identified studies.

Data collection and analysis

Selection criteria

We included studies in which MMR uptake was an outcome. The broad categories used meant that the review covered:

- Systematic reviews and reviews of primary research,
- Evaluations of interventions,
- Economic evaluations,

- Ecological studies,
- Non-intervention studies, such as surveys of health care professionals, examining factors associated with immunisations uptake,
- Non-intervention studies of parents examining factors associated with immunisations uptake,
- Evidence from qualitative studies.

Whilst not providing evidence of the effectiveness of a particular intervention to maximise immunisation uptake, further ecological studies and qualitative studies were included in the review to highlight the factors affecting uptake.

Exclusion

We excluded studies: which were not written in English, of immunisation uptake in developing countries; of interventions aiming to increase the uptake of HPV vaccine, hepatitis B and BCG for tuberculosis; and of interventions which were undertaken in prisons. Papers were not included in the review if they: were personal opinions and comments, described non-systematic reviews, were policy documents, or single case studies.

RESULTS

The results from 80 studies are grouped under the following headings:

1. Systematic reviews and reviews of primary research,
2. Evaluations of interventions,
3. Economic evaluations,
4. Ecological studies,
5. Non-intervention studies, such as surveys of health care professionals, examining factors associated with immunisations uptake,
6. Non-intervention studies of parents examining factors associated with immunisations uptake,
7. Evidence from qualitative studies.

1. Evidence summary from systematic review and meta-analyses

Data from 13 earlier reviews reporting from 1994-2005 were included (Table 1).

These studies examined:

- audit and feedback,
- computers in primary care consultations,
- factors affecting the uptake of immunisation,
- home visiting,
- immunisation delivery methods,
- lay health workers,
- office-based interventions,
- patient reminder and recall systems, and
- target payments.

The conclusions from these studies were that:

- Audit and feedback alone may be an effective strategy for improving immunisation rates but the number of well conducted studies is small and the effect is variable, so further well designed studies are needed to identify independent effects (Bordley et al, 2000).
- Computers in primary care consultations improves immunisation rates by 8-18% and other preventive tasks by up to 50% (Sullivan & Mitchell, 1995).

- There is no evidence that home visiting is effective in increasing uptake of immunisation (Elkan et al, 2000).
- Greater coverage rates were found:
 - for MMR with system-orientated interventions than client-orientated interventions;
 - personalised mailed reminders or health care;
 - practitioner-initiated telephone calls;
 - providing feedback on practice;
 - for influenza when aimed at hospital populations;
 - for pneumococcal, client-or system-orientated hospital interventions for high-risk patients (Gyorkos et al, 1994).
- For lay health workers, there were promising benefits in promoting immunisation uptake and improving outcomes for acute respiratory infections and malaria, when compared to usual care (Lewin et al, 2005). Lay support can be effective in increasing the uptake of vaccination, but because of differing cultural and sociodemographic factors, effects could be less marked when applied to British populations (Whittaker, 2002).
- Office-based interventions, particularly multiple interventions deserve continued development and enhancement (Anderson et al, 1998).
- Patient reminder and recall systems in primary care settings are effective in improving immunization rates in developed countries (Jacobson Vann et al, 2005).
- There was strong evidence of the effectiveness of population based interventions: client reminder or recall, multicomponent interventions, education, reducing out-of-pocket costs for vaccination, expanding access as part of a multi-component intervention, assessment and feedback for providers. There was sufficient evidence of the effectiveness of vaccination requirements for child care, school, and college attendance (in USA), interventions in Women, Infant and Children settings, and home visiting interventions (Briss et al, 2000).

- There was not enough evidence on whether target payment remuneration was associated with improvements in immunisation rates (Giuffrida et al, 1999).
- Unintended effects associated with MMR, exposure was unlikely to be associated with Crohn's disease, ulcerative colitis, autism or aseptic meningitis (Jefferson et al, 2003; Demicheli et al, 2005).

2. Evidence summary from intervention studies

Data from eight intervention studies reporting from 1998 – 2005 were included (Table 2). These studies examined the effectiveness of:

- A school immunisation programme,
- An evidence based decision aid,
- Catch-up and scheduled immunisation during hospital admission,
- Health visitor or mail follow-up,
- Medical education with improvement of “office systems”,
- Posting the MMR – The Facts leaflet to parents,
- Providing information on a) benefits and risk of immunisations, b) the role of emotional factors, and c) the focusing procedure,
- Teddy bears wearing T-shirts displaying a website address.

The conclusions from these studies were that:

- A school immunisation programme was effective due: to a dedicated team, the active follow-up of all defaulters, a comprehensive database made available to schools; availability of telephone numbers; a dedicated telephone line, avoidance of deferral for minor illness (Joyce-Cooney et al, 2003).
- A web based evidence based decision aid significantly improved parental attitudes to MMR vaccination (Wallace et al, 2005).
- Hospital provides the opportunity for catch-up and scheduled immunisation and can contribute to the health care of an often disadvantaged group (Conway et al, 1999).
- There may be some benefit from targeting young or primiparous mothers (Morgan & Evans, 1998).
- Continuing medical education combined with process improvement is effective in increasing rates of delivery of preventive care to children (Margolis, et al, 2004).

- More complex intervention than posting the MMR – The Facts leaflet to parents is required to influence the immunisation behaviour of parents (Mason & Donnelly, 2000).
- Providing information on a) benefits and risk of immunisations, b) the role of emotional factors, and c) the focusing procedure combined, as part of an antenatal decision aid, may increase the uptake of on time childhood immunisation. Further research is needed to improve understanding of the decision change (Wroe, et al, 2005).
- Teddy bears wearing T-shirts displaying a website address was not effective in influencing MMR uptake (Porter-Jones et al, 2008).

3. Evidence summary from economic evaluations

Data from 12 economic evaluations published from 1985-2004 were included (Table 3). These studies examined the cost-effectiveness or cost-benefit of:

- DTP, Hib, polio, MMR and varicella vaccination in the USA,
- Two-dose MMR vaccination in the USA,
- Computer-generated reminder letters for MMR,
- Parent notification or reminder systems for DTP,
- Seroprevalence or re-vaccination for measles,
- Routine varicella vaccination strategies for 12-18 months olds, 12- and 20-29 year olds in the USA,
- MMR screening and vaccinating medical students in Switzerland,
- Double vaccination programmes for rubella, aged 1-3 years and 6-9 years, in Japan.

The conclusions from these studies were that:

- The routine childhood vaccination schedule of DTP, Hib, polio, MMR and varicella in the USA is cost saving, and prevents substantial morbidity and thousands of deaths (Zhou et al, 2001). The two-dose MMR vaccination programme in the USA was highly cost-beneficial and resulted in substantial cost savings (Zhou et al, 2004). The combined MMR vaccine programme in an epidemiological cohort model in the US, in 1983, was assumed to be clinically equivalent with lower costs than a programme using separate antigens (White et al, 1985). The two-dose MMR vaccination in the USA, substantially reduces the pool of susceptible children but the cost of seroconversion was high (Watson et al, 1996).

- A letter followed by a telephone call was the most cost-effective option to improve the immunisation uptake among unimmunised children (Lieu et al, 1998). The use of computer generated recall letters to privately insured families with underimmunised children of 20 months of age improved immunisation delivery (Lieu et al, 1997). A recall system based on an autodialer in small private physicians' offices in the USA, was effective especially with a fully operational immunisation registry (Franzini et al, 2000). Vaccine coverage for pre-school children can be increased by the repeated use of automated parent notifications until the child is two years of age (Dini et al, 2000).
- In the USA, varicella antibody testing and vaccination may be cost-effective for adults of any age who are unlikely to have immunity, or who have a greater risk of developing chickenpox or its complications testing followed by vaccination of adults aged 20-29 (Smith & Roberts, 2000). The optimum feasible varicella prevention strategy in Germany, is to vaccinate 15-month old children and use catch-up vaccination for 12-year olds (Beutels et al, 1996).
- A targeted programme of MMR screening and vaccination for medical students in Switzerland was effective in increasing the immunisation rate (Germann & Matter, 1991).
- A double vaccination programmes in Japan, where the 1st vaccination was administered aged 1-3 years and the 2nd vaccination was based on the results of a urine test of children at primary school, aged 6-9 years, was the most effective strategy in improving the rate of rubella antibody detection. However, it was the most costly programme, but sensitive to the cost of urine antibody testing (Terada et al, 2000).

4. Evidence summary from ecological studies

Data from 17 studies which used existing data, for example, from Child Health Information Systems, Immunisation and Recall System and a cohort study and were published 3 earlier reviews reporting from 1995 – 2009 were included (Table 4).

These studies, mainly of MMR examined:

- The affect of adverse publicity on MMR uptake,

- Susceptibility to MMR in Ireland,
- Progress of a 'catch-up' programme in Wales,
- General practice factors associated with MMR coverage,
- Uptake of combined MMR and single antigen vaccines,
- Primary immunisation status and MMR uptake,
- Factors associated with partial immunisation,
- Continuity of care and MMR,
- Uptake of pre-school booster,
- MMR and older siblings,
- MMR uptake by ethnic group,
- MMR uptake and social deprivation,
- Call or recall systems,
- Neighbourhood uptake of MMR in Canada,
- Under-reporting of MMR in Sydney, Australia,
- MMR uptake among 10-11 year olds and HepB uptake among 13-14 year olds in Australia.

The conclusions from these studies were that:

- Having a strategic approach and easy access is important for general practices (Lamden & Gemmill, 2008). Immunisation records need to be up-to-date (Hawker et al, 2007). Strategies are needed to improve accurate reporting of coverage (Lawrence et al, 2003). Reminders of immunisation appointments and more accessible opportunities might be successful (Pearce et al, 2008). Practical suggestions include: Improving access to clinics, reducing inconveniences, home immunisation, flexible clinic times, flexible locations (Reading et al, 2004). In Seattle, USA, greater continuity of care is associated with MMR uptake (Christakis et al, 2000).
- MMR uptake varies between ethnic groups, with the lowest uptake in Black Caribbean children and the highest in Asian children, so ethnic data should be uniformly collected (Hawker et al, 2007). The greater the deprivation, the greater the tendency for late vaccination, especially in the most deprived category (Friederichs et al, 2006). The lowest rates of MMR coverage remain in urban areas, particularly inner cities, which also tend to show high levels of deprivation

(Wright et al, 2005). Social differentials in uptake could be used to inform targeted interventions to promote uptake (Pearce et al, 2008). Effective targeting of children living in deprived electoral wards could improve pre-school booster uptake (Evans & Thomas, 1998). Public health resources should continue to target inner city areas (Wright et al, 2005).

- Lone parenthood was identified as an important independent risk factor in London for non-completion of immunisation at 12 months, whilst unemployment may facilitate uptake as the parent does not have to take time off work to attend the clinic (Sharland et al, 1997). In Canada, there are significant inequalities in uptake which may be due to access to health centres, lack of a car or lack of support for single mothers (Avis et al, 2007). Practical help with child care may help (Reading et al, 2004). Targeting families for a domiciliary immunisation service may improve coverage (Sharland et al, 1997).
- Children who remain unimmunised with primary vaccines are also more likely not to receive MMR (Pearce et al, 2009). Infants with older siblings are less likely to be immunised on time (Reading et al, 2004).
- Children remain susceptible to infection because of parents' decision not to immunise (Pearce et al, 2008). Mothers of unimmunised infants differ in age and education from those of partially immunised infants (Samad et al, 2006a). Strategies are needed to address parental knowledge about the MMR (Lawrence et al, 2003). Ready access to evidence-based information about MMR is needed, tailored to particular concerns and beliefs of different groups (Pearce et al, 2008). Tailored information or improved access may help (Pearce et al, 2009). Practical suggestions include addressing concerns in immunisation advice in an unbiased and reasoned way (Reading et al, 2004). Different approaches are needed for different mothers (Samad et al, 2006a). Public health resources should focus on the concerns of the better educated about vaccine safety (Wright et al, 2005).
- The 'catch-up' programme may not have reached all the children in Wales in 1998 who most needed to be immunised (Thomas et al, 1998).

- Relatively little was known about the adolescent immunisation MMR and hepatitis B target population in Australia (Skinner et al, 1998). Further consideration was needed about the delivery in schools, clinics or by GPs (Skinner et al, 1998).
- A primary school top-up programme appeared to be necessary in Dublin in 1995 (Johnson et al, 1995). In Australia, school entry requirements appeared to be a primary driver for the 2nd MMR (Lawrence et al, 2003).

5. Evidence summary from studies of health care professionals

Data from four studies reporting from 2001 – 2008 focussed on assessing healthcare professionals' views in relation to immunisation uptake were included (Table 5). An overview of the concepts explored in these studies is presented below:

- Knowledge, attitudes and practices, particularly related to the 2nd MMR dose,
- Confidence in the vaccine following media coverage,
- Concerns about vaccine safety,
- Benefits of vaccination,
- Confidence in discussing issues with parents,
- Further training in vaccination issues.

Knowledge about vaccine

There appears to have been a significant fall in confidence about the MMR vaccine, in relation to safety and adverse side-effects, amongst healthcare professionals. Two studies that explored knowledge and attitudes towards the 2nd dose of MMR in particular found that a large number of healthcare professionals were unsure of the need for a 2nd dose, and that more research was warranted (Smith et al, 2001; Petrovic et al, 2001). A large proportion of practice nurses thought there was a link between MMR and Crohn's disease or autism, and one fifth of GPs reported that they had not read the relevant guidance on MMR (Petrovic et al, 2001).

Confidence with parents

The GP's role in education would appear to be central but many are afraid that broaching the subject with parents would put them off vaccination altogether (Pareek & Pattison, 2000). Health visitors and practice nurses were most often nominated as the best source of immunisation advice, with more health visitors reporting feeling

confident about discussing the vaccine with parents, compared to GPs (Petrovic et al, 2001). However in one study, practice nurses and health visitors reported less confidence than GPs (Smith et al, 2001). In all the studies, it was cited that 'further training on immunisation issues' was required.

Summary of recommendations from health care professionals' questionnaires

Further education initiatives should include all healthcare professionals involved in immunisation. Educational sessions may be combined with other measures shown to be effective, including reminders to doctors about children requiring vaccination, and assessment and feedback to practices on the vaccination coverage of children registered with them;

6. Evidence summary from surveys or questionnaires of parental views

Data from fifteen studies found to be relevant exploring parental views on immunisation, both from those groups who had and had not had their children immunised, were extracted (Table 6).

The parental studies explored the following concepts:

- Knowledge, attitudes and concerns of parents who had not completed immunisation,
- Comparing views of triple versus single vaccines,
- Reasons why parents choose not to vaccinate,
- Parental beliefs about MMR,
- Social and cultural influences, and health beliefs associated with low uptake,
- Intentions to vaccinate,
- Factors associated with non-uptake of the 2nd dose of MMR,
- Factors relevant to immunising and non-immunising parents and the extent to which these factors predicted decisions,
- Understanding of vaccine-preventable diseases, immunisation policies and practices,
- Concerns about vaccine safety.

Findings from the parental studies can be summarised into the following categories:

Information

A common finding was that parents lacked confidence in sources of information regarding the MMR vaccine. There appears to be an element of mistrust of the advice given by healthcare professionals, the government and through the media. Children's healthcare providers or GPs were often cited as the most important & trusted source of information about MMR (Pareek & Pattison, 2000; Gellin et al, 2000), but in one study, the most common source of information on side-effects of the vaccine was found to be the television (Pareek & Pattison, 2000). Another study found that 'non-acceptors' of the 2nd MMR dose were more likely to report having received information from newspapers or TV, and more likely to report having a lot or some influence from these media (Petrovic et al, 2003). One study reported that the influence of current research and the helpfulness of information packs significantly predicted vaccination status (Gellatly et al, 2005).

Vaccine safety

The majority of parents have concerns regarding the safety of the MMR vaccine (whether they choose to have their children immunised or not), but those parents who decline the vaccination tend to have stronger views on the overall practice of immunisation, with some perceiving it as an 'overload' for their child's immune system (Gellin et al, 2000). One study found that fewer mothers intended to take their children for the 2nd MMR vaccination compared with the 1st dose, expressing more negative beliefs about the vaccine outcome, safety and efficacy (Pareek & Pattison, 2000). The most common reason cited for not accepting the 2nd dose in another study, was that 'the child had had one dose already and that this was deemed enough' (Petrovic et al, 2003).

Risk

Perception of risk was often explored in these studies, and those parents who choose not to vaccinate their children with MMR often cited that they thought the vaccine was more risky than any of the illnesses that can occur. The importance of eradication of rubella was found to significantly predict vaccine uptake in one study (Gellatly et al, 2005). Another study reported that parental decisions were explained by emotion-related variables, specifically 'anticipated responsibility and regret', and that decisions are strongly influenced by the idea 'that harm that occurs as a result of

deciding to immunise is less acceptable than harm that occurs as a result of deciding not to immunise' (Wroe et al, 2005).

Perceived knowledge

A greater proportion of parents with unvaccinated children reported they had some 'knowledge' of MMR, but in fact they had less accurate information about the vaccine (Alfredsson et al, 2004). One study reported that 'non-compliers' were significantly more likely to have attended public meetings on immunisation, had read books on MMR and seen documentaries. Significantly more of these parents had also consulted a homeopath. Rejection of the vitamin K injection routinely offered at birth, was also strongly associated with non-uptake (Cassell et al, 2006).

Summary of recommendations from surveys or questionnaires of parental views

- Parents require information that is up-to-date, tailored to their individual needs and provided by healthcare professionals who are well informed;
- Communication efforts should focus on clarifying and reaffirming parents' correct beliefs about immunisation and on modifying misconceptions;
- School entry and at times when other vaccinations are given would be a good opportunity for catch-up;
- Educational campaigns need to emphasise the safety of MMR and the danger of vaccine-preventable diseases, but which also emphasise the efficacy of the vaccine and delineate the rationale behind the two-dose schedule;
- Science stories could be turned into 'narratives' that are interesting, accessible and informative;
- Healthcare professionals have to take time to listen to and discuss parental concerns, and it needs to be taken into account that parental knowledge or views may not be based on scientific data.
- A 'diagnostic analysis' should be undertaken to identify obstacles to change, and that any intervention planned should be targeted at overcoming them.

Whilst the above findings are helpful, it is important to acknowledge that questionnaires and surveys have methodological limitations and care should be taken when interpreting results. Limitations found in the studies reported here were:

- Low response rates,

- Non-response bias (i.e. survey not representative),
- Questionnaires not validated or piloted,
- Recall bias,
- Instruments not culturally appropriate,
- Lack of robust statistical analysis.

7. Evidence summary from qualitative studies

Fourteen papers relating to nine qualitative studies were identified that were relevant to the aims of the review were included (Table 7). The majority examined parents' decision making associated with first dose of MMR (MMR1) vaccination and the concerns and issues that influenced the decision-making process. One paper (Morgan et al, 2003) focussed specifically on parents of children exposed during a measles outbreak in a nursery school and their responses to offers of MMR vaccination. The studies identified cover Scotland and England but no qualitative papers were identified from Wales or Northern Ireland. Two papers (Morgan et al, 2003; Petts & Niemeyer, 2004) used mixed methods but only the qualitative data is reported in this summary. Four papers (McMurray et al, 2004; Brownlie & Howson, 2005a; Brownlie & Howson, 2006; Poltarak et al, 2005), analysed the views of health care professionals (HCPs) involved in immunisation specifically health visitors (HVs) and general practitioners (GPs) in addition to parents. Three papers specifically targeted recruitment of Asian (Petts & Niemeyer, 2004; Mixer et al, 2007), Afro-Caribbean (Mixer et al, 2007) and Orthodox Jewish parents (Henderson et al, 2008).

A striking feature of all the papers was that few, if any, parent approached the subject of immunisation and particularly MMR without some degree of fear which reflects the enormous public health challenge this presents.

The key narratives that emerged from the studies were:

- Lay understandings of immunity,
- Mumps, measles and rubella memory,
- Parental choice versus responsibility to others,
- Good and bad parents,
- Interpreting information to assess risk, probabilities and judging truthfulness,
- Role of Social networks in MMR talk and decision making ,

- Distrust of health care professionals,
- Distrust of government and public health ,
- Impact of the media in constructing distrust.

Lay understandings of immunity

A number of narratives emerged that diverge from the professional message of increased protection offered by immunisation. A child's immune system was considered in most parental accounts as essential to overall health, but inherently fragile, susceptible to stress (Evans et al, 2001) and vulnerable to threats (Poltarak et al, 2005). Hence children in general, and some children specifically, need protection, e.g. those with premature births, those with allergies, asthma and, or eczema, (Poltarak et al, 2005; Casiday, 2007). Protecting a child from immunological threat is a parental responsibility and any decision to vaccinate involves weighing up the individual child's ability to cope with the assault. Parents as the expert of their child are the only ones able to judge that ability to cope, the child's 'particularity' (Poltarak et al, 2005). Parents recognised that some children were healthy and some vulnerable (Raithada 2003; Poltarak et al, 2005; Casiday, 2007; Skea et al, 2008), this dichotomy was significant in terms of hardiness to cope with the effects of vaccination and/or building greater resistance through exposure to infectious diseases. Healthy children, not all children, were identified by some as the ones that should contribute to public health of others through immunisation (Skea et al, 2008).

The routinisation of childhood immunisation had traditionally created a confidence based on its ordinariness; this trust had been broken in the UK by the Wakefield controversy (Brownlie & Howson, 2005). This loss of trust in immunisation is not unique to the UK. For example vaccine controversies exist in the US linked to oral polio vaccine and preservatives used in the Hepatitis B vaccine (Daniels, 2002). Combined vaccines were perceived as presenting greater threat due to the magnitude of the immunological burden (Casiday 2007), thus overloading immature immune systems, particularly the vulnerable. There was much confusion across the studies surrounding the single versus combined vaccines. Injection of foreign 'disease' based substances for some parents was symbolically a powerful negative image (Henderson et al, 2008). However these arguments were far from consistent as many parents had accepted DPT at an earlier point. The threat posed by the MMR

vaccine was perceived as greater (Hilton et al, 2006b) than DPT. One explanation offered was that parents are more vaccine naïve when DPT is offered and therefore more likely to be vaccine compliant; whereas later after they have been exposed to 'MMR talk' (Poltarak et al, 2005; Brownlie & Howson, 2005; Henderson et al, 2008) they more likely to adopt the position that MMR immunisation posed a threat to their child.

Mumps, measles and rubella memory

The perception of threat from vaccine-preventable infections could be considered a successful outcome of public immunisation programmes (Raithada et al, 2003; Hilton et al, 2006a). In a number of the studies parents had reported contracting one or more of the conditions in childhood and most saw them as minor illnesses (Evans et al, 2001; Morgan et al, 2003; Hilton et al, 2006a). Acquiring minor illnesses was seen by some as contributing to building natural immunity (Evans et al, 2001; McMurray et al, 2004) and acquiring measles meant (erroneously) that MMR immunisation was unnecessary (Morgan et al, 2003). Experience of (McMurray et al, 2004), or knowledge of the serious side effects of measles (Petts & Niemeyer, 2005; Skea et al, 2008) such as deafness positively influenced uptake of MMR1 for some, and was particularly important in informing decisions to immunise among Asian parents (Mixer et al, 2007). Experience of measles, including outbreaks, failed to alter resistance to MMR immunisation for some (Evans et al, 2001; Morgan et al, 2003).

Some confusion appeared to exist about what exactly German measles was. Some parents were unclear if it was the same disease as rubella whereas others the preface 'German' was a slang term for measles (Hilton et al, 2006a). Some parents felt they were deceived into agreeing to immunise their sons against rubella as they would not get pregnant in later life and therefore it did not pose a health risk (Hilton et al, 2006). Mumps was not seen as a serious disease (McMurray et al, 2004), indeed more a childhood rite of passage and somewhat comical. It was linked by some parents with male infertility (Evans et al, 2001; Hilton et al, 2006a) and therefore seen as more significant for boys to receive protection than girls. All these arguments were more likely to be offered by parents in favour of single vaccine immunisation programmes (Brownlie & Howson, 2005). Learning about mumps, measles and rubella 'sold' MMR immunisation to parents (Petts and Niemeyer, 2004).

Parental Choice and responsibility to others

A parent's own child's health took priority over any responsibility to others (Casiday, 2007). Some factors such as informed rejection of Vitamin K at birth may be a predictor of MMR1 rejection (Poltarak et al, 2005); as might exposure to autism and, or MMR diseases might influence MMR1 acceptability (McMurray et al, 2005).

Making an assessment of whether their child was healthy rather than vulnerable contributed to a parent acting for the greater good by accepting their responsibilities to public health and herd immunity (Skea et al, 2008). Information plus an opportunity to quiz experts appeared to increase understanding of the benefits of mass vaccination for population protection (Petts & Niemeyer, 2004).

Good and bad parents

A good parent (to parents) was one that made the right immunisation decision for their child (Casiday, 2007). An aspect of making the right decision, and therefore being a good parent, was weighing up the probability of their child being vulnerable to any adverse outcomes of immunisation (Casiday, 2007). That said, some immunisers judged those parents who chose not to immunise 'healthy' children as bad parents (Skea et al, 2008) as they had greater responsibility to others.

Very few parents reached a decision about MMR vaccination on moral, religious or ideological grounds (Brownlie & Howson, 2005). Religious beliefs predicated on notions of no personal control over events did not protect parents from worrying about making the right decision (Petts & Niemeyer, 2004).

Some parents felt they were judged, by GPs and social services as good or bad by their willingness to comply with MMR immunisation invitations, (Poltarak et al, 2005). Indeed GPs perceived non-compliance or chronic immunisation default was greater among the poor whereas evidence suggests that MMR uptake decline was greater in affluent areas (Brownlie & Howson, 2006). Parents felt that if they asked questions they would be seen as being a nuisance by HCPs. Indeed one informant whose child was immunised reported "I'm sure they've got it on my file, "neurotic mother"." (Evans et al, 2001). Parents who participated in social network with other parents, such as Toddler Groups, were more likely to be perceived positively by others if they at least

discussed the risks, engaged in MMR talk, from immunisation. Parents who chose not to immunise and their child subsequently developed an infectious disease felt exposed to criticism from others (Raithatha et al, 2003).

Interpreting information to assess risk, probabilities and judging truthfulness

Decision-making around immunisation does not appear to be fixed; rather parents change their position over time, respond differently to some vaccines and make separate decisions for each child (Evans et al, 2001; McMurray et al, 2004; Henderson et al, 2008). No position was perceived as risk free, or safe, and decision-making involved navigating the territory of risk (Petts & Niemeyer, 2004; Casiday, 2007). Balancing the relative probabilities of autism versus measles were factors, but other risks such as social concerns (being perceived as a bad parent), or other health issues such as allergies were factors.

Information to assist decision making was insufficient, unreliable and health professionals, particularly GPs, unavailable to discuss concerns (Evans et al, 2001; Nagaraj, 2006). Information generally did not meet needs as truthfulness was judged on credentials (source), messenger, ease in which information could be incorporated into existing understandings and then applied to the discrete decision (McMurray et al, 2004).

Role of social networks in MMR talk and decision making

Autonomy and personal choice are significant issues surrounding pregnancy and for many it is the first significant engagement with balancing risk and choice in the context of personal health care. Once parents' birth experiences and managing ongoing choice are intertwined as is the experience of being with other parents (Poltarak et al, 2005). Other parents were seen as impartial sources of evidence, having no hidden agendas and their accounts were accessible and believable (Hilton et al, 2007). Paradoxically in another study they were perceived as poor sources of trustworthy information but important sources (Petts & Niemeyer, 2004). Nevertheless parenthood is a time when parents, most frequently mothers, engage in talk with others similarly placed. The relationship between talking about MMR and building relations with other mothers resulted in a failure to challenge concerns voiced by others about MMR safety. To not show concern about vaccine safety was

to be different (Poltarak et al, 2005) particularly when to bracket out uncertainties requires adopting a position of faith.

Mothers and parents are subject to MMR babble through which they navigate. This talk comes from multiples sources and is often conflicting and confusing. In MMR decision-making they have to make a 'leap of faith' and suspend belief in a particular position; suspension occurs within relationships and networks (McMurray et al, 2004; Petts and Niemeyer, 2004; Brownlie & Howson, 2005; Poltarak et al, 2005; Henderson et al, 2008; Skea et al, 2008).

Distrust of health care professionals

Impartiality of health care professionals was questioned (Hilton et al, 2007). Financial incentives received by GPs to promote MMR uptake created feelings of distrust (Evans et al, 2001; Petts & Niemeyer, 2004; Hilton et al, 2007), as was health care professionals willingness to follow the official line (McMurray et al, 2004). GPs' unwillingness to openly discuss, appeared dismissive or coercive and compounded parental distrust (Evans et al, 2001; McMurray et al, 2004). Efforts made by GPs to focus on the 'particularity' of the child and show concern were viewed positively (Casiday, 2007), as were personal relationships with health providers (Casiday, 2007; Skea et al, 2008). Motivations of HVs whose tone was overly resolute, or in contrast vague, were equally questioned (Hilton et al, 2007). Interestingly HVs reported that immunisation targets worked counter to their role as parent advocate and official information was insufficient to support informed choice (Brownlie & Howson, 2006). Further the levels on information accessed by parents made it difficult for HVs to treat parents other than homogenously, compete with volume of research, or keep up to date (Brownlie & Howson, 2006).

Embedded culture of trust in health care professionals linked to an almost reverence of medical expertise was highlighted as a factor in Asian parent decision-making (Petts & Niemeyer, 2004). Less awareness of single vaccines as an alternative to MMR was evident in the accounts from Asian parents (Mixer et al, 2007). Overall greater receptiveness and higher MMR uptake in Asian and Turkish communities were identified (Mixer et al, 2007; Anderson et al, 2008).

Opportunistic immunisation opportunities presented by visits to Out Patient Departments (OPDs) or Accident & Emergency (A&E) were perceived placing as undue pressure on parents to comply (Evans et al, 2001).

Distrust of government and public health

Government and particularly politicians were not seen as trustworthy in matters of health (Hilton et al, 2007). The recent origins of this distrust in government was their management of BSE in the early 1990s (Evans et al, 2001; Raithatha et al, 2003; Casiday, 2007), but compounded by Tony Blair's failure to confirm whether his son was immunised. This raised serious doubts about the safety of MMR vaccine among parents (Petts & Niemeyer, 2004). Government attempts to reassure following the sensationalised accounts of the autism-MMR link were treated with scepticism (Evans et al, 2001) yet parents needed to evaluate evidence for themselves (Casiday, 2007). Andrew Wakefield was not universally discounted, or recognised as discredited by parents and some saw him as a whistleblower (Hilton et al, 2007).

HVs delivering targets for GPs who themselves are working to deliver the governments agenda undermines professional judgement and undermines professional self regulation (Brownlie & Howson, 2006).

Impact of the media in constructing distrust

Two media representations of MMR have been sustained. One, the risk of autism from the triple MMR vaccine and, two, low uptake of MMR being represented as a 'social problem' (Brownlie & Howson, 2006). Although many parents recognised the scaremongering aspects of the media, and spoke negatively about the reporting of the Wakefield controversy, nevertheless found accounts relating to MMR and autism and bowel conditions compelling, and doubt-raising (Hilton et al, 2007). Even in parents who previously had not questioned the safety of immunisation (Evans et al, 2001). Health professionals perceived the media representations as undermining (Brownlie & Howson, 2006).

Level of integration, language and low level reporting of the link to autism in the Indian press was suggested as an effective barrier for minimising the effect of the media on MMR uptake among Asian parents (Mixer et al, 2007), This was not

mirrored in the Orthodox Jewish community where media seepage irrespective of level of community integration was thought to be influential (Henderson et al, 2008).

The use of real life stories to communicate information was seen as a particularly persuasive device (Petts & Niemeyer, 2004; Hilton et al, 2007; Casiday, 2007) by parents.

Uptake of second dose of MMR

Petts & Neimeyer (2004) who did a study of two focus groups with a health promotion intervention and found 15 of 64 (23%) participants did not know a booster was required at 5 years, including parents who had already had the first MMR. McMurray et al (2004) differentiated between a group of parents who had declined the second MMR but who had their child immunised with the first MMR, and another group who not yet had their child immunised with the second MMR but had immunised with the first MMR. "Reluctant vaccinators" agreed to having the MMR2 despite doubts, based on their assessment of a likely outcome of autism rather than the effect. Two factors influenced pro-second MMR uptake assessments in reluctant parents, and these were firstly, no detected problems with the first MMR and secondly, no evidence of autism in "their immediate social sphere" (McMurray et al, 2004).

Summary of recommendations

Health care professionals need to recognise the complexity of MMR decision-making for parents. The decision to immunise involves parents in a process of balancing risks and probabilities and a 'leap of faith' (Brownlie & Howson, 2005a). Health care professionals need to engage in trust building if they are to (re)gain the confidence of parents. This requires HCPs to allocate time and provide space for parents to discuss fears without engendering feelings that they must comply, or that their opinions are without credibility. This may be particularly important when increasingly the public have less confidence in expert knowledge, and the honesty of those in positions of power, and turn to alternative sources.

Information giving needs to be responsive and personalised, and personal disclosures by health care professionals may be valued in the context of immunisation. Information needs to appear balanced, should recognise the

controversy created by Wakefield, and acknowledge vaccination is not without risk. Informal opportunities and forums (such as Toddler Groups) might afford spaces where parents can discuss concerns with HCPs, or other 'champions', in an open and non-threatening way. Direct attacks on Wakefield and his alternative views may be counterproductive and merely serve to increase his status, albeit discredited, as a defender of the concerns of ordinary parents. HVs and GPs may need to distance themselves from financially incentivised targets and act with professional autonomy with parents to support them through decision-making.

Measles, mumps and rubella are poorly understood as diseases, and as public health threats. The potential dire consequences of measles was not necessarily seen as a health problem for children in an affluent country like the UK, indeed there was considerable weight behind the misplaced view that exposure might bring health benefits such as enhanced resistance to other infectious diseases thus making the child stronger. The different sequelae of rubella and mumps exposure for girls, and boys, appeared poorly understood, this may contribute to increased requests for single vaccines or non-compliance. Information should communicate the immediate risks that can occur as a consequence of contracting the diseases, and potential impact on those who may be put at risk through inadvertent exposure. This may be best achieved through use of personal accounts and stories.

Social networks appear to be particularly significant in influencing the decision to immunise against MMR. Other mothers (friendship networks) and elders (e.g. grandparents) and relatives (kinship networks) appear to be particularly significant. Strategies that identify role models and champions for MMR immunisation that could then influence MMR uptake may bring sizeable benefits.

Limitations of the studies

There was a tendency to recruit parent populations from toddler groups and, or GP practices this may have inadvertently excluded some parents such as those in full time employment. In keeping with qualitative tradition, sampling was largely purposive, or convenience. Some attempts were made to achieve greater representation across social classes, in some cases ethnicity and include fathers.

The majority of the reports were dependent on data collected in the aftermath or the following five years since the original Wakefield controversy hit in 1998. The regular reporting of outbreaks of measles may begin to change opinion and this would be useful to capture.

SUMMARY AND CONCLUSIONS

Summary of evidence of groups where uptake is lower

This review has identified, mainly from the examination of existing datasets, a number of groups where coverage for MMR is likely to be lower. These are children:

- Living in deprived electoral, urban areas, particularly inner cities, (Pearce et al, 2008; Friederichs et al, 2006; Samad et al, 2006a; Wright et al, 2005; Evans & Thomas, 1998), larger family size,
- With a lone parents (Pearce et al, 2008; Sharland et al, 1997; Avis et al, 2007),
- Who are Black Caribbean in Birmingham (Hawker et al, 2007),
- In a family where there is no car (Avis et al, 2007),
- Who have older siblings (Pearce et al, 2008; Reading et al, 2004),
- Who remain unimmunised with primary vaccines (Pearce et al, 2009),
- With a mother aged under 20 (Pearce et al, 2008),
- With a mother aged over 34 when they were born, (Pearce et al, 2008),
- With a mother who was more highly educated (Pearce et al, 2008; Wright et al, 2005),
- With a mother who was not employed (Pearce et al, 2008),
- With a mother who was self-employed (Pearce et al, 2008).

The review has also identified that children who are more likely to be partially immunised are those:

- Resident in wards with disadvantage (Samad et al, 2006a),
- In ethnic wards (Samad et al, 2006a),
- In a larger family (Samad et al, 2006a),
- With a lone parent (Samad et al, 2006a),
- With a teenage parent (Samad et al, 2006a),
- Whose mother smoked in pregnancy (Samad et al, 2006a),
- Who were admitted to hospital by 9 months (Samad et al, 2006a).

The review has also identified that children more likely to have a delay in pertussis immunisation are those:

- With more older siblings (Reading et al, 2004),
- Without housing tenure (Reading et al, 2004), and

- According to the mother's social class when the child was an infant (Reading et al, 2004).

The children who are more likely to receive a single vaccine are those whose mothers are older, better educated and where there is a higher household income (Pearce et al, 2008). 1.9% of mothers of unimmunised infants were educated to degree level or above and 3.1% were aged 40 or more (Samad et al, 2006a).

Pre-school booster coverage was more likely to be lower among children living in urban areas and in more deprived electoral wards (Evans & Thomas, 1998).

Summary of reasons for incomplete immunisation

The review has identified that the reasons most commonly reported by parents for incomplete vaccination are:

- Lack of knowledge about the age the second dose was due (29%) (Lawrence et al, 2003)
- Medical reason of contra-indications to MMR vaccination (15%-18%) (Pearce et al, 2008; Lawrence et al, 2003),
- A practical reason (6%) (Pearce et al, 2008),
- Forgetting the MMR was due (16%) (Lawrence et al, 2003),
- Disagreement or concern (14%), most commonly because of the perception that the risks outweighed the benefits (Lawrence et al, 2003).

Many partially immunised children have only minor conditions, such as upper respiratory tract infections which might warrant deferral rather than contra-indicate future immunisation (Samad, 2006b). Following up these parents would help ensure the course of immunisation was complete.

The review has identified that some of the reasons why parents choose not to vaccinate are that:

- Parents lack confidence or trust in sources of information regarding the MMR vaccine,
- Parents have concerns regarding the safety of the MMR vaccine,
- Parents think the vaccines are harmful and more risky than any of the illnesses,

- Parents think that the diseases are harmless or even beneficial,
- For a child who had had one dose already that this is deemed enough,
- Acquiring minor illnesses is seen as contributing to building natural immunity and acquiring measles meant that MMR immunisation was unnecessary,
- Not enough time was allocated for questions and discussions.

Summary of issues relating to health care professionals

The review has identified that since 1998 there has been:

- A significant fall in confidence among health care professionals about the safety and adverse side-effects of MMR,
- A large number of healthcare professionals were unsure of the need for a 2nd dose,
- Practice nurses and health visitors reported less confidence than GPs,
- Further training on immunisation issues was required.

Summary of evidence of effectiveness of structural interventions

The review has identified that there is evidence of the effectiveness of the following in improving the uptake of immunisation:

1. Having a strategic approach,
2. The use of computers in primary care,
3. Audit and feedback to practices,
4. Patient reminder and recall systems, especially a postal reminder, followed by a telephone call,
5. Education for health care professionals.

In addition, the review has identified some practical difficulties for which there is currently no evidence of effectiveness. For example, practices need to be more flexible in providing easy access for some parents, as illustrated in the quotation below, (Samad et al, 2006b).

“ . . . transport problems due to having two small children . . . and the surgery is quite far away and they only do the surgery on Wednesday and I can't get from the nursery to the surgery easily.”

Parents requirements prior to immunisation

The review has identified, from parent questionnaires and from the qualitative data, a series of issues from parents' perspective. Childhood immunisation is more of a process than an isolated action and the decision to vaccinate may be influenced by factors other than risk (Hobson-West, 2003).

Whilst we did not find evidence of the effectiveness of the following issues, we highlight here possible methods that have been recommended to address parents' concerns about immunisation.

It is recommended that primary care strategies are needed to help parents make an informed choice about vaccination for their infant. Parents need access to trusted support and information which:

- Is provided by a trusted healthcare professional who is well informed, takes time to listen to and discuss parental concerns,
- Helps parents to understand that measles, mumps and rubella are seen as public health threats,
- Treats every immunisation as different and special for those parents who wish to discuss before deciding,
- Provides ready access to reliable evidence-based information about MMR,
- Provides information about the danger of vaccine-preventable diseases,
- Addresses parental knowledge about the safety and adverse side-effects of MMR,
- Addresses any misconceptions about contra-indications,
- Is tailored information to particular concerns and beliefs of different groups,
- Is easily incorporated into existing understandings,
- Address concerns in immunisation advice in an unbiased and reasoned way,
- Offers different approaches for different mothers,
- Uses 'narratives' or real life stories that are interesting, accessible and informative,
- Explains specifically the different sequelae of rubella and mumps exposure for girls, and boys,
- Takes into account that parental knowledge or views may not be based on scientific data.

Immunisation in non primary care contexts

Although the focus of this review has been on identifying interventions to maximise the uptake of primary infant immunisation and MMR, there are particular groups of children and parents with particular needs in relation to immunisation. Where possible, primary health care practitioners should seek opportunities to collaborate with secondary care services, such as A&E and paediatric wards, education and social care, to develop, implement and evaluate innovative cost-effective interventions, to maximise the uptake of childhood immunisation among the whole community.

Hospitals

In a study in England and one in America, children who were hospital in-patients (Conway et al, 1999) or who attended an Accident and Emergency context (Schenker et al, 1995) were identified as eligible for vaccination for a missed or late immunisation. The proportions of children who were eligible and who were vaccinated were 15% and 25% in the English and American studies respectively (Conway et al, 1999; Schenker et al, 1995) indicating that hospital attendance provides opportunities for catch up and routine immunisation.

Schools

School-based programmes are intrinsically more successful at maximising uptake of vaccination because they have a 'captive audience' (Skinner et al, 1998). Within school immunisation programmes, the issue of absenteeism has to be addressed (Skinner et al, 1998). 'Mop-up' vaccination days have been advocated as a method of maximising uptake, requiring the full child outcomes-operation of schools, parents and health services.

A school immunisation programme could be effective, if it incorporates the successful elements from an Irish study (Joyce-Cooney et al, 2003). The elements were a dedicated team, the active follow-up of all defaulters, a comprehensive database made available to schools; availability of telephone numbers, a dedicated telephone line, and avoidance of deferral for minor illness.

In some countries, vaccination is required either before nursery or school. Each Australian state and territory has legislation that requires evidence of a child's vaccination history when they start school (Lawrence et al, 2003) and parents appear to know more about the school entry requirements than the Australia Standard Vaccination Schedule (Lawrence et al, 2003). In the UK the DH and the British Medical Association do not consider compulsory vaccination as an option (POST, 2004).

Universities

One study explored factors influencing MMR decisions following mumps outbreak on a university campus in Kent (Hamilton-West, 2006). Students and staff were advised to attend for immunisation but only a third of the sample chose to have the immunisation. Students were unlikely to have an injection when the perceived risks of immunising were equivalent to the perceived risks of not immunising (Hamilton-West, 2006).

Children looked after by the local authority

A study of 593 children looked after by a single health authority found that the children received poor health supervision and that the children aged 2-5 years were significantly less likely to be immunised against diphtheria, tetanus, pertussis, polio, Hib and MMR compared with the whole of the county population of 2-5 year olds (Payne & Butler, 1998), further contributing to disadvantage among these children. Missing records contributed to the problem. The authors suggested that a person should be nominated with protected time to take responsibility for monitoring and improving the health of this population of looked after children (Payne & Butler, 1998).

Young, single mothers

Among lone parent families there are single, separated, divorced and widowed mothers. They may experience difficulties with arranging time off work, low income, dependence on public transport, temporary housing, or poor motivation to immunise (Sharland et al, 1997).

Targeting lone parents (Sharland et al, 1997) or parents of infants with older siblings (Reading et al, 2004) for a domiciliary immunisation service may improve coverage by overcoming some of the practical barriers for parents to increase the chance that the infant will be immunised on time.

In two studies, one of 290 poor, black mothers living in an Eastern US city (Hardy & Street, 1989) and another of 262 mothers living in a deprived area in Dublin (Johnson et al, 1993), support was offered in the form of ten to twelve home visits from experienced, specially trained, mothers, who had lived in the community previously. The intervention provided education and encouraged the mothers to keep appointments at well-baby clinics. A third study of a service for 243 black, unmarried mothers aged 17 years or less (O'Sullivan et al, 1992) focused on avoiding new pregnancies, completing the baby's immunisation programme, and returning to school. The outcome common to all three trials was childhood immunisation; the infants in the intervention group were more likely to be fully immunised than were those in the control group, but a seven year follow-up in the Dublin study found no differences between the two groups (Johnson et al, 2000). There are potential economic advantages of applying the skills of experienced mothers living in the community, but the results were not robust enough to use as the basis for practice recommendations. Moreover there was no evidence of the cost-effectiveness of any of the interventions in a non-UK setting.

Immunisation services for refugees, immigrants and migrant workers

In a study in Western Sydney, 194 students who were refugees and migrant young people were surveyed and reported low immunisation rates. Those who were not immunised were offered immunisation for hepatitis B and MMR. As part of the school-based programme, 74% (142/194) received MMR vaccine. The study illustrates the health care needs of refugee and migrant young people in a high infection risk situation. It also illustrates the benefits of education and health working together (Milne et al, 2006).

In Germany, a campaign to screen children of immigrants when they enrolled for school found that the children were poorly protected with MMR vaccination (Pallasch et al, 2005). Since they found that information events were not successful, they

decided to train key people from within the groups to motivate the immigrant parents to take the children to the vaccination stations set up in the district (Pallasch et al, 2005).

SUMMARY OF REVIEW

This review has identified from published research, a number of groups where coverage for MMR is likely to be lower, the contexts in which children are more likely to be partially immunised, those who are more likely to have a delay in immunisation, those who are likely to receive a single vaccine and those who are unlikely to immunise at all.

The review has also identified interventions which may be effective in a primary care context and possibly cost-effective in a UK context, as well as some interventions which are unlikely to be effective.

The review has identified some of the concerns and problems among primary care practitioners, specifically GPs, health visitors and practice nurses, all of whom are involved in the immunisation process with parents.

Furthermore, the review has tapped into the rich information about why parents have concerns about immunising their infants and some of the reasons they choose not to immunise.

We have made recommendations about what might be considered to maximise immunisation uptake, based on available evidence.

We have also proposed measures which aim to address the concerns of health care practitioners and other measures to address the concerns of parents. However, there is no available evidence for these measures.

RECOMMENDATIONS

Our recommendations are therefore as follows:

1. Education for health care professionals should be a priority to address parental concerns,
2. Practices should use a strategic approach to maximise uptake of immunisations,
3. Practices should accurately record immunisation uptake, including single antigens, and use computers for identifying parents who need to be reminded,
4. Practice should use a postal reminder, followed by a telephone call to parents,
5. Practices should perform regular audit with feedback to all health care professionals involved in immunisations,
6. Practices should consider collaborating with schools to plan 'mop-up' vaccination days.
7. Practices should consider initiating interventions with regard to looked after children and refugees and immigrants.

We strongly recommend that interventions which are newly introduced should be evaluated, ideally using a mixed methods approach, with a randomised controlled trial and qualitative evaluation, to capture evidence of an uptake of immunisation along with the perspectives of parents and health care practitioners.

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Table 1: Results of review studies included

Authors, Year	Design / Method	Aim	Study designs and dates	Interventions	Data	Results	Authors' conclusions
Anderson et al, 1998	Meta-analysis.	To perform a meta-analysis of office-based interventions to determine their impact on three domains of preventive care: screening, immunisation, and counselling.	Randomised controlled trials and non-randomised controlled trials based in the USA, published in the English language to January 1997.	Office-based interventions aimed at increasing provider performance in an ambulatory care setting, classified as feedback to providers, prompting to providers, prompting and ongoing monitoring.	43 studies were included. 14 were immunisation studies.	Provider: Mean effect size for immunisation: weighted=0.18, unweighted=0.16. Patient: Mean effect size for immunisation: weighted=0.15, unweighted=0.13.	“Office-based interventions deserve continued development and evaluation for enhancing the delivery of preventive services.” “Our findings also point to the need for multiple interventions.” Unable to draw conclusions about the long-term effects on provider adherence.
Bordley et al, 2000	Systematic Review.	To assess the effectiveness of audit and feedback (A&F) on immunisation delivery by health care professionals.	Randomised controlled trials (RCTs), published 1966 - 1998 controlled before and after studies (CBA), interrupted time series (ITS) and simple before and after studies (BA). Studies had to include A&F.	Included studies of universally recommended childhood or adult vaccines. A&F defined as any summary of clinical performance gathered over a defined period of time, presented to the health care provider after collection.	Participants in the studies were children aged 12 months to 9 years or adults aged 50 or more. n=5 studies on childhood immunisation (DTP, Oral polio, MMR, Hib, pneumococcal, influenza). 1 RCT, 2 ITS, 4 BA. 10 studies on adult immunisation. 4 RCTs, 6 BA or ITS.	In general, the published studies assessing the impact of A&F on childhood immunisation rates demonstrate a positive association, although the number and quality of the studies identified was limited. Only 2 studies examined the effect of A&F as the sole intervention and it is difficult to evaluate the independent effect of A&F and the magnitude of its effect on childhood immunisation rates.	The evidence from published studies suggests that A&F alone may be an effective strategy for improving immunisation rates. The number of well-conducted studies is small and the effect is variable. Recommendations Additional well-designed studies are needed to identify the independent effects of A&F, optimal format and frequency of A&F, and to examine its long term effect on provide immunisation practices and costs.

Authors, Year	Design / Method	Aim	Study designs and dates	Interventions	Data	Results	Authors' conclusions
Briss et al, 2000	Systematic review.	A systematic review of the effectiveness, applicability, other effects, economic impact, and barriers to use of selected population-based interventions intended to improve vaccination coverage.	Primary studies published from 1980 – 1997, in industrialised countries, comparing a group of people exposed to an intervention with a group who had not been exposed or who had been less exposed. Execution of studies was classified as good, fair or limited. Studies with limited execution did not qualify for the review.	Interventions intended to improve routine delivery of universally recommended vaccinations.	Total 183 included studies. 42 of reminder/recall interventions. 17: multicomponent interventions that include education. 9: vaccination requirements for child care, school, college attendance. 1: community-wide education. 3: clinic-based intervention. 3: client/family incentives. 3: client held medical records. 19: reducing out-of-pocket costs. 16: expanding access in health care settings. 4: vaccination programmes in Women, Infant and Children (WIC) settings. 7: home visits. 1: schools vaccination programmes.	<ul style="list-style-type: none"> · Reminder/recall interventions – a median 8% change. Adjusted cost-effectiveness ratios ranged from \$4-£46 per additional vaccination. · Lower incidence of measles and mumps and more likely to have 'documented immunity'. · Education interventions – a median 16% change in vaccination coverage. Costs range from \$7.65 to \$23 per vaccination delivered. · Community-wide education – improvements in the number of measles vaccinations delivered in children aged 6 years. · Studies reducing out-of-pocket costs found a median 15% change in coverage. · Studies WIC settings showed a 4-34% improvement in vaccination coverage. · Studies that evaluated 	<ul style="list-style-type: none"> · Strong evidence exists that client reminder/recall is effective in improving vaccination coverage. · Strong evidence exists that multicomponent interventions that include education are effective in improving vaccination coverage. · Sufficient evidence exists that vaccination requirements for child care, school, and college attendance are effective in improving vaccination coverage and immunity and / or reducing rates of disease. · Insufficient evidence of community-wide education in improving knowledge or attitudes or improving delivery of vaccinations. · Insufficient evidence of clinic-based education in improving vaccination coverage. · Insufficient evidence from incentives for improving vaccination coverage. · Insufficient evidence to assess effective of client-held records. · Strong evidence that reducing out-of-pocket costs for vaccination is effective in improving vaccination coverage.

<p>29: provider-based reminder/recall interventions. 14: assessment and feedback for vaccination providers. 11: standing orders (non-physicians deliver vaccinations without direct physician involvement). 4: education only.</p>	<p>reminder/recall only found a 17% median change in coverage. · Studies of assessment and feedback for vaccination providers found a median 16% change in coverage.</p>	<ul style="list-style-type: none"> · Strong evidence exists that expanding access as part of a multi-component intervention improves coverage among children and adults in a range of contexts. · Sufficient evidence of effectiveness of interventions in WIC settings in improving vaccination coverage. · Sufficient evidence exists that home visiting interventions are effective in improving vaccination coverage. · Insufficient evidence to determine the effectiveness of school-based vaccination interventions. · Strong evidence exists of the effectiveness of reminder/recall interventions. · Strong evidence exists for the effectiveness of assessment and feedback for vaccination providers. · Strong evidence that standing orders are effective for improving coverage in adults, but insufficient evidence of improvement in children. · Insufficient evidence of the effectiveness of provider education in improving vaccination coverage due to few studies of limited design.
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Table 1: Results of review studies included (continued)

Authors, Year	Design / Method	Aim	Study designs and dates	Interventions	Data	Results	Authors' conclusions
Elkan et al, 2000 Canada, England, Ireland, USA	Systematic review.	To conduct a systematic review of the effectiveness and cost-effectiveness of home visiting by Health Visitors (HVs).	Studies published 1980-1997 including a comparison group, RCTS, non-RCTS, and controlled before and after comparisons.	Home visiting programmes.	102 studies evaluating 86 home visiting programmes; 11 reporting uptake of immunisation.	Meta-analysis of the RCTs with comparable measurement of uptake produced an OR=1.67 (95% CI, 1.29 to 2.15) and heterogeneity between treatment effects was significant ($\chi^2=16.6$; 4df: $p=0.002$).	Our review of the effectiveness of home visiting programmes suggests that they are not effective in increasing uptake of immunisation or uptake of other preventive child health services. Recommendations There is a need for more studies with rigorous experimental designs to evaluate the effectiveness of home visiting by British HVs and for further studies comparing the effectiveness and cost-effectiveness of professional and non-professional home visitors.
Giuffrida et al, 1999	Cochrane review.	To evaluate the impact of target payments on the professional practice of primary care physicians (PCPs) and health care outcomes.	Randomised trials, controlled before and after studies and interrupted time series analyses of interventions.	Target payments to primary care professionals vs. alternative methods of payment, on patient outcomes, health services utilisation, health care costs, equity of care, and PCP satisfaction with working environment.	Two studies were included involving 149 practices.	The use of target payments in the remuneration of PCPs was associated with improvements in immunisation rates, but the increase was statistically significant in only one of the two studies.	Evidence from the studies in this review is not of sufficient quality or power to obtain a clear answer as to whether target payment remuneration provides a method of improving primary health care. Efforts should be directed in evaluating changes in remuneration systems. Although it would not be difficult to design a randomised controlled trial to evaluate the impact of such payment systems, it would be difficult politically to conduct such trials.

Table 1: Results of review studies included (continued)

Authors, Year	Design / Method	Aim	Study designs and dates	Interventions	Data	Results	Authors' conclusions
Gyorkos et al, 1994	Literature Review.	To review the effectiveness of immunisation delivery methods for influenza; pneumonia; hepatitis B; measles, mumps, and rubella (MMR); diphtheria, pertussis, tetanus and polio (DPTP).	Randomised controlled trials, cohort studies, clinical trials, observational community studies, published from 1979 to September 1992.	Interventions were categorised as: client-orientated, e.g. mailed reminders to patients); orientated to the provider, e.g. chart reminders to physicians; or system related, e.g. legislation. Where interventions were orientated to more than one group they were classified as mixed.	Fifty-four articles in total: 24 influenza, 11 pneumonia, 1 hepatitis B, 13 MMR and 5 DPTP.	<p>Influenza. Total: pooled effect 18.6% (95% CI: 17.7, 19.5). RCTs: pooled effect 12.9% (95% CI: 10.2, 15.7).</p> <p>Pneumococcal. Total: pooled effect 29.7% (95% CI: 24.9, 34.5).</p> <p>Hepatitis B. 1 study was included, an RCT of weak internal validity. Increased coverage of target population: Mailing only: 1.9% (95% CI: -4.1, 7.9). Mailing plus decision analysis: 6.3% (95% CI: 1.0, 11.6).</p> <p>Childhood immunisations.</p> <p>MMR. Pooling of studies was not appropriate because of differences in, e.g. intervention and target population. Of 2 client-orientated studies, 1 increased coverage by 62% (baseline 3.1%) and the other increased coverage by 5% (baseline 42%).</p> <p>System-orientated: studies were legislation, public versus private type of services and technical resources. Legislation had the biggest effect.</p> <p>Target population coverage: In school age children or older, all studies showed effects of 44% or higher. In pre-school</p>	<p>Influenza. Interventions for improving immunisation coverage have largest effect when aimed at hospital populations. Standing orders for vaccine in hospitals and clinics has a positive effect. A high response is achieved with personalised mailed reminders or health care practitioner-initiated telephone calls. Analysis of baseline coverage suggests a ceiling effect; studies having baselines of 50% or higher have significantly less improvement levels than others.</p> <p>Pneumococcal. Client- or system-orientated hospital interventions for high-risk patients can ensure high vaccination rates. 1 study found increased rates could be affected when the health department promotes and offers the vaccine. Lack of relevant studies especially in a community setting. Further research should be promoted to address feasibility, effectiveness and cost-effectiveness.</p> <p>Hepatitis B. 1 study with limited applicability to general population so further research</p>

children the effect ranged from -43.5 to 25%.

A letter reminder had little effect (5%); legislation had a large effect (44%); and change in the immunisation schedule resulted in a decrease in coverage (-42%).

DPTP. Inappropriate to calculate pooled effects because of small number of studies. Individual effects of interventions are presented. Feedback of immunisation practice: large effects (56.1%, 95% CI: 42.2, 70.0), postcard reminders (33.9%, 95% CI: 19.9, 48.0). Changing the timing of MMR vaccination from 12 to 15 months resulted in a decrease in coverage levels of the DPT booster at 18 months.

in this field is imperative.

Primary immunisations (MMR and DPTP). Greater coverage rates found with system-orientated interventions than client-orientated interventions. Computerisation, being served by a Health Maintenance organisation, and providing feedback on practice were all shown to result in increases in coverage. Changing the schedule of DPT vaccine administration from 12 to 15 months resulted in a decrease in coverage.

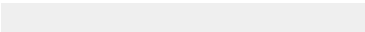


Table 1: Results of review studies included (continued)

Authors, Year	Design / Method	Aim	Study designs and dates	Interventions	Data	Results	Authors' conclusions
Jacobson Vann et al, 2005	Cochrane review.	To assess the effectiveness of patient reminder and recall systems in improving immunization rates, and compare the effects of various types of reminders in different settings or patient populations.	Randomized controlled trials (RCT), controlled before and after studies (CBA), and interrupted time series (ITS) studies written in English published from 1966 to 1998.	Any intervention that falls within the EPOC scope and that includes patient reminder or recall systems, or both, in at least 1 arm of the study. Health care personnel who deliver immunisation and children (birth to 18 years) or adults (18 years and up) who receive immunisation in any setting.	Four new studies were added for the 2007 update for a total of 47 studies. Data were reported as odds ratios (Ors) for being up to date or having received vaccinations as recommended if one received a reminder.	Reminders effective for childhood vaccinations (OR = 1.47, 95% CI = 1.28, 1.68), childhood influenza vaccinations (OR = 2.18, 95% CI = 1.29, 3.70), adult pneumococcus, tetanus, and Hepatitis B (OR = 2.19, 95%CI = 1.21, 3.99), and adult influenza vaccinations (OR = 1.66, 95% CI = 1.31, 2.09). The effectiveness of patient reminders for childhood influenza vaccinations declined overall from an odds ratio of 2.87 in the previous review. Reminders were not effective in the 1 new study of adolescent immunizations in an urban setting (OR = 1.14, 95% CI = 0.98, 1.31). All types of reminders were effective (postcards, letters, telephone or autodialer calls), with telephone being the most effective but also the most costly.	Patient reminder and recall systems in primary care settings are effective in improving immunization rates in developed countries.

Table 1: Results of review studies included (continued)

Authors, Year	Design / Method	Aim	Study designs and dates	Interventions	Data	Results	Authors' conclusions
Kendrick et al, 2000	Systematic review and meta-analysis.	To evaluate the effectiveness of home visiting programmes on the uptake of childhood immunisation.	Empirical studies with control groups.	Studies had to report immunisation outcomes relevant to British health visiting with parents of infants due to receive childhood immunisations.	Eleven controlled studies were included. Two studies not included in the analyses as did not provide outcome measures that permitted pooling; one reported positive outcomes.	Uptake of immunisations (n=9). Pooled odds ratio (OR) 1.17 (95% CI: 0.33-4.17). Significant heterogeneity between studies (chi-squared = 22.1, p<0.005).	The review has failed to demonstrate a beneficial effect of home visiting on uptake of immunisation. Other methods of increasing uptake and reducing inequalities in uptake will need to be explored.
Lewin et al, 2005	Cochrane review.	To assess the effects of LHW interventions in primary and community health care on health care behaviours, patients' health and wellbeing, and patients' satisfaction with care.	Randomised controlled trials of any intervention delivered by 'lay health workers' (paid or voluntary) in primary or community health care and intended to promote health, manage illness or provide support to patients.	A 'lay health worker' (LHWs) defined as any health worker carrying out functions related to health care delivery; and having no formal professional or paraprofessional education.	43 studies. 210,110 consumers. Diversity in the aims, content and outcomes of interventions. Most in high income countries (n=35), nearly half of these focused on low income and minority populations (n=15).	Promising benefits in comparison with usual care were shown for LHW interventions to promote immunisation uptake in children and adults (RR=1.30 [95% CI 1.14, 1.48] p=0.0001) and LHW interventions to improve outcomes for selected infectious diseases (RR=0.74 [95% CI 0.58, 0.93] p=0.01).	LHWs show promising benefits in promoting immunisation uptake and improving outcomes for acute respiratory infections and malaria, when compared to usual care. There is also insufficient evidence to assess which LHW training or intervention strategies are likely to be most effective. Further research is needed in these areas.
Roberts et al, 2002	Bayesian synthesis of qualitative and quantitative evidence.	To explore the feasibility and value of synthesis of qualitative and quantitative evidence of uptake of immunisation.	11 qualitative and 32 quantitative studies of factors affecting uptake of childhood immunisation published from 1970 – July 1999.	Any factor that affected the uptake of childhood immunisation in developed countries.	43 published studies.	Lay beliefs, advice from health professional, Child's health history, Structural issues, Social position, Forgetting, Religious / moral beliefs, Role of parent, Postnatal period, Media representation. Type and pattern of service used.	Qualitative or quantitative research alone may not identify all factors, or result in inappropriate judgements and formulation of evidence-based policy.

Table 1: Results of review studies included (continued)

Authors, Year	Design / Method	Aim	Study designs and dates	Interventions	Data	Results	Authors' conclusions
Sullivan & Mitchell, 1995	Systematic review of world reports.	To review findings from studies of the influence of desktop computers on primary care consultations.	1984 to 1994.	30 evaluations of computers in primary care. 6 examined the effects on the consultation process. 21 evaluated effects on clinicians' performance of tasks. 3 measured the impact on patient outcome.	The emphasis was on immunisation and other preventive tasks (n=14) and on prescribing (n=4), fewer studies being concerned with the management of disease.	Immunisation rates for tetanus and influenza improved by 8-18% and other preventive tasks performed improved by up to 50%.	Use of a computer during consultations improves immunisation rates by 8-18% and other preventive tasks by up to 50%. Future research should centre on outcomes of care for patient. Need to look at new methods of evaluating these major changes in "the essential unit of medical practice".
Whittaker, 2002	Review.	To identify whether the involvement of lay workers in community child health services is effective in improving the uptake of childhood immunisation.	Randomised controlled trials published from 1993 – 2000.	Studies involving support to parents comparing conventional child health services with involvement of lay or non-professional workers, conducted in economically deprived communities.	1. n=267 first time mothers in Ireland. 2. n=163 parents of children under 2 years of age from a New York immigrant community from the Dominican Republic.	1. 85% Intervention group children vs. 65% control completed primary immunisations by their 1 st birthday (RR 1.31, 95% CI 1.21 to 1.54, p<0.001). 2. 75% intervention group vs. 54% control were up to date with immunisation (RR 2.8, 95% CI 1.21 to 6.54, p<0.05).	<ul style="list-style-type: none"> · Lay support can be effective in increasing the uptake of vaccination. · Equally, intervention effects could, because of differing cultural and sociodemographic factors, could be less marked when applied to British populations, in which the parents of pre-school-aged children have access to immunization support from a generic health visiting service.

Table 2: Results of intervention studies included

Authors, year, Place	Design / Method	Aim	Intervention	Participants	Results	Authors' Conclusions
Conway et al, 1999 Leeds, England	Before and after study.	To assess the potential for administering catch-up and scheduled immunisation during hospital admission.	Junior doctors instructed to offer appropriate vaccination before discharge. Consultants asked to reinforce this proactive policy on ward rounds.	Carers of n=1000 consecutive preschool age children.	789/1000 (78.9%) had been immunised. 142 (14.2% had missed an age-appropriate immunisation. 41 were due a scheduled immunisation. 43/183 (23%) were offered vaccination. 28/183 (15%) accepted. 140 vaccinations opportunistically administered. Uptake rates of 94.7% for MMR and over 95% were achieved for all the vaccines in the programme.	<ul style="list-style-type: none"> · Admission to hospital provides opportunities for catch up and routine immunisation. This can contribute to the health care of an often disadvantaged group. · Junior doctors must be encouraged to see opportunistic immunisation as part of their routine work.
Joyce-Cooney et al, 2003 Longford, Ireland	Before and after study.	To document uptake rates achieved for vaccinations administered in a school immunisation programme in a school year.	Information packs delivered by schools to parents (letter, leaflets, consent form). Area medical officer gave explanatory talk. Issues discussed in private. Phonecall follow-up of non-attenders.	Parents of MMR=6436 school children in 115 schools.		<ul style="list-style-type: none"> · The programme's success was due: to a dedicated team, relieved of all other responsibilities, which facilitated the active follow-up of all defaulters as identified by the clear comprehensive database made available to schools; the availability of telephone numbers; and a dedicated telephone line. Avoidance of deferral for minor illness was also a key factor, as children well enough to be in school were considered to be well enough for vaccination.
Margolis, et al, 2004 North Carolina USA	Randomised trial in primary care.	To examine effectiveness of "office systems" to improve the delivery of preventive care (including immunisation) to children.	Practice based continuing medical education. Project staff coached practice staff to review, perform, identify, test, and implement new care processes (e.g. chart) to improve delivery of preventive care.	Random sample of 44 private paediatric and family practices allocated to intervention or control group.	Intention to treat analysis. Proportion of children per practice with age-appropriate delivery of all 4 preventive services (4 scheduled injections of DTP, polio, MMR, 3 Hib, 3 HepB by 24 months) changed after 1 year of implementation - 7% to 34% in intervention. 9% to 10% in control.	<ul style="list-style-type: none"> · Continuing education combined with process improvement is effective in increasing rates of delivery of preventive care to children.

Table 2: Results of intervention studies included (continued)

Authors, year, Place	Design / Method	Aim	Intervention	Participants	Results	Authors' Conclusions
Mason & Donnelly, 2000 Lechyd Morgannwg Health Wales	Randomised controlled trial, with allocation using computer generated random letters. Sample size calculation estimated 219 participants per group were required.	To investigate the effect on vaccine uptake of posting the <i>MMR – The facts</i> leaflet to parents of children who had not received MMR vaccine by 21 months of age.	Computerised child health record system used to generate a monthly list of parents. Randomly selected parents in the intervention group were sent a personal reminder letter and leaflet. Control group parents had usual care (no action).	Parents of children who had not received MMR vaccine by 21 months of age. 511 were recruited, 255 to intervention group and 256 to control group.	12/255 children (4.7%) had already been immunised. In the intervention group, 7.2% (18/249) vs. 6.1% (15/244) in the control group (95% CI, -3.5 to 5.5).	<ul style="list-style-type: none"> · The data recorded on the child health system underestimated uptake by 4.8%. · More complex intervention is required to influence the immunisation behaviour of parents. · Interventions from health care professionals known to the parents might be more effective than interventions from health authorities.
Morgan & Evans, 1998, Cardiff Wales	Randomised controlled trial. Weekly computer generated lists of children were randomised using computer-generated numbers, to one of two interventions or control group.	To examine the effectiveness of two contrasting interventions; HV or mail follow-up.	Intervention A. a non-directive phone call to the child's HV to confirm the child's detail and immunisation status. <i>The HV was not informed of the trial.</i> Intervention B. was a single mailed reminder to the child's parent together with a questionnaire about reasons for non-immunisation. <i>The parents were also not informed about the trial.</i>	451 children resident in the former county of South Glamorgan, born 1 April – 30 September 1995, who had not completed the primary course of DTP and Hib by 9 months OR born 1 April – 30 September 1994 who had not completed MMR by 21 months.	Intention to treat analysis. Four groups: 1. DTP, HV, 2. MMR, HV, 3. DTP, letter, 4. MMR, letter. Examining DTP by 1 st birthday and MMR by second birthday, there was no significant difference between any of the groups.	<ul style="list-style-type: none"> · · · “District-wide initiatives directed at individual families are unlikely to be worthwhile, although there may be some benefit from targeting young or primiparous mothers.”

Table 2: Results of intervention studies included (continued)

Authors, year, Place	Design / Method	Aim	Intervention	Participants	Results	Authors' Conclusions
Porter-Jones et al, 2008 Flintshire Wales	Pragmatic randomised controlled trial. Sample size calculation estimated 469 participants would be needed to achieve 80% power to detect a 7% difference at $p < 0.05$.	To examine a low-cost simple attempt to improve MMR uptake.	Issue of teddy bears wearing T-shirts displaying a website address and telephone number that provided information re MMR vs. standard MMR information to all parents.	994 children. 432 received standard MMR information alone. 542 received a teddy bear.	87.3% intervention group received MMR vs. 88% control group. No calls were made to the telephone helpline. 62 people accessed the website. 86.1% males vs. 89.2% females were immunised ($p = 0.143$). 90.2% first-borns vs. 85.8% others were immunised ($p = 0.041$).	<ul style="list-style-type: none"> · This method of promoting sources of information about MMR vaccination does not appear to have influenced MMR uptake. Most parents were not interested in using a website. · Possibly too few parents had internet access. · Calls out of office hours may have been missed.
Wallace et al, 2005 Australia and New Zealand.	Before and after study.	To determine whether an evidence based decision aid on the MMR vaccine changed parents' attitudes towards vaccination.	Evidence based decision aid with text and graphical representation of the possible outcomes of measles, mumps and rubella diseases compared with MMR vaccination.	Of $n = 1277$ people accessed a website, $n = 158$ completed online questions.	55% participants were 'leaning towards' vaccination after using the decision aid than before, 39%, ($p < 0.001$).	<ul style="list-style-type: none"> · A web based decision aid significantly improved parental attitudes to MMR vaccination. Residual concerns about autism and bowel disease and the rare chance of serious complications remained as attitudinal barriers to some parents. · Of interest would be whether the aid improved the timeliness and completion of MMR vaccine among children of parents concerned about the vaccine safety. · Note: of the 158 people who used the aid, 62 (39% supplied demographic details and 52 (84%) were parents of children of vaccination age, and 39 had a university degree, indicating the possibility of respondent bias.

Table 2: Results of intervention studies included (continued)

Authors, year, Place	Design / Method	Aim	Intervention	Participants	Results	Authors' Conclusions
Wroe, et al, 2005 Auckland New Zealand	Controlled study. Allocation to group unclear.	To investigate the impact of an intervention that includes: a) The provision of more detailed information on the benefits and risk of immunisations according to scientific evidence, b) information on the possible role of emotional factors, and c) the focusing procedure.	A4 size, 20-page booklet "Deciding about immunisation: the benefits and the risks." plus information on the possible role of emotions, such as anticipated regret, information on 'the golden rule' and that immunising or not are both 'active decisions'. The control group was sent an A5-size 19 page booklet published by the Ministry of Health, "Immunisation Choices."	99/135 women attending one of 10 hospital antenatal classes. Classes were alternately assigned.	There was a greater difference between pre-experimental ratings and post-experimental ratings of the likelihood of immunising in the intervention group than the control group. Post-experimental ratings were significant higher in the intervention group than the control group (difference=11.81, 95% CI 5.37 to 18.25). Participants' decisions to immunise were strongly predicted by their antenatal likelihood of immunising ratings. In the intervention group 45 (90%) immunised the infant on time vs. 35 (70%) in the control group.	<ul style="list-style-type: none">· An antenatal decision aid may benefit in overcoming the problem of low immunisation uptake. The study highlights the ability to successfully intervene antenatally.· No single factor could be associated with the outcome as a 'package' was delivered.· The sample size was small, there may have been selection bias and the participants were not individually randomised.· The study may be culturally specific (New Zealand).· Replication in another country would investigate the generalisability of the findings.

Table 3: Results of economic evaluations included

Authors, Year, Country	Design / Method	Aim	Study population	Interventions	Data	Results	Authors' conclusions
Beutels et al, 1996 Germany	Cost-effectiveness analysis of routine varicella vaccination strategies. Non-randomised study with historical controls and 1-year post vaccination follow-up.	To compare the cost-effectiveness of three strategies: 1. 'Children strategy' 2. 'Adolescent strategy' 3. 'Children including catch-up' strategy'.	A hypothetical cohort of healthy children aged 12-18 months and 12-year-olds with a negative history of varicella infection (excluding immunodeficient patients and those with cancer). Sample comprised 82 vaccinated children and an unvaccinated control.	1. Vaccination of all 12-18 month old children 2. Vaccination of susceptible 12-year olds 3. Combination of strategy 1 and vaccination for 11 years of susceptible 12-year olds. Comparator used 'no vaccination' (as standard practice due to the general mildness of infection in healthy children.	1991 and 1994 US data and reports, costs derived from 1986 and 1991-94 studies adjusted to 1995. 1995 prices were used, in German Marks (DM).	The attack rate was 12% in the intervention group, vs. 86% in the control group. 57% infections prevented using the 'children' and 37% the 'adolescent' strategies. 20-35% deaths prevented. 175 'adolescent', 401 'children' and 576 'Children including catch-up' strategy' life-years gained. The adolescent strategy resulted in cost savings.	From a societal perspective, the optimal feasible varicella prevention strategy is to vaccinate 15-month old children, use catch-up vaccination of 12-year olds for 11 years and from the 12 th year onwards, continue to routinely immunise 15-month old children. The validity of the conclusions depends on the integration of the programme into the current MMR programme in Germany and on its full public provision. The results may be applicable to other European countries.

Table 3: Results of economic evaluations included (continued)

Authors, Year, Country	Design / Method	Aim	Study population	Interventions	Data	Results	Authors' conclusions
Dini et al, 2000 Denver, Colorado, USA	Cost-effectiveness analysis. 1227 children randomised into one of four groups with 22-month follow-up. Primary outcome was series completion at 24 months of age.	To assess the sustained impact during the first two years of life, and cost-effectiveness of three types of computer-generated reminder/recall messages (A. phone and letter, B. phone only, and C. letter only), compared with D. no notification.	Children aged 60-90 days who had received 1 st dose of DTP or PV vaccines, and had telephone numbers in pre-existing computerised health department database.	Three types of computer-generated reminder/recall messages sent to the families of children aged 60-90 days who had received the first dose of DTP or PV vaccines.	Evidence and resource use data corresponded to the period 1993-1996. Prices were in US Dollars.	Intention to treat analysis as well as treatment completers only. Most parents were positive about the phone contact. 49.2% intervention group vs. 40.9% control group completed the immunisation series by 24 months. 50.2% in group A. phone and letter. After discounting start-up costs, the cost for each additional child completing the immunisation series was \$46 at 18 months and \$79 by 24 months. B. phone only, and C. letter only.	<ul style="list-style-type: none"> · The study suggests that vaccine coverage of pre-school children can be increased by repeated use of automated parent notifications during the 1st 2 years of a child's life. · The cost results may not be generalisable outside the study setting. · Further studies need to define the cost-effectiveness of computer-generated messages and determine the optimal number and sequence. · Note: significant ethnic and language differences between groups.
Franzini et al, 2000 Houston Texas USA	Cost-effectiveness analysis. Case control study, each site randomly allocated to one of the study arms. 1130	To assess the cost-effectiveness of different immunisation reminder/recall systems on return visits and immunisation coverage with	1130 children under one year of age, and undergoing their 1 st , 2 nd or 3 rd DTP vaccine of DTaP vaccine.	A postcard sent 7 days before the target date for a return visit vs. a phone contact (autodialer) with a computer automated message sent 7 days before the	Data on effectiveness and resource use were gathered from may 1997 to April 1998. Prices were in US dollars.	350 returned in the mail group, 292 in the autodialer group and 287 in the control group. The additional number of immunised children relative to control group was 161 in the mail, group and 224 in the autodialer group. The cost perspective	<ul style="list-style-type: none"> · The system based on the autodialer was the most effective in return visits and immunisations. · The analysis supported the use of a recall system based on autodialer, in small private physicians' offices, especially in

	children presenting at one of 6 study centres.	no reminders.		target date for a return visit, vs. no reminding.		was that of the provider of immunisation services. The cost per child was higher in the mail group than in the autodialer group in all cost analyses.	conjunction with a fully operational immunisation registry. Since start-up costs were quite high, the autodialer system appeared more cost-effectiveness in large patient populations.
Germann & Matter, 1991 Bern, Switzerland	Cost-effectiveness analysis. Prospective cohort study in one centre.	To assess the cost-effectiveness of two different strategies, 1. Determination of immunity followed by MMR vaccination, 2. Universal MMR immunisation. To document the proportion of students not immunised and any increase in vaccination rate.	816 3 rd year male and female medical students on a 5-year course.	Vaccination of medical students against measles, mumps and rubella using either the immunisation of non-immune students or a universal immunisation programme.	Effectiveness data were based on the authors' opinion and resource use was estimated using data for 1994-1997. Prices were in Swiss Francs.	Intention to treat principle. Primary health outcome was the immunisation rate. The screen and vaccinate programme achieved a greater than 95% immunisation level. 82/87 (94.3%) of students who were identified by the screening process as non-immune were vaccinated. Screening costs were only 80% of the total costs. Screening and vaccination was more cost-effectiveness at an immunity rate of 73.5%.	· A targeted programme of MMR vaccination was successful in increasing the immunisation rate of medical students against MMR to more than 96%. The cost results may not be generalisable outside Switzerland.

Table 3: Results of economic evaluations included (continued)

Authors, Year, Country	Design / Method	Aim	Study population	Interventions	Data	Results	Authors' conclusions
Lieu et al, 1997 Oakland, California USA	Cost-effectiveness analysis.	To estimate the cost-effectiveness of sending a computer-generated recall letter to parents of children with overdue MMR immunisation compared with sending no reminders. Parents randomised by random generator to receive a recall letter (intervention) or no letter (control group).	Parents of a hypothetical cohort of children aged 20 months who have not yet had their MMR immunisation and were members of the Kaiser Permanente facilities in North Carolina, followed-up to age 24 months.	A computer-generated recall letter to parents of children with overdue MMR immunisation.	Effective and resource data related to 19994. Prices were in US dollars at 1996 prices.	Intention to treat analysis. Primary outcome the number of children not vaccinated by 24 months. 54% of letter group received MMR by vs. 35% control group (p=0.001). Intervention would result in an additional 4% of the population receiving immunisation. The cost-effectiveness ratio for the intervention was \$4.04 per child appropriately immunised in 1996 prices.	· The use of computer generated recall letters to privately insured families with underimmunised children of 20 months of age improved immunisation delivery compared with families who were not sent a recall letter. It was not clear if this was the most cost-effective strategy.
Lieu et al, 1998 Northern California USA	Cost-effectiveness analysis. Randomised controlled trial using the Kaiser Permanente immunisation tracking system.	To evaluate the cost-effectiveness of 4 interventions: 1. automated phone message, 2. a letter, 3. automated phone	752 underimmunised children aged 20 months.	Sending letters, automated phone messages of both to families with underimmunised children aged 20 months to improve immunisation rates.	Effectiveness and resource use data were obtained from September 1996 to January 1997. The price year was 1997. Prices were in US Dollars.	The percentages of underimmunised children who received any needed vaccination were: · 44.2% (95% CI, 36.6 – 51.9) for phone, · 43.8% (95% CI, 36.1 – 51.5) for letter, · 53.3% (95% CI, 45.7 – 60.9) for phone -	· A letter followed by telephone call was the most effective option to improve the immunisation rates among underimmunised children. Letters followed by phone messages were more cost-effective than either type of message alone.

		message followed by a letter, 4. A letter followed by an automated phone message.				letter, · 57.8% (95% CI, 49.9 – 65.7) for letter – phone. The results for letter-phone were statistically significantly from the groups receiving a single message (p<0.05). relative to no intervention, the cost per child immunised by 24 months of age was \$9.80 for phone, · \$10.50 for letter, · \$7.00 for phone - letter, · For adding letters to an existing phone strategy, the incremental cost-effectiveness would be \$8.30 per child immunised.	
Smith & Roberts, 2000 Pittsburgh, USA.	Cost-utility analysis.	To estimate the cost-effectiveness of varicella vaccination strategies for adults in the USA with no history to chickenpox.	Hypothetical cohort of 20-29 year olds or 30-year old and older adults.	Varicella testing then vaccination, No testing and vaccinating all, Vs. No vaccination.	Effectiveness data derived from 6 studies published in 1978 and 1992. Prices and resources derived from websites accessed in 1998. Prices were in US dollars.	For those aged 20-29, varicella testing then vaccination generated 16.6 quality-adjusted hours and the vaccination all strategy generated 0.17 quality-adjusted life hours. Incremental costs were lower for the varicella testing then vaccination strategy. The preferred strategy was dependant on the probability of immunity level, the costs	· Varicella testing followed by vaccination of adults aged 20-29 years in the USA may be cost-effective relative to conventional criteria among those motivated to complete the vaccination protocol. In older adults, testing is expensive compared with accepted interventions for other medical conditions. However, varicella

						of the immunity test and the cost of the vaccine.	antibody testing and vaccination may be cost-effective for adults of any age who are unlikely to have immunity, or who have a greater risk of developing chickenpox or its complications.
Terada et al, 2000 Okayama Japan	Cost-effectiveness analysis.	To examine the cost-effectiveness of double vaccination programmes for rubella, from the perspective of the Japanese health care system.	Japanese children in the community aged 1-3 years for the first rubella vaccination and 6-9 years for the second vaccination.	Programme 1. 1 st vaccination administered individually aged 1-3 and 2 nd vaccination administered individually aged 6-9. Programme 2. 1 st vaccination administered individually then 2 nd administered as part of a primary school vaccination programme. Programme 3. 1 st vaccination administered individually, but 2 nd vaccination administered based on the results of an annual urine test in primary school.	Effectiveness data derived from studies published in Japan from 1997 – 2000. Prices were in Japanese yen.	The vaccination success rate was 95%. The school rubella vaccination coverage rate was 70%. The school urine test coverage rate was 97%.	· Programme 3 where the 1 st vaccination was administered on an individual basis aged 1-3 and the 2 nd vaccination based on the results of a urine test at primary school was the most effective strategy in improving the positive rate of rubella antibody detection However, it was the most costly programme, but sensitive to the cost of urine antibody testing.

Table 3: Results of economic evaluations included (continued)

Authors, Year, Country	Design / Method	Aim	Study population	Interventions	Data	Results	Authors' conclusions
Watson et al, 1996 Portland, Oregon, USA.	Cost-effectiveness analysis and measles seroprevalence study on a cohort of children followed-up for 12-33 days (median 14).	To assess the efficiency of routinely vaccinating (2-dose schedule) children aged 4-6 years against measles.	679/ 2305 invited parents of children aged 4-6 years who had received 1 dose of measles vaccine aged 15-17 months, who had never been diagnosed as having cancer, leukaemia, or a serious defect of the immune system.	Initial antibody testing for measles followed by revaccination and antibody testing of those who were seronegative.	The effectiveness data corresponded to 1990.	37 children were measles seronegative and were re-vaccinated and 36 (97%) responded by seroconversion. Maternal education was the only factor associated with non-response to initial vaccination. Of 679 children re-vaccinated, an additional 36 (5%) seroconversions were achieved relative to the initial vaccination option.	<ul style="list-style-type: none"> · Revaccination substantially reduces the pool of susceptible children. The cost of seroconversion was high at \$415. A two dose schedule should significantly reduce the risk and impact of outbreaks of measles in vaccinated cohorts. · Further studies are needed to validly state the cost and effectiveness of measles revaccination relative to initial vaccination alone.
White et al, 1985. USA	Cost-effectiveness analysis. Epidemiological cohort model of survival and disease.	To compare 1. MMR vaccine with no immunisation programme, 2. MMR vaccine with vaccination using separate measles, mumps and rubella antigens, 3. Separate measles, mumps and rubella antigens with no immunisation programme.	All infants in the United States.	1. MMR vaccine 2. Measles, mumps and rubella as separate vaccines.	Direct costs were to the health service and the patient with price information related to 1983.	The cost-benefit ratio was 14.4: 1 for MMR vaccine vs. no immunisation programme. The cost-benefit ratio was 8.9: 1 for separate measles, mumps and rubella vaccines vs. no immunisation programme. For MMR vaccine vs. measles, mumps and rubella separate vaccines, the incremental cost was negative and benefits were zero.	<ul style="list-style-type: none"> · The combined vaccine programme dominated the individual vaccines, assuming equivalence, but lower costs.

Table 3: Results of economic evaluations included (continued)

Authors, Year, Country	Design / Method	Aim	Study population	Interventions	Data	Results	Authors' conclusions
Zhou et al, 2001 USA	Cost-benefit analysis.	To investigate the costs and benefits of the routine childhood vaccination schedule in the USA compared with no immunisation.	The hypothetical study population was the 2001 US birth cohort.	Routine childhood immunisations.	Effectiveness data were derived from studies published 1992 – 2004, national databases and expert opinion. The resource use and cost data related to 1985 – 2004. Prices in US dollars related to 2001.	Incidence. Without vaccination, the annual incidence of disease per 100,000 population was estimated to be: 600 for diphtheria 0.3 for tetanus 4,720 for pertussis 104 for Hib meningitis 9.4 for Hib epiglottitis 12 for Hib septicaemia 13.4 for Hib pneumonia 14.7 for Hib cellulites 2.7 for Hib arthritis 1.3 for Hib other invasive disease 31 for paralytic poliomyelitis 10,641 for measles 6,205 for mumps 3,300 for rubella 9,839 for varicella. With vaccination, the annual incidence of disease per 100,000 population was estimated to be: 1 for measles, 7 for mumps, 0.2 for rubella 33 for pertussis 1,091 for varicella 0 for polio and <0.1 for all the other above Hib-related conditions.	<ul style="list-style-type: none"> · The full vaccination schedule would prevent 13,622,004 infection cases and save 33,101 deaths. · The current schedule of vaccinations in the USA is cost saving. For every dollar spent, the vaccination programme saved more than \$5 in direct costs and approximately \$11 in additional costs to society. · Caution is required in interpreting the results and generalising to other settings because of the assumptions made in the model.

Table 3: Results of economic evaluations included (continued)

Authors, Year, Country	Design / Method	Aim	Study population	Intervention	Data	Results	Authors' conclusions
Zhou et al, 2004 USA	Cost-effectiveness analysis and cost-benefit analysis.	To evaluate the cost-effectiveness and economic impact of the two-dose MMR vaccination programme in the USA.	Hypothetical birth cohort of 3,803,295, infants born in 2001 in USA, followed up to the age of 40.	Two dose MMR vaccination or one dose MMR compared with no vaccination.	Effective data derived from a review or synthesis of literature published from 1962 – 2000. resources referred to 1985 – 2001. Prices in US dollars related to 2001.	<p>Coverage with 1st dose of MMR was 3.98% in children aged <1 year and 90.2% - 95.0% in children aged 1-6 years. Coverage with 2nd dose of MMR was 0.99% in children aged <1 year and 79.19% in children aged 1-6 years. Incidence.</p> <p>In a cohort of 3,803,295 children, without MMR vaccination there were 3,433,722 cases of measles, 2,100,718 mumps cases, 1,786,334 rubella cases, 616 cases of CRS and 2,888 deaths occurred over 40 years. without MMR with a 2-dose MMR vaccination programme there were 686 cases of measles, 4,801 mumps cases, 2,304 rubella cases, 14 cases of CRS and 3 deaths occurred over 40 years.</p> <p>Compared with the 1-dose MMR, the 2-dose programme prevented 66,712 cases of measles or mumps, and 16 deaths. The 2-dose MMR resulted in an additional 1,070 life years saved. The net saving from the 2-dose programme was \$3.513M. The cost-benefit ration of the 2-dose programme remained greater than 1 in all scenarios examined.</p>	<p>The 2-dose MMR vaccination programme from total direct and societal perspective was highly cost beneficial and resulted in substantial cost savings. The 2nd dose eliminated endemic measles, which was not achieved with the one-dose strategy. The relative cost-effectiveness of the 2-dose strategy was comparable to that of other life-saving interventions in the USA.</p> <p>Note: The magnitude of the cost-benefit ration is specific to the size of the patient cohort examined and cannot be generalised.</p>

Table 4: Results of ecological studies included

Authors, Year, Country	Design / Method	Aim	Population	Data	Results	Authors' conclusions
Lamden & Gemmell, 2008 Cumbria and Lancashire	Demographic and structural analysis.	To identify general practice factors associated with high MMR coverage.	257 general practices in Cumbria and Lancashire in 2005.	CHIS (Child Health Information Systems) of 8 PCTs Practice structure, census indicators for deprivation Ethnicity data At lower level SOA.	Mean MMR uptake 86.4% (range 59-98%). 28% (74/257) achieved DH higher target payment level of 90%. Uptake not associated with practice size, number of GPs or Practice Nurses (PNs). No correlation between uptake and deprivation or white or non-white population. Negative association between uptake and barriers to housing and services ($r = -0.2330$, $p < 0.001$).	Having a strategic approach is important. Practices should ensure easy access to child vaccination High uptake can be achieved by practices in deprived areas. Further research is needed to identify practice system factors associated with high MMR uptake.
Avis et al, 2007 Saskatoon Canada	Ecological study design.	To utilise newly available data from the Saskatchewan Immunisation Management System (SIMS) to examine city and neighbourhood uptake of MMR vaccine and identify potential factors that contribute to low uptake in Saskatoon.	All 10,827 two-year olds living in the city of Saskatoon from 1999 – 2002, covered by the Saskatchewan Health Plan.	Data from 10,287 SIMS records of each child who had MMR from 1/01/96 – 31/12/2002 used as the numerator. Saskatchewan Health Covered Population Report provided the number of 2-year olds. Postcode information enabled neighbourhood assignment. Vehicles per capita per neighbourhood from vehicle data from City of Saskatchewan.	Immunisation rates were relatively stable between 1999 and 2002. 80.6% of variation in up-to-date immunisation uptake could be explained by the proportion of single-parent families headed by females and the number of vehicles per capita registered in the neighbourhood.	There are significant inequalities in immunisation uptake at neighbourhood level in Saskatoon. These findings may indicate the presence of real or perceived barriers to immunisation in some Saskatoon neighbourhoods. Inequalities in uptake of MMR may be due to lower accessibility of health centres, due to lack of a car and possible lack of support available for single mothers.

Table 4: Results of ecological studies included (continued)

Authors, Year, Country	Design / Method	Aim	Population	Data	Results	Authors' conclusions
Christakis et al, 2000 Seattle USA	Analysis of automated data system.	To assess whether continuity of care is associated with timely administration of MMR vaccine.	11,233 eligible children on the Group Health Co-operative (GHC) of Puget Sound, born 1 January 1993 to 31 December 1997.	Automated database of GHC, 11,233 children with comprehensive records of immunisation and out-patient visits. Logistic regression used to model the odds that the MMR vaccine was administered by 15 months of age.	Medium continuity on the Continuity of Care Index (OR 1.20, 95% CI, 1.08 to 1.33) and high continuity (OR 1.36, 95% CI, 1.22 to 1.52) were associated with an increased likelihood of being immunised by 15 months compared with patients with low continuity of care.	Greater continuity of care is associated with more timely MMR immunisation. MMR uptake might be improved in the context where health care professionals and patients know each other better.
Evans & Thomas, 1998 Glamorgan Wales	Analysis of data from the computerised child health system.	To identify factors associated with non-uptake of pre-school booster immunisation.	All 6184 children born in 1990 and living in South Glamorgan.	Computerised child health system.	Pre-school booster coverage was 91.4%. Booster uptake was lower among children living in urban areas and in more deprived electoral wards. Uptake was strongly associated with primary immunisation for DTP or 1 st dose MMR. Identifying children who miss either primary immunisation predicts 52.4% of those who miss the pre-school booster.	Effective targeting of children who have missed primary immunisation could improve pre-school booster uptake and ensure at least one dose of MMR.

Table 4: Results of ecological studies included (continued)

Authors, Year, Country	Design / Method	Aim	Population	Data	Results	Authors' conclusions
Friederichs et al, 2006 Glasgow Scotland	Analysis of Scottish Immunisation and Recall System (SIRS) population database.	To determine the impact of adverse publicity on MMR uptake and measles susceptibility, including whether vaccination is delayed and the role of deprivation.	1,079,327 children born 1987 – 2004.	A population database for Scotland containing immunisation records for over 1 million children born 1987 – 2004. Included postcode and deprivation category.	6% reduction in coverage from 1998 – 2001. The greater the deprivation, the greater the tendency for late vaccination, especially for the most deprived category. Most affluent areas tend to be vaccinated promptly or not at all. An 8-fold rise in number of districts with greater than 20% susceptibility in this group.	Increasing measles susceptibility in nurseries is concerning, particularly in the most vulnerable areas. These figures are likely to increase as MMR uptake has not returned to previous levels. Increased susceptibility can also be expected in primary schools.
Hawker et al, 2007 Birmingham England	Cohort analysis of existing database of child immunisation records.	To examine whether there are differences in MMR uptake by ethnic group and whether MMR uptake changed by ethnic group following adverse publicity.	Cohort of children born in Birmingham 1 January 1992 – 31 December 1998.	Computerised child immunisation records, including ethnic group.	MMR uptake in Birmingham: Fell from 91.1% in 1994 to 89.8% in 2000. Highest in Asian children 93.1%. Lowest in Black Caribbean children – 86.3%.	Significant differences between ethnic groups in Birmingham. Ethnic data should be collected uniformly. Computerised child immunisation records need to be up-to-date. Further research needed to explore the mechanisms underlying the differences.
Henderson et al, 2004 Highlands, Scotland	Analysis of childhood immunisation uptake rates.	To investigate the influence of practice type and call / recall systems on childhood immunisation coverage.	General practices in the Highland Health Board in Scotland.	Immunisation uptake of individual practices obtained from the Information and Statistics Division of NHS Scotland.	Uptake of all vaccines in children reaching the age of 2 years was lower in practices using their own call / recall system than those engaged with the national system. Inducement practices	Engagement with the national recall system was associated with higher immunisation coverage for children reaching 2 years of age. Inducement status was associated with low uptake.

					<p>achieved a lower uptake than non-inducement practices for every immunisation studied, with differences from 4.7% to 7.8%. Uptake was less in single handed practices than group practices with differences from 2.4% to 11.4%. Higher uptake of diphtheria and MenC was associated with the use of the national recall system.</p>	
Johnson et al, 1995 Dublin Ireland	Cross-sectional sero-survey and monitoring trends in measles notifications and mortality.	To determine the susceptibility of 3-14 year old children to measles mumps and rubella and to relate the results to the epidemiology of measles.	837 children attending paediatric out-patient clinics in Dublin in 1991 and 1992.	Data from the infectious disease notification system and vital statistics to examine trends in morbidity and mortality. Blood samples taken whilst children were already having blood taken for other investigations. Sera tested for measles, mumps and rubella IgG/IgM antibody.	The prevalence of measles antibody was: 84% for age 3-6, 83% for age 7-10 and 95% for 11-14. For mumps, antibodies were present for: 48% for age 3-6, 60% for age 7-10 and 65% for 11-14. For rubella antibody prevalence was: 78% for age 3-6, 63% for age 7-10 and 74% for 11-14.	Outbreaks are inevitable given the sub-optimal uptake of MMR. A 2-dose MMR vaccination programme is essential. A primary school MMR 'top-up' programme would appear to be necessary.

Table 4: Results of ecological studies included (continued)

Authors, Year, Country	Design / Method	Aim	Population	Data	Results	Authors' conclusions
Lawrence et al, 2003 Sydney Australia	Cross sectional design and cohort analysis of existing data. Telephone interviews with a sample of 506 parents with no record of 2 nd MMR.	To assess under-reporting of MMR vaccination to the Australian Childhood Immunisation Register (ACIR). To estimate MMR coverage among 5-year old children and the proportion immune to infection. To identify factors related to non-uptake of MMR.	64,000 aged five years born 1 October to 31 December 1995, registered with ACIR on 4 May 2001.	506/1020 (50%) parents consented to computer-assisted telephone interviews conducted in July 2001. MMR coverage calculated for entire birth cohort at 5 th birthday then on 4 May 2001 to correct for under-reporting to the ACIR.	MMR coverage for the cohort was 52.9% at 5 years of age, and 84.1% at around 5.5 years of age. 93% was immune to measles due to vaccination. 42% of parents with a child with no record of 2 nd MMR had received the MMR before their child was 5.5 years of age. The most commonly reported reason for incomplete vaccination was lack of knowledge about the age the second dose was due (29%) and medical contra-indications to MMR vaccination (18%) or that they had forgotten the MMR was due (16%). Disagreement or concern was reported by 14% parents, most commonly because of the perception that the risks outweighed the benefits.	Continued effort will be required to eliminate measles in Australia. School entry requirements may be a primary driver for 2 nd dose of MMR. Strategies are needed to address parental knowledge about the MMR vaccination schedule and contra-indications. Strategies are needed to improve accurate reporting of coverage.

Table 4: Results of ecological studies included (continued)

Authors, Year, Country	Design / Method	Aim	Population	Data	Results	Authors' conclusions
Pearce et al, 2008 UK	Nationally representative prospective cohort study. Trained researchers interviewed the main caregiver, usually the mother, at home. Socio-economic characteristics were collected.	To estimate the uptake of the combined MMR vaccine and single antigen vaccines to explore factors associated with uptake, and reasons for not using MMR.	The millennium cohort study; a longitudinal study of children born in the UK from September 2000 to January 2002. 14,630 participated from 18,296 invited. Immunisation data were available for 14,578.	A random sample of electoral wards, stratified to ensure representation of England, Scotland, Wales and Northern Ireland, deprived areas and high proportions of families from ethnic minorities. Also data from the UK data archive at the University of Essex. Forward stepwise Poisson regression analysis used to identify characteristics associated with MMR uptake.	88.6% Immunised with MMR 5.3% received vaccines in a single dose. 5.2% Immunised with at least one antigen, Children living in a household with other children or with a lone parent, or whose mother was under 20, or over 34 when they were born, or more highly educated, or not employed, or self-employed were more likely to be unimmunised. Use of single vaccines increased with household income, maternal age and education. 67% of parents who did not immunise made a 'conscious decision' not to immunise. 15% a medical reason, 6% a practical reason.	MMR uptake is recovering. A substantial proportion of children remain susceptible to infection because of parents' decision not to immunise. Social differentials in uptake could be used to inform targeted interventions to promote uptake. Reminders of immunisation appointments and more accessible opportunities might be successful. Ready access to evidence-based information re MMR, tailored to particular concerns and beliefs of different groups.

Table 4: Results of ecological studies included (continued)

Authors, Year, Country	Design / Method	Aim	Population	Data	Results	Authors' conclusions
Pearce et al, 2009 UK	Nationally representative Millennium Cohort Study. Stratified clustered sampling design.	To investigate the relationship between primary immunisation status and MMR uptake.	14,578 children born in the UK, 2000 – 2002, with immunisation data.	Millennium Cohort Study (MCS). Information collected about 9-month old infants and 3-year old infants. Analysis included 14,578 children aged 3 years who had information on MMR reported by the mother.	At 9 months, 95.4% were reported to be fully immunised with primary vaccines and 3.5% partly immunised. By 3 years, 96% were fully immunised with primary vaccines and 88.6% were immunised with MMR. 5.2% received vaccines in a single dose. 6.1% were unimmunised against measles mumps and rubella at age 3 years. Children unimmunised with primary vaccines at 9 months were 12.6 times more likely to be unimmunised against measles mumps and rubella compared with children who were fully immunised. Children unimmunised with primary vaccines at 3 years were 16.9 times more likely to be unimmunised against measles mumps and rubella compared with children who were fully immunised.	Data from a nationally representative, contemporary study have shown that children who remain unimmunised with primary vaccines are also more likely not to receive MMR. Children who do not catch up with their missed primary immunisation are at greatest risk. Tailored information or improved access may help. More work is needed to determine how best to target this group.

Table 4: Results of ecological studies included (continued)

Authors, Year, Country	Design / Method	Aim	Population	Data	Results	Authors' conclusions
Reading et al, 2004 Norwich UK	A cohort analysis of cumulative immunisation uptake of 616 children aged 1 – 4 years.	To investigate whether a delay in infant immunisation is associated with the number of older siblings.	616 children aged 1 – 4 years selected from the lists of 12 general practices in and around Norwich for a case-control study of atopic dermatitis.	Data on family characteristics and social circumstances were collected at interview with the child's mother. Immunisation data were taken from the computerised district health records. Data were collected from 1999 to 2001 with a further check on immunisation status in 2003. unadjusted odds ratios were calculated for the effect of explanatory variables on delayed immunisation uptake. Unconditional multiple logistic regression was used to identify independent effects.	98% (606/616) children completed the primary pertussis immunisation and 94% (581/616) had an MMR. Number of older siblings was strongly associated with a delay in pertussis immunisation but not in MMR immunisation. Delay in pertussis was significant associated with housing tenure and mother's social class when the child was an infant. Delay was associated with more disadvantage. Younger children and those with older mothers were more likely to have delayed immunisation.	Infants with older siblings are at greater risk of pertussis infection from intrafamilial contagion yet are less likely to be immunised on time. Practical suggestions include: Improving access to clinics Reducing inconveniences Home immunisation Flexible clinic times Flexible locations Practical help with child care. Address concerns in immunisation advice in an unbiased and reasoned way.
Samad et al, 2006a UK	Prospective cohort study	To compare demographic, social, maternal and infant related factors associated with partial immunisation in the 1 st year of life in the UK.	Sample of electoral wards in England, Wales, Scotland and Northern Ireland, stratified by measures of ethnic	Millennium Cohort Study (MCS). 14,578 children born in the UK, 2000 – 2002, The sample was stratified by UK country, and electoral wards to adequately represent infants from ethnic minority groups,	3.3% infants in the UK were partially immunised and 1.1% were unimmunised at 9 months. Rates were highest in England. Factors independently associated with partial immunisation status were:	Mothers of unimmunised infants differ in age and education from those of partially immunised infants. Interventions to reduce incomplete immunisation in infancy need different approaches.

			composition and social disadvantage. 18,488 infants born from September 2000 to January 2002, resident in the UK and eligible to receive child benefit at age 9 months.	disadvantaged backgrounds and the three Celtic countries. The survey response rate was 72%. Survey interview data were gathered when the infants were 9 months old. Data from 18,488 singletons or 1 st born infants were analysed and estimated rate ratios using Poisson regression.	Residence in wards with disadvantage, ethnic wards, larger family size, lone parenthood, teenage parenthood, maternal smoking in pregnancy, admission to hospital by 9 months. 1.9% of mothers of unimmunised infants were educated to degree level or above, 3.1% were older (aged 40 or more), were highly qualified, 4.7% of mothers of unimmunised infants were of black Caribbean ethnicity.	
Sharland et al, 1997 London UK	An ecological study with analysis of COVER (Cover of vaccination evaluated rapidly) data and data from the 1991 census.	To determine associations between indicators of social deprivation and the uptake of primary immunisation in London to identify characteristics of families that might predict non-completion of immunisation and so facilitate targeting of resources.	28 inner and outer London district health authorities in 1991.	Immunisation coverage data from 28 inner and outer London district health authorities in 1991 and small area statistics from the 1991 census. Univariate linear regression then stepwise linear regression.	Coverage of DTP at 12 months varied from 68% to 95% (mean 86%). Coverage of MMR at 24 months varied from 61% to 94% (mean 84%). A significant negative correlation was found at 24 months for lone parent families and MMR coverage. A small positive association was found with unemployment and MMR coverage.	Lone parenthood was identified as an important independent risk factor in London for non-completion of immunisation at 12 months of age. Unemployment may facilitate uptake as the parent does not have to take time off work to attend the clinic. Targeting families for a domiciliary immunisation service may improve coverage. An economic evaluation is needed to determine whether such a service would be cost-effective.

Table 4: Results of ecological studies included (continued)

Authors, Year, Country	Design / Method	Aim	Population	Data	Results	Authors' conclusions
Skinner et al, 1998 Melbourne Australia	Prevalence surveys of uptake rates of age 10 – 11 years MMR uptake and age 13 – 14 hepatitis B vaccination.	To measure the uptake of MMR among 10 – 11 year olds and hepatitis B vaccination among 13 – 14 year olds.	Survey of 1160 school children aged 10 – 11 and 1102 school children aged 13 – 14.	1160 school children aged 10 – 11 and 1102 school children aged 13 – 14.	Coverage of MMR was 83%. Uptake of HepB was 77%. There was a higher uptake of MMR in non-government primary schools.	Relatively little is known about the adolescent immunisation target population. Further research is required to assess factors influencing uptake of vaccination in the adolescent age group (school vaccination policy, teacher commitment, teacher-delivered material, school nurse role). Further consideration need to be given to the delivery in schools, clinics or by GPs.
Thomas et al, 1998 Wales	Prevalence survey of MMR uptake.	To assess progress in the 'catch-up' programme in immunisation coverage for each birth cohort and each of the five Welsh HA.	126,550 children born in Wales from January 1990 to march 1993.	The child health computer system	63,855 (50.5%, range: 35.4 – 58.3%) had received two doses of MMR. 120,668 (95.4%) had received one dose. 5,882 (4.6%) had no record of receiving any MMR. 18.4% unimmunised attended for the MMR catch-up.	The 'catch-up' programme may not reach the children who most need to be immunised. Successful elimination may depend on targeting this group.
Wright et al, 2005 England	Ecological study of immunisation coverage by second birthday	To assess the geographical variation in trends in MMR coverage and identify factors affecting MMR coverage at population level.	Children whose birthday was 1 st April 1999 and 31 st March 2000 in 95 DHAs.	Routinely collected of COVER (Cover of vaccination evaluated rapidly) data from 1993 – 2004 for England and a summary KC50 form completed by individual health authorities. Trends were assessed for 95 District Health Authorities. Also Experian Mosaic data which uses housing and vehicles when measuring social class.	Since 2000 MMR coverage declined in most areas of England. Population density and deprivation strongly correlated with MMR uptake. Decline in coverage related to proportion of educated population. Greater in densely populated areas. % coverage for DTP and polio significantly related to MMR coverage (r=0.76, p=0.00).	1 st study to examine socio-economic factors influencing MMR uptake. In all DHAs peak MMR coverage was in 2000 or earlier. Decline in coverage affected most areas of England. The lowest rates of MMR coverage remain in urban areas, particularly inner cities, which also tend to show high levels of deprivation. Public health resources should target inner city areas, and focus on concerns of the better educated about safety.

Table 5: Results of studies of health care professionals (surveys & questionnaires)

Authors, year	Aim of study	Design methods	Sample	Response Rate	Results/Findings	Comments/Study Limitations
Henderson et al (2004) Scotland	Assessment of GPs' views on vaccination issues.	Semi-structured postal questionnaire (2 mailings).	GPs working in the Highland Region of Scotland (n=282).	73%.	28% expressed concerns about side-effects of MMR compared with other vaccines (p<0.000); 98% thought benefits of vaccination outweighed possible risks, however, only 91.7% and 85.7% believed this to be true for 1 st and 2 nd dose of MMR respectively (p=0.007); Only 57% were 'very confident' in discussing MMR vaccine with parents, compared to 75% for DTP-Hib vaccine (p<0.001); A number of GPs held erroneous beliefs regarding the adverse events associated with MMR, with 1 in 5 being unaware of the true side-effects; GPs felt that parents distrusted government information regarding MMR; 44.6% expressed a wish for further training on immunisation issues.	Questionnaires had been used in previous studies; Pilot study was undertaken; Analysis of non-respondents was undertaken (no differences); HVs were found to have a more prominent role in vaccination compared with GPs, and therefore data may not be an accurate reflection of issues. Study recommendations <ul style="list-style-type: none"> · Further education initiatives should include all healthcare professionals involved in immunisation; · Educational sessions may be combined with other measures shown to be effective, including reminders to doctors about children requiring vaccination, and assessment and feedback to practices on the vaccination coverage of children registered with them; · A 'diagnostic analysis' should be undertaken to identify obstacles to change, and that any intervention planned should be targeted at overcoming them.
Lamden & Gemmell, 2008 Cumbria and Lancashire England	To identify general practice factors associated with high MMR coverage.	Confidential questionnaire survey sent to each practice, for one collective response.	PNs in 257 general practices in Cumbria and Lancashire.	195/257 (75.9%) responded.	No association between MMR uptake and number of PNs. MMR given by a GP in 42.8% practices, a PN in 54.8% and a HV in 60.5% practices. The proportion of HVs vaccinating in each PCT ranged from 28% - 100%. PNs said: 91.8% had a 'teamworking' approach to MMR, 79.4% had a self-reported strategic	There was no association between immunisation by GP, PN or HV. Having a strategic approach with clear objectives was the only factor significantly associated with achieving an MMR uptake of over 90%. Further research is needed to identify practice system factors associated with high MMR uptake.

Petrovic et al (2001) North Wales, UK	To determine the knowledge, attitudes and practices among health professionals regarding MMR, particularly the 2 nd dose.	Postal survey questionnaire.	GPs (n=206), HVs (n=148), PNs (n=239).	80% GPs (n=165), 95% HVs (n=140), 85% PNs (n=204)	approach with clear objectives, 42.3% discussed MMR in detail at a practice meeting. 82% had a system for contacting non-attenders, 15% used the MMR video, 11% had audited reasons of non-attendance. 24.7% knew their MMR uptake. 48% of the sample had reservations about 2 nd dose, and 3% disagreed with giving it. HVs were nominated as the best source of advice. 61% of HVs compared with 46% of GPs reported feeling very confident about explaining the rationale of a two dose schedule to a well-informed parent, but only 20% would recommend the 2 nd dose to a wavering parent. 33% of PNs thought there was a link between the vaccine and Crohn's disease, and 27% that it was associated with autism. Nearly one fifth of GPs reported they had not read the relevant guidance on MMR.	Self-selection and non-response bias? In response to this study, North Wales Health Authority's department of public health is constructing a MMR vaccination resource pack that contains evidence-based information and is designed for use by health professionals during consultation with parents.
Smith et al (2001) Greater Manchester, UK	Exploration of health professionals' confidence in MMR vaccine Assessment of health professionals' knowledge and attitudes towards MMR 2 nd dose.	Questionnaire Survey (2 rounds) sent to all GPs, PNs and HVs in Salford and Trafford Health Authority area.	GPs (n=236), PNs (n=78) and HVs (n=40) of Salford and Trafford Health Authority.	Overall = 62% (GPs=57%) (PNs=64%) (HVs=75%).	Confidence in vaccine fell from 59.4% to 40.9%; 40% of respondents were unsure about the need for a 2 nd dose; 1 in 10 respondents stated that 2 nd dose was not necessary; PNs and HVs were less confident than GPs; 61% of sample felt that more research was warranted; GPs were more aware of the need for a 2 nd dose; Health professionals were more likely to encourage uptake of the 1 st dose compared with 2 nd .	20% of response data were "randomly validated" using a computerised questionnaire application (SNAP); No exploration of non-respondents; No statistical analysis of results, yet authors report a 'significant fall in confidence'; No information about questionnaire validation. Study recommendations · HVs and nurses in particular should be targeted.

Table 6: Results of studies of parental surveys & questionnaires

Authors, Year, Location	Aim of study	Design /Method	Sample	Response rate	Results/Findings	Comments/Study Limitations
Alfredsson et al, (2004) Sweden	To study reasons why parents choose not to vaccinate against MMR.	Postal questionnaire.	Parents of two identified birth cohorts with children born in 1995 & 1996 (n=250)	42% (28% in areas with high non-vaccination rates; 32% from vaccinated children).	Children without MMR vaccination were also more likely to be unvaccinated against other diseases (p=0.003); The main reasons for choosing not to vaccinate were that vaccines were thought harmful, and that the diseases were harmless or even beneficial; A greater proportion of parents with unvaccinated children reported they had some knowledge of the MMR vaccination before the visit, but they had less accurate information about the vaccine; 20% of the parents with unvaccinated children had not decided upon vaccination before the clinic visit – these parent were the least satisfied with the way they were received at clinic and the information given; 40% of unvaccinated group and 30% of vaccinated group stated that not enough time was allocated for questions and discussions (p<0.05).	Low response rate; Data biased in relation to children who are already vaccinated. Study recommendations <ul style="list-style-type: none"> Physicians have to take more time to listen and discuss in order to strengthen the doctor-patient relationship; It needs to be taken into account that parental knowledge may not be based on scientific data.

Table 6: Results of studies of parental surveys & questionnaires (continued)

Authors, Year, Location	Aim of study	Design /Method	Sample	Response rate	Results/Findings	Comments/Study Limitations
Cassell et al (2006) Brighton, UK	To explore social and cultural influences, and health beliefs associated with low uptake of MMR.	Postal questionnaire.	Parents of children aged 15-24 months whose children had and had not been vaccinated (n=1,135).	39.8% (n=452).	Mothers were more likely to accept MMR for a first child than for subsequent children (p=0.002); 17.5% had chosen single jabs; 10.6% had chosen to delay a decision about vaccination; Of the non-compliant mothers, 32.6% had consulted a homeopath, compared with 10.1% of compliers (p=0.001); Rejection of the vitamin K injection routinely offered at birth was strongly associated with non-compliance (p<0.001); 58% of non-compliers reported concerns about MMR before the birth of their child, being more concerned about family health issues related to MMR, and less likely to see measles as a serious disease; Non-compliers were significantly more likely to have attended public meetings on immunization (p<0.001), had read books on MMR (p<0.001), and seen documentaries	Low response rate; Not representative of normal population Study recommendations · The findings demonstrate the need for immunisation information that acknowledges and addresses lay concepts of immunity.

					(p=0.048); Mistrust of the government and pharmaceutical companies was strongly expressed; A significantly higher proportion of non-compliers claimed to have stopped eating beef because of BSE, with 35% being vegetarian already; and also checked food labels to see if they contain GMOs.	
Flynn & Ogden (2004) Brighton, UK	To describe parents' beliefs about MMR and to explore the best predictors of uptake by the age of 2 years.	Prospective questionnaire and analysis of subsequent uptake data from child health records.	Parents of children who were due to receive an invitation for MMR immunisation (n=898).	56.9% (n=513).	Over half the respondents showed only moderate agreement that they had been encouraged by others to have their children vaccinated, with only a small minority reporting they had clearly been discouraged; Almost half of respondents disagreed that vaccines were unhealthy, but almost as many were unsure; The majority reported having little faith in the media, and had mixed confidence in doctors; Uptake of MMR was related to: previous attendance for vaccination, increased faith in the medical profession, increased faith in the media, and a lower belief that vaccination is unhealthy.	Questionnaire was developed from previous qualitative studies and piloted; No analysis of non-respondents Study recommendations · If doctors wish to encourage parents to vaccinate their children, they need to promote positive views about both themselves and the MMR vaccination itself. · Doctors could place more emphasis on encouraging uptake for earlier, less controversial vaccinations and use these vaccinations as an opportunity for discussing issues about MMR. Such an early emphasis may create a culture of vaccination uptake which could itself become self-perpetuating.

Table 6: Results of studies of parental surveys & questionnaires (continued)

Authors, Year, Location	Aim of study	Design /Method	Sample	Response rate	Results/Findings	Comments/Study Limitations
Gellatly et al (2005) Edinburgh, UK	To identify factors relevant to MMR immunising and non-immunising parents and the extent to which these factors predicted decisions.	Two-stage mixed-method design. Delphi technique elicited parents views of factors which were then incorporated into a questionnaire. Logistic regression was used to predict outcome.	Cluster sample of all parents whose children attended day-care nursery (n=182).	60.4% (n=110). Of these, 72.7% had had their child vaccinated and 27.3% had refused the vaccine.	4 factors significantly predicted vaccination status: the influence of current research (OR=0.18, 95% CI=0.07-0.51), the helpfulness of leaflets and information packs (OR=3.27, 95% CI=1.38-7.75), the importance of eradication of rubella (OR=2.42, 95% CI=1.01-5.78), and the importance attached to the risk of adverse reactions (OR=0.65, 95% CI=0.48-0.87).	These factors have not previously been identified as salient, although only 2 out of 4 have high ORs. An alternative way of interpreting these should have been that those who did not vaccinate their children placed more importance on these factors (current research and risk of adverse reaction). Study recommendations · Parents of both groups perceive the health advice they receive on this issue to be entirely distinct from relevant research findings. More needs to be done to demonstrate that current advice is informed by and reflects the state of accumulated research knowledge.
Gellin et al (2000) USA	To assess parents' understanding of vaccine-preventable diseases, vaccines, immunization practices and policies.	Telephone survey.	Nationally representative group of parents with children aged 0-6 years, and expectant parents (n=16,248 telephone calls).	1600 interviews were conducted.	87% of respondents deemed immunization extremely important, but a significant minority held misconceptions such as believing the child's immune system could become weakened and that children get more vaccinations than is good for them. Children's healthcare providers were cited as the most important source of information.	Interviews were only conducted in English, low response rate. No analysis of non-respondents. Study recommendations · Communication efforts should focus on clarifying and reaffirming parents' correct beliefs about immunization and on modifying misconceptions.

Table 6: Results of studies of parental surveys & questionnaires (continued)

Authors, Year, Location	Aim of study	Design /Method	Sample	Response rate	Results/Findings	Comments/Study Limitations
Gust et al (2003) USA	To explore parental perceptions surrounding risks and benefits of immunisation.	Data from national survey	4,800 adults.	72%.	57% of parents found numbers and statistics most helpful when asked about understanding the benefits and risks of vaccines. A substantial minority (17%) of parents were somewhat or not confident in vaccine safety. Parents with less confidence agreed less with following their doctor's advice. Parents in the lowest income category had a significantly lower level of agreement in the protective value of vaccines, had a higher level of agreement that their child may have a serious side-effect, and a lower level of agreement that their child may get the disease and cause others to get the disease if unvaccinated. High school graduates had a significantly lower level of agreement in the protective value of vaccines and whether their child may get a disease if unvaccinated.	<p>Study recommendations</p> <ul style="list-style-type: none"> The positive relationship between confidence in vaccine safety and reliance on doctors for advice may indicate the need for healthcare providers to identify opportunities to (1) solicit questions about vaccine safety, (2) address vaccine safety-related questions in a way meaningful to parents, and (3) strengthen doctor-patient relationships.

Table 6: Results of studies of parental surveys & questionnaires (continued)

Authors, Year, Location	Aim of study	Design /Method	Sample	Response rate	Results/Findings	Comments/Study Limitations
Murphy et al, 1994 Dublin, Ireland	To establish the need for opportunistic MMR immunisation among paediatric A&E attenders in three Dublin paediatric hospitals and examine the relationship between immunisation status and socio-economic factors.	Two-month cross-sectional study in May and June 1991. Survey interview data were compared with information on the Eastern Health Board record system.	337 parents of eligible children were born between 1 st May 1986 and 31 st December 1989; aged 15 months to five years.	98.2% (337/343).	There was a history of MMR vaccination in 66% (223/337) children. Reasons given for non-vaccination were 30% for medical reasons, such as frequent colds and a family history of epilepsy, and 30% were overlooked.	<p>Study recommendations</p> <ul style="list-style-type: none"> · Increase parental knowledge of the implications of measles and rubella. · Educate health care professionals about appropriate contra-indications. · Data quality standards to be improved. · A&E departments to be equipped to ascertain immunisation status. · Opportunistic immunisation initiated in paediatric A&E departments. · Immunisation should be performed in A&E departments by a nominated nurse with protected time to carry out this role.
Pareek & Pattison, 2000 Birmingham, UK	An investigation of factors that influence the intentions of mothers to vaccinate with MMR.	Survey.	300 mothers of children aged between 5 and 12 months (prior to first MMR vaccine) and between 21 and 35 months (prior to second MMR vaccine).	59%.	Fewer mothers intended to take their children for the 2 nd MMR vaccination than the 1 st (p<0.001). These mothers expressed more negative beliefs about the vaccine outcome (p<0.001), were more likely to believe it was unsafe (p=0.004) and that it rarely protected (p=0.014). 29.8% cited autism as a side effect; The most trusted source of information was the GP, but	<p>Non-response analysis undertaken – no differences in vaccination rates, but there was an over-representation of white British respondents, and an under-representation of ethnic minorities (comparable with other surveys of this nature).</p> <p>The GP's role in education would appear to be central but many are afraid that broaching the subject with parents would put them off vaccination altogether.</p>

					<p>the most common source of information on side-effects was the TV.</p> <p>For those approaching the 1st MMR vaccination, only 'vaccine outcome beliefs' significantly predicted uptake;</p> <p>For those approaching the 2nd dose, 'vaccine outcome beliefs', 'attitude to the MMR vaccine', and 'prior MMR status' all predicted intention.</p>	<p>Study recommendations</p> <ul style="list-style-type: none"> · Educational campaigns at the national and local level need to emphasise the safety of the MMR vaccine and the danger of vaccine-preventable diseases, but which also emphasise the efficacy of the vaccine and delineate the rationale behind the two-dose schedule.
<p>Petrovic et al, 2003 North Wales, UK</p>	<p>To identify factors associated with non-uptake of the 2nd dose of MMR.</p>	<p>Case control study comparing responses from questionnaires (2 repeat mailings).</p>	<p>Parents of children who had accepted all vaccines including MMR (n=200) compared with parents of children who had received all vaccines except the 2nd dose of MMR (n=101).</p>	<p>74.3% for non-acceptors (n=75) and 77.5% for acceptors (n=155).</p>	<p>Non-acceptors were more likely to report having received information from newspapers/TV or from the GP; and more likely to report having a lot or some influence from these mediums. (95% CI). Non-acceptors were significantly more likely to have a worry about the MMR vaccine.</p> <p>The most common reason for not accepting the 2nd dose was that the child had had one dose already and this was deemed enough, and that parents were worried about the side-effects.</p>	<p>Recall bias could be a problem</p> <p>Study recommendations</p> <ul style="list-style-type: none"> · Parental concerns require an open, empathetic dialogue in which health professionals need to effectively communicate the best and most up-to-date scientific evidence, while bearing in mind the internal validity of parental concerns and the multi-faceted nature of risk perception and risk communication. · School entry and times when other vaccinations are given would be good opportunities for catch up in a school setting. · Parents' objections appear transient, and catch-up campaigns are therefore likely to have a significant impact on coverage.

Table 6: Results of studies of parental surveys & questionnaires (continued)

Authors, Year, Location	Aim of study	Design /Method	Sample	Response rate	Results/Findings	Comments/Study Limitations
Samad et al, 2006b UK	Prospective longitudinal cohort study. Mothers interviewed at home when the baby was 9 months old.	To examine the reasons given by mothers for either incompletely or not immunising their infants with the primary vaccines, (DTP, polio, Hib and MenC).	Millennium Cohort Study (MCS). 18,819 infants born in the UK, September 2000 – January 2002. Sample of electoral wards in England, Wales, Scotland and Northern Ireland, stratified by measures of ethnic composition and social disadvantage to adequately represent infants from ethnic minority groups, disadvantaged backgrounds and the three Celtic countries. 18,488 infants born from September 2000 to January 2002, resident in the UK and eligible to receive child benefit at age 9 months.	The survey response rate was 72%. Survey interview data were gathered when the infants were 9 months old.	95.6% infants (17,544/18,488) were reported to be fully immunised, 3.3% (712/18,488) partially, and 1.1% (232/18,488) unimmunised. For infants partially immunised, 45% (328/697) mothers cited medical reasons, 32% (235/697) cited problems with health services / accessibility, and 12% (57/697) cited beliefs or attitudes towards immunisation. For non-immunised infants, 33% (84/228) mothers cited medical reasons, 12% (29/228) cited problems with health services / accessibility, and 47% (92/228) cited beliefs or attitudes towards immunisation.	The first large scale study to explore the incompleteness of immunisation uptake. An understanding of maternal reasons for incomplete immunisation may assist in identifying appropriate interventions to maximise uptake. Accessible health care services should be provided. Children who do not attend should be followed-up appropriately. Health care professionals require training to ensure parents are provided with accurate and consistent information and ally parental concerns.

Table 6: Results of studies of parental surveys & questionnaires (continued)

Authors, Year, Location	Aim of study	Design /Method	Sample	Response rate	Results/Findings	Comments/Study Limitations
Simpson et al, 1995 Bath UK	To explore reasons for non-uptake of childhood immunisation.	Postal questionnaire.	Parents who had not taken up immunisation for their children (n=106).	82% (87/106) replied.	21% (22/106) parents gave homeopathy as the reason they did not have their child immunised. 16% (17/106) said religious beliefs were the reason and 5% (5/106) said the reason was 'medical'.	"The study has allowed the identification of groups that might benefit from more informed and accurate information." Families should have the opportunity to discuss concerns with the district immunisation co-ordinator.
Smailbegovic et al (2003) London, UK	Exploration of knowledge, attitudes and concerns of parents who have not completed immunisation course.	Questionnaire (2 rounds) and interview.	Parents of children resident in the London Borough of Hackney identified from the child health database as having defaulted for one or more primary immunizations (n=129).	69% (10 respondents were interviewed).	MMR vaccines were most frequently omitted (57%); 33.8% thought immunization with above vaccine was more risky than non-immunization; Those interviewed were notably concerned about MMR vaccine, but not immunization in general; Parents in interview group perceived information provided by health professionals to be 'poor', and 'biased' although this was not found in questionnaire sample; All mothers in interview sample had 'major' concerns relating to MMR vaccine; Ethnicity and religious beliefs affected perceptions of risk.	Questionnaire was piloted (n=7); No statistical analysis; Immunisation information reported for non-respondents to address non-response bias; Generalisability of findings is limited due to small numbers; Interview sample were self-selecting (half the families had contact with parents of children with autism and suspected a link). Study recommendations · Parents require information that is up-to-date, tailored to their individual needs and provided by health professionals who are well informed; · Interventions aimed at improving overall uptake may serve to widen the gap in uptake across social classes.

Table 6: Results of studies of parental surveys & questionnaires (continued)

Authors, Year, Location	Aim of study	Design /Method	Sample	Response rate	Results/Findings	Comments/Study Limitations
Wroe et al (2005) Bromley, London, UK	To investigate parental decisions about MMR and single vaccinations.	Questionnaire.	Parents recruited via Bromley PCT (n=216).	52.7% n=114.	Parental decisions were explained by emotion-related variables, specifically anticipated responsibility and regret; Parents decisions were strongly influenced by the idea that harm that occurs as a result of deciding to immunise is less acceptable than harm that occurs as a result of deciding not to immunise; Media reports that were emotional and sensationalised were likely to have a direct effect on emotions, possibly increasing the sense of responsibility and anticipated regret of an action that may cause harm.	Low response rate, possible bias Sample was more educated than normal population sample; Conclusions based on theoretical assumptions. Study recommendations · It is important that decision-makers are provided with the best available evidence, and are given help to use this information in a way that fits with their values, as opposed to basing decisions on emotional information. · Science stories could be turned into 'narratives' that are interesting, accessible and informative.
Yarwood et al, 2005 (and Ramsay et al, 2002)	To obtain information on mothers' knowledge of immunisation; attitudes towards immunisation; experiences of immunisation; and to	20 surveys from October 1991 to March 2001. Random location sampling.	15,000 interviews with parents as part of the Immunisation Policy, Monitoring and Surveillance.	150 consecutive households in 132 randomly selected enumeration districts until quota obtained.	Spontaneous awareness of MMR and MenC has increased. Mothers are most likely to rate the consequences of getting meningitis C and polio as 'very serious' compared with the other illnesses. A rapid decline in perceived safety of MMR was apparent from 2000 – 2001.	Comments/Study Limitations · The parents are most likely to discuss immunisation with the HV in particular. · Mothers are more influenced by the perceived risks a vaccine carries, rather than balancing the overall risks and benefits from vaccinating or not vaccinating. · Whilst there had been an increase in mothers concerns about the safety of MMR, 92% of mothers still

monitor the recall an interpretation of NHS II advertising and immunisation information materials.

MMR is most likely to be considered to present a greater risk than the disease it protected against.
About 55% of respondents had discussed immunisation with a HV, 20% with a GP and 10% with a midwife or clinic nurse. Almost 30% discussed it with a husband or partner.
The two most frequently mentioned sources of publicity were television advertisements and leaflets.
Recognition of an immunisation leaflet declined to 50% in 2001.
"Parents' fears over vaccine safety are reflected by uptake data".
May be because mothers no longer aware of the risk of disease or have difficulty assessing risk.

intended to fully immunise any future child.
Materials must be accessible to the wider community to explain the importance of immunisation, not just those directly involved.

Table 7: Qualitative studies included

Authors, Year, Place, Country	Design / Method	Aim	Description of Participants	Sample size	Results	Recommendations
Brownlie & Howson, 2005a, & 2006. Scotland.	Secondary qualitative analysis of transcripts from data sets from commissioned projects (1 and 2).	To explore the interpretative elements of trust evident in parental and professional talk of MMR vaccination.	Study 1: Original data set included eight focus groups with parents (stratified by deprivation category) and three focus groups with HVs and Practice Nurses and 15 telephone interviews with GPs. Study 2: Eight focus with parents from three health boards, three focus groups with HVs and 5 telephone interviews with GPs.	Not given.	<p>Trust or mistrust emerges as an issue when the individual making the decision struggles with judging probabilities.</p> <p>Uncertainties may have a basis in knowledge gaps e.g. why cannot single vaccines be given?</p> <p>Knowledge gaps merely reinforce the difficulties of being informed. Good parents 'know'.</p> <p>Suspension of trust does not happen in isolation and occurs within relationships and networks. Trust peers more than HCPs.</p> <p>Building trust is an important part of trusting HCPs. GPs have minimal contact with parents and therefore few trust building opportunities. HVs greater contact but trust building threatened by targets.</p> <p>HCPs make non compliant parents feel like 'bad parents'.</p> <p>Risk anxiety made worse by mistrust in government health messages.</p> <p>MMR represents a 'leap of faith' by parents and building trust may make it easier for parents to accept information as reliable.</p>	<p>Avoid problematising MMR uptake as parental non compliance as a consequence of faulty information processing.</p> <p>Move from information giving to (re)building trust so any information is perceived as trustworthy.</p> <p>Personal disclosures (by GPs & HVs) about MMR decision making seen as important in contributing trustworthy information.</p>

Table 7: Qualitative studies included (continued)

Authors, Year, Place, Country	Design / Method	Aim	Description of Participants	Sample size	Results	Recommendations
Casiday, 2007 Durham & Cambridge. England	Focus Groups (n=16)and individual (n=71) interviews.	To explore parental decision- making about MMR vaccination.	Volunteer and snowball sample. 77 mothers, 10 fathers 56 MMR immunisers, 16 SV immunisers, 10 non immunisers, and 5 undecided. MMR uptake rates 83% and 88%.	n=87.	<p>Process of weighing risks: Statistical probabilities, which risks were unacceptable, risks of exposure, social context, previous experience and emotions. Overloading the immune system a concern Specific children as more vulnerable/susceptible particularly if they already have asthma/eczema.</p> <p>Fear of being considered a bad parent increased compliance Dissonance between responsibilities to public health (herd immunity) and protecting own child – if perceived MMR risk low and MMR vaccine risk high then no desire to immunise to protect others Government perceived as mishandling/dishonest in MMR debate.</p> <p>GPs who demonstrated concern for their child trusted but those that sought to protect the population or their professional reputation were not trusted.</p>	<p>GPs need to engage in discussions with parents and listen to fears/risk concerns.</p> <p>The right narrative needs to be presented by a believable voice.</p>

Table 7: Qualitative studies included (continued)

Authors, Year, Place, Country	Design / Method	Aim	Description of Participants	Sample size	Results	Recommendations
Evans et al, 2001 Avon & Gloucestershire . England	Focus Group Modified Grounded Theory.	To investigate parents' decisions to accept or refuse MMR.	Purposive sample. Parents of children 14 months - 3 years 43 Female, 5 Men Age 22- 48 years Immunisers and non-immunisers in separate Focus groups (numbers not given) 54% graduate.	n=48.	All unhappy about MMR and few approached MMR with confidence Non-immunisers felt risk of serious complications from measles low. Previous experience of serious illness did not influence MMR uptake. Some children perceived as more vulnerable and therefore at greater risk from side effects of immunisation. Important to increase natural immunity. Combined vaccine created undue immunological stress. Factors that contributed to decision making were: Media. DH Guidance/Government treated with distrust GPs were not perceived as independent (immunisation for reward). HCPs did not give balanced information. Pressure to comply increased resistance. Exercise of choice. Single vaccine preferred. Immunisation decision was not rational risk/benefit analysis Preferred behaviour act of omission rather than commission.	HCPs need help to develop more open approach and skills in shared decision making with patients. Range of information available prior to decision including MMR schedule Risk for boys & girls Duration of protection. Rationale for boosters Immunity and breast milk. Optimum age for protection. Suggested that MMR1 be given pre-school.

Table 7: Qualitative studies included (continued)

Authors, Year, Place, Country	Design / Method	Aim	Description of Participants	Sample size	Results	Recommendations
Henderson et al, 2008 North East London. England	Qualitative interviews.	To assess reasons for low uptake of immunisation amongst orthodox Jewish families.	Volunteer and snowball sample orthodox Jewish. Mothers (n= 25) and health care workers (n=10).	n=35.	Community perceived themselves to be relatively insulated from media but talk nevertheless persuasive. Media scares related to MMR created anxiety whilst community insulation from TB created a sense of safety with the consequence of low BCG uptake.	Challenge of community norms best done through existing social networks to communicate positive messages. Avoid assumptions that religious beliefs act as a barrier to immunisation uptake.
Hilton* et al, 2006a Glasgow, Scotland	Focus Groups.	To explore parents' understanding of immunity.	Purposive sample. Full demography of parents (mothers and fathers) not given but sampling included range of ages, socio-economic and family characteristics, immunisers and non-immunisers.	n=72.	Concerns about maturity of children's immune systems and coping with vaccine overload (note many already accepted DTP). If offered choice would go for single vaccines Immune vulnerability of children and MMR added burden And/or too healthy to need MMR protection. Risk assessment by parents includes (1) risk of disease(s), (2) risk from vaccine and (3) parental perception of child's immune capacity to cope with disease and/or vaccine.	Need to address gaps in understanding of child immune systems and fears of immune overload.

Note: Hilton et al (2006a, b, & 2007) all relate to the same study but present different thematic analysis of data.

Table 7: Qualitative studies included (continued)

Authors, Year, Place, Country	Design / Method	Aim	Description of Participants	Sample size	Results	Recommendations
Hilton* et al, 2006b Glasgow. Scotland	Focus Groups.	To explore perceptions of vaccine preventable diseases.	Purposive Full demography of parents (mothers and fathers) not given but sampling included range of ages, socio-economic and family characteristics, immunisers and non-immunisers. Targeted two high uptake areas >95% and two low <75%.	n=72	Supported vaccination against Meningococcal meningitis “insist on getting” vaccine. Mumps, measles and rubella not perceived as threat and mumps and rubella perceived as gender specific problematic conditions Efficacy of MMR doubted. Pentavalent prevented diseases not seen as a threat in the UK and knowledge less particularly Hib. Understood tetanus but could get jab if in an accident.	Need to overcome misunderstandings and gaps in knowledge of vaccine preventable diseases (success of immunisation programme has produced memory loss). Those involved in supporting decision-making need to recognise the complex role of personal choice and family history as contributing.
Hilton* et al, 2007 Central Scotland. Scotland	Focus Groups.	To explored nature of concerns about MMR safety.	Purposive n=64 mothers (age range 15-53 years) and n=8 fathers (age range 31-51 years) sampling included range of ages, socio-economic and family characteristics, immunisers and non-immunisers.	n=72	Evidence from parents who believed MMR harmed their children could not be discounted. Parents could assess trustworthiness of parents’ stories but not research evidence. Drawn to real life stories in the media. Politicians were untrustworthy sources of health information. Concerns about the objectivity of GPs (incentives for immunisation targets) and others. HVs could sound too ‘resolute’. Wakefield seen as credible and parent champion.	Use of anecdotal stories involving real people. Use of parents to communicate about MMR to the public. HCPs must avoid ambiguous messages or presenting entrenched views.

Note: Hilton et al (2006a, b, & 2007) all relate to the same study but present different thematic analysis of data.

Table 7: Qualitative studies included (continued)

Authors, Year, Place, Country	Design / Method	Aim	Description of Participants	Sample size	Results	Recommendations
McMurray et al, 2004 Leeds. England	Qualitative interviewing and 'framework' analysis.	To explore parents' accounts of MMR decision making	Purposive sample. Parents of children aged 4-5 years 65 mothers, 4 fathers. MMR uptake 75% plus 18% lost at 2 nd dose PHC practitioners, co-ordinators and managers. (n=12).	n=69.	<p>Measles, mumps and rubella seen as 'positive' diseases for building immunity.</p> <p>Vaccination decisions based on day to day observation of child rather than science. Media increased concerns which led to parents undertaking personal research.</p> <p>Friends and families shared feelings and concerns.</p> <p>GPs and HVs accessed for advice but little influence on decision as HCPs perceived as too biased. GP consultations too rushed for discussion. No information received prior to appointment for 2nd vaccination (MMR2) and could not recall receiving information for 1st dose.</p> <p>Official information dull and not relevant to real lives.</p> <p>Attendance at clinic for MMR1 perceived as informed consent.</p>	<p>Drop-in sessions and forums to discuss issues and concerns.</p> <p>Use of Information intermediaries.</p> <p>Written information prior to appointments with case studies.</p> <p>At vaccination appointment the interaction should be two way.</p> <p>To increase trust in MMR remove target payments.</p>

Table 7: Qualitative studies included (continued)

Authors, Year, Place, Country	Design / Method	Aim	Description of Participants	Sample size	Results	Recommendations
Mixer et al, 2007 Brent, NW London. England	Focus Groups.	To explore relationship between ethnicity and uptake of MMR1 vaccine.	Convenience sample of mothers (Asian [Uptake 87.1%], Afro-Caribbean [74.7%]and white [57.5%].	n=37.	Asian mothers consulted elders (mothers in law) for advice and they had illness memory and largely pro-immunisation. Asian mothers more likely to trust GPs or HVs advice and were 'shielded' from MMR controversy in media. Trust in HCPs least in white and Afro-Caribbean mothers as most exposed to the English-language media. Paradoxically in MMR greater knowledge more likely to reduce compliance.	No recommendations given.
Morgan et al , 2003 North West London, England	Telephone interviews.	To assess MMR response to measles outbreak.	Parents of children attending nursery school with measles outbreak.	Not given.	Measles not seen as a serious illness. Catching measles also seen as protection against rubella and mumps. HCPs were confused by non-schedule recommendations regarding immunisation regime.	Non-schedule advice to GPs re: MMR should come with rationale and authority.
Petts & Neimeyer, 2004 West Midlands, England	Two phase interactive discussion groups and textual data analysis. Two questionnaires administered (i) after 1 st meeting children's	To explore the information strategies parents' use to make sense of health risks particularly MMR.	Random on-street recruitment by agency. 89% mothers, 30% from Asian Muslim community, included immunisers, those yet to make the decision and fathers.	n=64.	Mixed experience of GPs particularly Asian parents felt ignored. Low exposure to official information, high awareness of autism links. Perception that side effects of immunisations unknown. Heightened awareness if MMR challenged convictions about benefits	Information wanted on risks to health, certainty of science, balance of risks with having/not having vaccine. User centred risk communication.

immunisation history and (ii) after 2nd interview concerning MMR information needs, mode of delivery and trusted sources. Participants asked to undertake personal research between meetings and could question an immunisation specialist at 2nd interview.

and previous decisions (with other children).

Media representation of MMR had shaken pre-existing beliefs (including Blair's non response regarding immunisation of his son).

Informal MMR talk from friends was primary source of information about single vaccines.

Parental choice important particularly when perceived they were pressured by government.

Ranking of trustworthy sources of information (questionnaire) not consistent with important sources identified in interviews.

Full information (expert input part of research design) about mumps, measles and rubella "compelling".

Sought information about media generated issues from expert and these not evident in official leaflets.

Only British mothers with high socio-economic status reported positive engagement with GPs in relation to MMR.

Table 7: Qualitative studies included (continued)

Authors, Year, Place, Country	Design / Method	Aim	Description of Participants	Sample size	Results	Recommendations
Poltarak et al, 2005 Brighton. England	Ethnographic/biographical Face to face in-depth Interviews. Group discussions Work shadowing and follow up interviews with HVs (HVs).	To explore how parents' were thinking about MMR for their own children.	GPs from target practices (n=8) Practice nurses (n=3) HVs (n=6). Mothers from local toddlers groups Immunisers (n=12).	n=29.	Mothers: History (immunisation and disease) influenced decision-making – notions of overload, vulnerability and individual immunity. Only 4four were confident in MMR most were suspicious of Drs, drug companies, and pressure to immunise. Parental choice (link made to birth choices and MMR decision). Relationship between motherhood camaraderie/friendship development and ways of discussing MMR. Need to do personal research to make decision but creates greater doubt. GPs not consulted and deemed partial. Mothers perception of being patronised/intimidated read as acquiescence by GPs. Decision to immunise did not resolve concerns about MMR.	Parents learn from listening and sharing in toddler groups. Joint parent decision. Personalised framing demands personalised approach to immunisation and parental decision-making. MMR talk may be more influential than public health information therefore need to change the messages in the talk. HCPs need to be in dialogue with parents.

Table 7: Qualitative studies included (continued)

Authors, Year, Place, Country	Design / Method	Aim	Description of Participants	Sample size	Results	Recommendations
Raithatha et al, 2003 Norwich, England	In-depth interviews.	To assess parents' vaccine risk perception.	Convenience sample. Local rate of MMR uptake >90%. All immunisers Two groups (Town & Village) 33 Female, 1 male. Mean age 34 years Social class I-IV.	n=35.	Parents perceived vaccines as risky and doubted the science. Felt unfairly pressurised by HCPs to vaccinate. Lack of information and conflicting advice. Distrust of government agencies. Distrust of GPs (financial incentives). Doubts of knowledge base of and accuracy of Drs. Scandals tarnished image of Drs. Consequences of decision to immunise were heavy but parents felt they would be criticised if their child contracted the disease.	Messages should be balanced. HCPs must listen to concerns. GP incentives re-evaluated. Information should be locally not nationally disseminated .
Skea et al, 2008	Internet discussion forum. (www.mumsnet.com). Thematic analysis using modified framework analysis.	To explore parents' perceptions of public health responsibilities through MMR.	Members anonymised postings no personal data solicited for the study Informants largely immunisers (n=72).	n=89.	Parents were aware and concerned about responsibilities to the wider community. Avoiding harm to others and contributing to herd immunity were important considerations. Parents balanced probabilities of personal concerns for own child with responsibility to others. Parents differentiated between healthy and vulnerable children. Parents were expected to act to benefit society but felt more should be done to compensate those harmed by vaccines.	Vaccine promotional material should include explanations of herd immunity <i>and</i> pay attention to lay concepts of immunity including vulnerable and healthy children.