The effect of perceived risks on the demand for vaccination: a discrete choice experiment

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1. Introduction

Vaccination is one of the most effective public health interventions of the 20th century. Successful vaccination programmes over many decades have led to the decline of many diseases, while simultaneously people have become more aware of side effects of vaccines. This has led to declining vaccine uptake rates in many developed countries, and accordingly much attention is given to parental acceptance of vaccinating their child. The concept of 'perceived risk' is central to vaccination behaviour. This is particularly important when there are two sources of risks to be taken into account – the risk of disease if not vaccinated, and the risks of vaccine side-effects if vaccinated. Perception of being at risk of disease has a positive effect on the demand for vaccination, while the perceived risk of vaccine-associated side effects has a negative affect. In the case of childhood vaccination, parents act as agents for their child by weighing up the benefits and the costs from their decision to vaccinate or not, choosing the option that maximises their expected utility (or minimises their regret). In doing so, parents inevitably make trade-offs between the risks that their child faces. These trade-offs are not confined to the consideration of risk only, since the decision to vaccinate may also be contingent on other variables such as the cost of obtaining vaccination. Vaccination behaviour is also likely to be dependent on emotional response as decision makers seek to regulate not only health threats, but also their own emotional response. It is important to investigate these tradeoffs and their effect on vaccination choices, knowledge of which will be useful in predicting vaccination uptake rates and in evaluating vaccination programmes.

The revealed preference data that are traditionally used to analyse vaccination choice lack information on crucial factors like perceived risks and perceived severity of health effects that are likely to influence the vaccination decision. If data can be made available, analysis of

such substitutability in attributes would reveal interesting relationships in the determinants of demand for vaccination. This paper aims to address such issues by eliciting stated preferences for vaccination and identifying the determinants of demand for two hypothetical vaccines – (a) Rotavirus vaccine (which helps protect against rotavirus diarrhoea, the most common cause of severe diarrhoea in infants and young children), (b) Pneumococcal vaccine which helps prevent both non-invasive pneumococcal disease (NIPD) (the consequences of which include lower respiratory tract infection such as pneumonia), and invasive pneumococcal disease (IPD) (which may lead to meningitis or blood poisoning). All these vaccines will help avoid significant morbidity, hospitalisations and perhaps mortality. The rotavirus vaccine is currently being considered for introduction into the UK, and the conjugate pneumococcal vaccine that offers protection against both invasive and non-invasive disease has recently been introduced. We are interested to examine the role of perception in affecting threat responsiveness behaviour and aim to identify the differential impact of risk and severity on demand for vaccination.

We have used a Discrete Choice Experiment (DCE)[1] where individuals are presented with pairs of scenarios described in terms of attributes and associated levels, and asked to choose their preferred scenario. The technique is based on the premise that any good or service can be evaluated by its attributes and the extent to which an individual value it depends upon the nature and level of these attributes (Ryan et al, 2001). DCE, if carefully designed, is a good substitute for observed data under which actual choices are made (Louviere, 1988). Moreover this technique offers the advantage of analysing the behaviour of those individuals who have some propensity to vaccinate but not large enough to make a choice for it, that many of the studies using observed market led data on immunisation behaviour fails to take account for. DCE are increasingly being used in health economics. For the updated literature review of the application of DCEs in health care, see Ryan and Gerard (2003); Scott and Vicky (1999); and Kjaer (2005).

The paper is organised as follows. Background and objectives of the study are discussed in section 2; section 3 discusses the methods applied, and results are illustrated in section 4. Finally section 5 provides a discussion.

[1] This technique has the advantage of directly evaluating the trade offs between the characteristics of a particular good or services, many of which characteristics are not observable in market data but are expected to be influential in decision making.

2. Background and objectives

2.1. Disease background

Rotavirus is the leading cause of diarrhoea-related illness and death among infants and young children. The incidence of rotavirus infection is quite similar in both developed and developing countries, but mortality rates are very high in developing countries. Even though deaths in developed countries are almost negligible, the burden of the disease is still high because of clinic visits and hospitalisation (Harris et al., 2007). Rotavirus is the most common cause of severe diarrhoea in infants and young children in the UK. An earlier estimate suggests that rotavirus is responsible for about 17810 admissions each year in the UK – five admissions for every 1000 children under the age of 5 (Ryan et al., 1996). A Rotavirus vaccine, Rotashield, was initially licensed in the United States in 1998 and was recommended for routine immunisation. However, in 1999 it emerged that the vaccine was associated with a rare type of bowel obstruction (intussusception) in some infants during the first 1-2 weeks after vaccination. The risk of vaccine side effects was approximately 1 in 10,000 children (Weijer, 2000; Bines, 2005). On the basis of this finding, the vaccine was withdrawn from the market. Now, two new vaccines have been developed and large scale clinical trials have shown that these new vaccines are safe and highly effective at preventing rotavirus associated severe gastroenteritis. These new vaccines are not linked with an increased risk of intussusception (WHO, 2007; Ruiz-Palacios et al., 2006). Both new vaccines are being considered for introduction in the UK and many other countries. Before making a decision whether to introduce to mass vaccination, the demand for such vaccines needs to be assessed. Given the previous scare of side effects, it is essential to examine the effect of perceived risks – risk of vaccine and risk of infections – on the potential uptake of vaccination.

Pneumococcal bacterial infection is another leading cause of death and illness in children under two years of age (Melegaro et al., 2006). Pneumococcal infection can cause very serious illness such as meningitis and septicaemia as well as pneumonia and otitis media (ear infections). Even though this infection can be treated with the use of antibiotics, global deaths from this infection has remained quite high in the last 40 years. Pneumococcal infections cause around 100,000 cases of meningitis, bloodstream infections, and pneumonia every year in children less than 5 years of age. In England and Wales, there are about 170 cases of pneumococcal meningitis and about 450 cases of pneumococcal bacteraemia reported in children less than five years throughout the UK per year (Melegaro et al., 2006). 50 British

children under the age of five die each year due to pneumococal disease, and many more are left struggling with severe disabilities. Given the burden of the disease, pneumococcal vaccine, which helps preventing the diseases associated with this infection, was introduced into the childhood immunisation program in the UK in September 2006. The vaccine is expected to prevent 90% of the infections caused by pneumococcas infection, but a much lower proportions of non-invasive infections (pneumonia and otitis media). There is no serious side effects associated with the vaccine, other than the mild side effects which include mild soreness, lump, and fever.

2.2. Aim of the paper

This paper aims to examine the preferences for vaccination for the above vaccines and identify the determinants of demand. The above mentioned vaccines have different characteristics in terms of the disease that they prevent, and the associated side effects. These differential characteristics of the vaccines will be useful in analysing demand side determinants, especially to identify the effect of perceived risk and severity. Firstly, rotavirus is vaccine prevents very contagious and highly prevalent rotavirus related disease, but there were alleged side effects about this vaccine in the past. Secondly, pneumococcal vaccine prevents both invasive and non-invasive pneomococcal disease, and has no history of serious side effects - only milder side effects are being reported. Invasive and non-invasive pnemococcal infections varies considerably in terms of risks and severity. Non-invasive pneumococcal infections may lead to pneumonia, otitis media and other infections. Invasive pneumococcal infections can lead to blood poisoning, brain damage, deafness, loss of vision, and even to death. The disease can be very serious, but the risk of infection is relatively rare as compared to non-invasive-pneumococcal disease and rotavirus disease. A comparative analysis of the demand for these two vaccines may show differential impact of perceived risk and perceived severity on consequent vaccination choice due to their different background characteristics.

The demand for vaccination depends on the perceived costs and benefits of the vaccinations, under uncertainty (Mullahy, 1999). Health belief models also predict that individual perception of susceptibility to disease and severity of disease affect the probability of taking preventive actions (Rosenstock, 1966; Becker, Drachman, Kirscht, 1974), but they considered wide range of influences on such perception besides objective risks. Following this literature, as well as our previous theoretical analysis (Sadique et al, 2005), we

hypothesise that there are threshold risks (the risk of infection relative to risk of side effects) below which an individual prefers to remain exposed to the infectious disease, and will accept vaccine if her subjective risk is above this threshold level.[2] The objective of the paper is to test the following hypotheses.

(1) The higher the perceived cost of side effects, the lower the propensity to vaccination. Individual's perceived cost of side effects is influenced by risks of vaccine side effects and its severity. Demand for vaccine will therefore be negatively related with the risk of vaccine and severity of vaccine associated side effects. On the other hand, the higher the perceived cost of infection (which is influenced by both cost of infection and the severity of infection), the higher the propensity to vaccination.

(2) The usual 'expected utility' (EU) hypothesis applied in vaccination choice infers that consumers to obtain preventive services when the expected gain from the reduced risk of the disease exceeds the utility loss from financial cost of the services. But whether a choice is right or wrong can only be learnt in retrospect, when it may be the case that another choice has been preferable. There is a large possibility of non-realisation of *ex ante* expectation in the *ex post* situation which can bring a sense of loss, or regret (Loomes and Sugden, 1982). This is especially relevant to vaccines that provide imperfect immunity or are linked to side effects (or at least perceived risks of side effects).

Previous theoretical analysis (Sadique et al, 2005) shows how the feeling of regret/rejoice can affect the propensity to vaccination. The testable hypotheses are as follows:

(i) The higher the anticipated regret from vaccine side effects, the lower the propensity to vaccinate.

(ii) The higher the anticipated regret from infection (if not vaccinated), the higher the propensity to vaccinate.

(3) The strength of different predictors is reflected in their relative influence on vaccination choice. Moreover, the strength is also reflected in the marginal rate of substitution (trade offs) between a predictor (attribute) of demand and cost, which will indicate the compensating

[2] This threshold criterion rationalises the low response of parents to immunise their children when vaccines have largely eliminated the threat of serious infectious diseases in childhood. As the incidence of vaccine-preventable diseases has declined and concern of side effects has allegedly increased, the threshold level of risk has gone up which lowers the propensity to vaccinate.

variation (CV) for a given change in the attribute needed to leave the individual indifferent between the original attribute and the new attribute. We expect that the value of CV for the risk of vaccine is higher than the CV for the risk of disease. This implies that the marginal monetary valuation of disease risk is larger than that of vaccine risk on vaccination choice.

3. Methods

To enumerate parents' preferences for vaccinating their child we used a DCE technique which will allow us to investigate the influence of risk perceptions, health impacts, and cost parameters on their vaccination behaviour directly. The choice experiment involves a forced choice between two alternatives – 'vaccinate' and 'don't vaccinate', each with different attribute levels. From the tradeoffs respondents implicitly make between different attributes of the alternatives, the researcher can derive the utility of the product characteristics.

3.1. Development of attributes

The attributes and their levels and their importance to decision choice have been determined in two steps: Firstly, from literature review we have identified three relevant attributes in relation to vaccination choices: price, risk, and severity. Price is included as an indication of indirect cost (travel cost, cost of waiting time) associated with vaccination. Moreover, inclusion of price helps generating welfare estimates for other determinants of vaccination choice.

Since the decision to vaccination is a forced choice between vaccinate versus non-vaccinate, each attribute is divided into two groups. For example, risk has two types – risk of infection and risk of vaccine side effects, and severity of health consequences has two types – severity of infection, and severity of side effects, and similarly price of vaccine associated with vaccinate decision, and price of infection (which is zero) associated with no vaccination decision. In the second stage a small pilot study was carried out on small group of respondents (n=15) to check the feasibility of the DCE, and consistency of the survey instruments. The task of piloting was to determine the number of attributes and actual values of the attributes that ensures credibility. In stated preference technique (like DCE) respondents are not always familiar with the attributes presented, and a general problem associated with DCE is the trade-off between the complexity of the choice experiment and

the quality of response, known as 'task complexity'[3]. The presence of probability (risk) and severity in our experiment makes it even more difficult to get rational and informed decision from our respondents. Pilot sampling was informative in designing the choice experiment in a way that minimised the task complexity, and how best to present the probabilities, and how to include the questions on regret. Following extensive piloting, we have compiled the important attributes and levels associated with those attributes (reported in appendix table 1)

3.2. Experimental design and questionnaire development

Three attributes, as described above, were risk, severity, and price of vaccine where each of the attributes has three levels (values). The levels of risk and severity attributes for each disease area were grouped in way that the description of levels differed clearly, and was chosen to reflect actual risks and severities of those health conditions. According to full factorial design there will be $3^3 = 27$ profiles or choice sets. Using a fractional factorial design method we find that there are 9 choice sets[4] for each decision option –vaccinate and refuse vaccination. However, since our aim was to include both vaccinate and not vaccinate choice in the same profile, we have derived another 9 choice sets for the other options using a 'foldover design'. A typical choice set in such a case will have the following format where respondents will be presented with the choices and for each will be asked their preferred decision (vaccinate or not):

If you vaccinate your child	**If you don't vaccinate your child**
The out of pocket cost to you is **£ 150**	The out of pocket cost to you is **£0**
The chance of having vaccine associated side effects is **20 in 100,000 children vaccinated**	The chance of having rotavirus related disease is **20,000 in 100,000 children**
If your child has vaccine side effects, his/her health condition may be affected in the following way ▪ Mild irritability (3-6 days) ▪ Loss of appetite (3-6 days) ▪ Fever & fatigue (3-6 days)	If your child is infected with the disease, his/her health condition may be affected in the following way ▪ Fever & abdominal pain (3–5 days) ▪ Vomiting and diarrhoea, leading to moderate dehydration (loss of body fluids) (3-5 days)

Would you choose to vaccinate your child? (Please √)

☐ YES ☐ NO

[3] It depends on number of choice sets presented to respondent, number of alternatives in each choice set, the number of attributes describing those alternatives and the correlation between attributes for each alternative (Swait and Adamowics, 2001)

[4] Using Hann and Shapiro catalogue (1966), we find that main effects design for 3, 3-level attributes corresponds to plan code 16a, master plan 3, use column 1,2,4 and there are 9 profiles.

Given that there are 9 orthogonal scenarios for each of the three diseases, each respondent will face 27 scenarios. However, respondents participated in pilot study mentioned their difficulties in answering such a large number of choice sets. We therefore have allocated 3 scenarios for each disease (Rotavirus, Non-invasive Pneumococcal, and Invasive Pneumococcal) into 3 different versions of questionnaires resulting in 9 scenarios in each version. From these 9 choice sets in each version, a further 3 choice sets has been randomly selected for which regret questions were asked. For each version, in order to cover all the 9 scenarios for which regret question is presented, we further divided each choice set into another 3 versions, leading to a total 9 versions of questionnaire. Each version includes 9 choice sets and a further 3 choice sets with the regret questions. In the regret section we assessed the extent to which parents would experience emotions if their vaccination decision has adverse outcomes. When parents decide to vaccinate their child, there are possibilities that their child can be affected by vaccine side effects. On the other hand, if they decide not to vaccinate, their child has a chance of getting the disease. Under each circumstance, we would like to know how parents would anticipate feeling about the decision to vaccinate (or not to vaccinate). On the basis of the attributes and levels in the corresponding choice set for which respondents have already indicated their preference, respondents were asked to indicate how they would experience a particular state of emotion on a 0-10 scale[5] if their vaccination decision were to turn out badly. Here respondents were asked - (a) "If you have decided to **vaccinate**, how likely you are to regret this decision given that there is some chance that your child may experience vaccine associated side effects as described above?" and (b) "If you have decided to **not vaccinate**, how likely you are to regret this decision given that there is some chance that your child may experience disease as described above?". The scale of measuring emotions is anchored at 0 (I would not experience this at all), and 10 (I would experience this a lot).

In order to check consistency of responses one scenario has been added in the choice set where the attributes for vaccination are set at the best level and the attributes for exposed decision are set at the worst level. Responses will be considered as consistent if they choose the dominant option.

[5] The scale of regret measurement is based on previous studies (Connolly and Reb, 2003; Brehaut, 2003)

3.3. Recruitment and data collection

Ethical permission for conducting the survey was obtained from City University Research Ethics Committee. The data for the analysis was colleted from mothers who have at least one child under the age of 5 from a nationally representative sample of the UK. The sample was recruited and data was collected by a commercial marketing agency. Eligible mothers who agreed to participate in the survey were presented with a questionnaire, covering 13 sets of choices and socio-demographic questions including knowledge, awareness, and beliefs regarding vaccination against infectious disease in general, and sources of information regarding the child vaccination related issues.

3.4. Data analysis

The theoretical underpinnings of DCE are rooted in Random Utility Theory (McFadden, 1981). Faced with the alternatives of vaccination decision, a respondent will choose the alternative with higher level of utility. The decision making process within DCE can be seen as a comparison of utility values V_{ij},

$$V_{ij} = v_j(b_j, s_i, \varepsilon_{ij})$$

Where $v(.)$ represents the indirect utility function for individual i for a vaccination choice with vector of attributes b_j. Socio-demographic characteristics are denoted by s_i, and error term by ε_{ij}. With an additive error term, an individual will choose alternative j over k if:

$$w_i(b_j, s_i) + \varepsilon_{ij} \geq w_i(b_k, s_i) + \varepsilon_{ik}$$

Here, $w_i(.)$ is the deterministic component of the utility that is observable to researcher and therefore can be estimated, while the error terms reflect unobservable factors that vary with the individual and alternatives. The utility function $w_i(.)$ can be inferred from observed choices by assuming that the probability P_{ij} of choosing j over k, given the vector of attributes, equals the probability of the difference in utilities –

$$P_{ij} = \Pr[w_i(b_j, z_i) + \varepsilon_{ij} \geq w_i(b_k, z_i) + \varepsilon_{ik}]$$

Given that the vaccinate/not vaccinate choice is a (0, 1) variable, the model can be estimated by either logit or probit techniques depending on the assumption being made about the distribution of the error terms. Since respondents have to make several choices, the underlying data in our experiment has a panel structure, making random effects specification

more appropriate. We have used the Random-Effects Probit regression. The random effects approach accounts for the potential correlation in responses between the 13 choices completed by each respondent. Assuming a linear utility function[6], we have followed the following specification (limiting the specification to the attributes identified):

$$\Delta V = \alpha + \beta_1 price + \beta_2 vaccine\_risk + \beta_3 vaccine\_severity - \beta_4 disease\_risk - \beta_5 disease\_severity + \varepsilon_{ij}$$

where ΔV is the change in utility from vaccination over non-vaccination utility, α is the difference in alternative specific constant, β s are the coefficient associated with price, risk and severity under both vaccination and non-vaccination alternatives respectively, and $\varepsilon_{ij} = \varepsilon_{ij} - \varepsilon_{ik.}$ For estimation, the attributes (price, risks, and severity) are dummy coded where each of the attributes has been grouped into 2 levels, and the lowest level has been taken as the base case.

The influence of the attributes is reported as the coefficients from the estimated model. The results are reported in terms of marginal effects, where the estimated coefficients indicate probability. For each attribute, WTP/CV was calculated as the corresponding estimated probit regression coefficient divided by the negative (expected) estimated coefficient of price.[7] Confidence intervals for the WTP/CV ratio are calculated with Krinsky-Robb method using 2,000 replications (Krinsky and Robb, 1986).

4. Results

Questionnaires were completed by 369 participants, yielding a total of 4753 observations. The 369 respondents were spread across the 13 choice sets. The level of inconsistent results is small – 5.96% of all responses suggesting that there is high level of internal consistency in the responses. Characteristics of respondents are reported in table 1.

[6] There is empirical evidence that a linear specification leads to good predictions in the middle ranges of the utility function (Hensher, 1997).

[7] Hicksian welfare measures depend on identifying the marginal utility of income. Since it is not available to the choice situations, we make a common assumption that marginal utility of income is equal to the negative of the disutility of the price of vaccine.

Table 1: Characteristics of respondents

	sample (N=369)		sample (N=369)
Age		**Education**	
17 – 22	9.76%	Degree or equivalent	13.55%
22 – 29	36.59%	Higher education below degree	14.36%
30 – 39	43.36%	A level	14.63%
40 – 49	9.49%	GCSE	37.40%
Refused to answer	0.81%	CSE	4.61%
Region		None	14.91%
North West	15.99%	Refused to answer	0.54%
North East	5.64%	**Socioeconomic status**	
Wales	22.26%	Managerial AB	19.78%
South East	5.64%	Supervisory/clerical C1	21.68%
London	10.97%	Skilled manual C2	21.68%
South West	10.03%	Unskilled manual DE	34.42%
West Midlands	9.09%	Refused to answer	2.44%
Scotland	11.29%		
Yorks	9.09%		

Aggregating the stated choices of all respondents over all choice sets in the DCE, we find that the vaccination rate for all vaccines is 76.94%, the highest rate (90.83%) being observed in case of Invasive-Pneuomococcal disease, and the lowest rate (67.88%) being observed for Rotavirus disease.

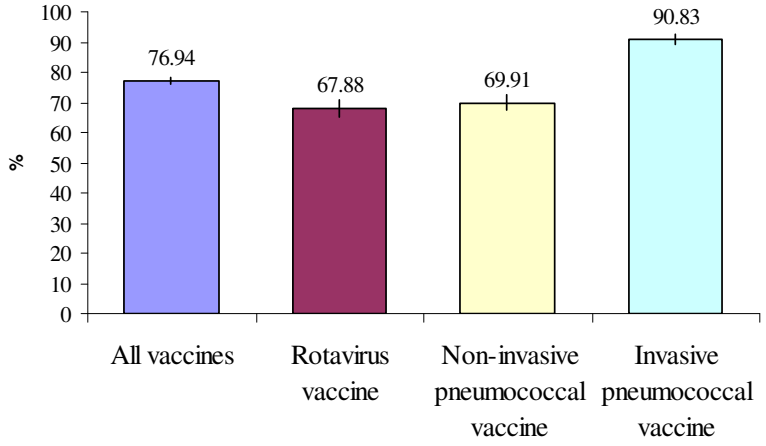

Figure 1: Vaccination rate (vertical bars give the 95% CI)

The effects of attributes on vaccination choice are reflected in the parameter estimates as reported in Table 2. The significant value of rho suggests that the random effect specification was appropriate. The estimated value of rho, the intra-class correlation coefficient is 0.589 indicating that 58.9% of the unexplained variation in vaccination choice under different scenarios is attributable to the individual effect, suggesting a high degree of persistence.

Table 2: baseline model

parameter	***coefficient***	***z***	***P>|z|***
price	-0.001	-4.68	0.000
risk of vaccine high	-0.038	-2.52	0.012
risk of disease high	0.053	2.73	0.006
severity of vaccine high	-0.148	-8.28	0.000
severity of disease high	0.183	7.55	0.000
rho	0.561		
LogL	-1443.587		
Correct prediction	76.94%		
n	3660		

The effect of the attributes on the decision to vaccinate is reflected in the parameter estimates from the random effects probit model, shown in Table 2. Most of the estimated coefficients are highly significant and have the expected signs. Respondents are less likely to vaccinate when the risk of vaccine is high. When the risk of vaccine associated side effects increases from low to high, the probability of a child being vaccinated reduces by 3.8%. The risk of disease, in contrast, shows that respondents are more likely to vaccinate their child when the risk of disease is severe. Based on the absolute value of the coefficients, we can infer that extreme severity of disease (coefficient of 0.183) is the most important attribute to the respondents, followed by extreme severity of side effects, risk of disease, and risk of side effects. The price of vaccine has a modest but statistically significant impact on vaccination decision. The price elasticity of vaccine demand is 0.088 for all vaccines. Demand for vaccine is less elastic for vaccine that protects IPD (0.002), followed by that of Rotavirus (0.209) and NIPD (0.229).

The role of emotions in the decision about vaccination has been a topic of increasing interest. While indicating the feeling of anticipated regret on a 0 to 10 scale, the results show that in general respondents anticipate higher regret from a decision not to vaccinate (i.e., to remain exposed to disease) (mean 7.10, se 0.074) than regret from vaccination (mean 3.95, se 0.085). The regret attributes are also explored with other predictors of demand (see Table 3).

Table 3: Regret model

parameter	***Marginal effect***	*z*	***P>|z|***
price	-0.001	-3.23	0.001
risk of vaccine high	0.011	0.26	0.791
risk of disease high	0.028	0.67	0.503
severity of vaccine high	-0.081	-2.55	0.011
severity of disease high	0.241	4.92	0.000
anticipated regret vaccination	-0.022	-4.17	0.000
anticipated regret exposed	0.055	6.49	0.000
rho	0.558		
LogL	-1428.563		
Pseudo-R^2	0.236		
Correct prediction	78.65%		
n	1093		

These results indicate that both regret from vaccination and non-vaccination decision are significant predictors of demand, and the signs of the coefficients are in line with theoretical expectation. It is interesting that the regret variables are less important to respondents (as reflected in the absolute value of the coefficient) as compared to severity and risks, but still the feelings of anticipated regret are significant determinants of vaccination behaviour.

The relative importance of the attribute can also be determined in monetary terms from the WTP/CV coefficients. The results of the monetary coefficients should be interpreted with caution. A negative coefficient indicates the WTP, while a positive coefficient will represent a CV. The set of CV estimates based on Krinsky-Robb methods are reported in Table 4.

Table 4: WTP

parameter	baseline model		regret model	
	WTP	**95% CI**	**WTP**	**95% CI**
risk of vaccine high	**-46.94**	**-109.96, -8.85**	7.64*	-56.09, 76.76
risk of disease high	**59.16**	**15.84, 139.15**	19.60*	-34.30, 107.31
severity of vaccine high	**-193.49**	**-331.22, -124.67**	**-66.47**	**-191.43, -9.22**
severity of disease high	**177.44**	**-130.77, 166.71**	**136.61**	**86.27, 283.98**
anticipated regret vaccination	**-**	**-**	**-16.56**	**-41.28, -8.53**
anticipated regret exposed	**-**	**-**	**40.42**	**24.32, 95.45**

*not statistically significant

The point estimates (column 3 and 5) confirm the earlier findings that the severity of vaccine side effects and that of disease have the highest impact on utility. Respondents on average would be willing to accept the extreme severity of vaccine side effects for a compensation of £193.49. On the other hand, if the severity of disease is extreme, respondents are willing to pay £177.44. The CV/WTP for the corresponding risk figures are relatively smaller, confirming the fact that demand for vaccination is more sensitive to the description of the severity of the disease and side effects than their actual risks. The monetary value regarding anticipated regrets shows that average WTP to avoid regret from a decision not to vaccinate is £40.42, and the CV for regret from vaccination is £16.56.

In order to account for the heterogeneity in choice we have estimated the WTP/CV values according to different socio-demographic indicators. The results of sub-sample WTP values are reported in Table 5.

Table 5: Sub-sample WTP

	Social Grade		Perceived disease severity	
	Managerial	**Manual worker**	**serious**	**not serious**
risk of vaccine high	-69.94	-32.61	-3.72	-79.98
risk of disease high	103.06	33.44	28.97	82.57
severity of vaccine high	-251.47	-161.30	-145.95	-228.76
severity of disease high	208.22	159.21	147.07	196.32

Sub-sample analysis is based on parent's social grade (as a proxy for income variable), education, and the level of awareness of infectious disease risk. The educational background of the mothers (i.e., respondents) didn't show any differential impact on their monetary valuation of the attributes (results are not reported here).

The social grade of parents show clear differences in WTP – parents with higher social grade (managerial grade) are willing to pay more to avoid risk of disease and severity of disease as compared to parents of lower social grade. On the other hand, in terms of compensation required to accept risks of vaccine and severity of vaccine side effects, CV of parents of higher social grade are higher than that of low social grade parents. This indicates that parents with high social status are more responsive than parents of lower social grade. This result indicates that the WTP/CV estimates are more linked to parent's ability to pay.
Similar results were observed with respect to mothers' perceived severity of rotavirus infection (which we have taken as a proxy for mothers' awareness of infectious disease). Mothers who perceive rotavirus infection to be serious are willing to pay more to avoid disease risk and severity, and ask for more compensation to accept the risk of vaccine, and severity of vaccine side effects than mothers who thinks rotavirus is not a serious threat to their child health.

The extent of the influence of each attribute on vaccination uptake is reflected in the range of effects reported in Table 6. These predicted values clearly suggest that the demand for vaccine is increasing with severity of disease, and negatively related with severity of vaccine side effects. The price of vaccine expectedly has a negative influence on vaccine uptake, but the effect of cost is not monotonously decreasing in some price range. Predicted probability of vaccination is highest against IPD when the vaccine has a very mild side effects, and the lowest probable uptake arises for Rotavirus when severity of disease is mild.

Table 6: Predicted probability of attributes

		Rotavirus	NIPD	IPD
cost of vaccine	low	0.876	0.870	0.932
	medium	0.713	0.723	0.725
	high	0.860	0.861	0.862
severity of vaccine	mild	0.975	0.974	***0.984***
	moderate/extreme	0.737	0.736	0.737
severity of disease	mild	***0.631***	0.634	0.634
	moderate/extreme	0.909	0.910	0.938

5. Discussion

This paper attempted to elicit demand for vaccination with respect to price, risks, and severity of health consequences where respondents were forced to balance the risks and severity of both vaccination and non-vaccination choice under hypothetical choice scenarios. While hypothetical, the choice setting represents a realistic decision making situation that parents in real life do face. The factors included in the analysis are all significant, with the exception of risk which is not always significant. These findings are consistent with other research into attitudes to immunisation, confirming the factors that are most important to parents when they decide whether or not to vaccinate their child. This research has particularly has shown that the severity descriptions of disease and vaccine side effects are the most important drivers of vaccination decision. Monetary valuation of the attributes presents similar results. The CV/WTP analysis show that the marginal compensation required to accept the severity of side effects is in the range £331 - £124, on the other side the marginal WTP for to the extreme severity of disease is £130 - £166. These figures are higher than monetary valuation of the probability of vaccine and disease related adverse outcomes. Several socio-demographic characteristics were found to have significant effect upon the WTP/CV to choose to vaccinate. Social gradients with respect to social grade and awareness of mothers are observed in vaccination decision.

The uptake of vaccination has been observed as high as 76.94%, where the highest rate been found for invasive pneumococcal vaccine, followed by non-invasive pneumococcal and rotavirus vaccine. The finding of higher demand for invasive pneumococcal vaccine is in line with the expectation that demand for vaccine is more sensitive to severity of infection (since in general invasive pneumococcal disease as described in the choice sets are more serious than that of rotavirus and non-invasive pneumococcal disease). What this approach adds to the attitudinal research is the ability to predict the proportion of the target population that would immunise under different scenarios. Moreover, the price elasticity will be useful in identifying the demand for these hypothetical vaccines in the private market.

The results indicate that the anticipated regrets are significant determinants of demand. The effect of anticipated regret on intention to vaccinate against influenza vaccination as explored by Gallagher and Povey (2006) show that emotional feelings have significantly increased the intention to vaccinate. Ryan (1998) has found that the feeling of regret and disappointment are major motivators for individuals seeking assisted reproductive techniques.

These findings have useful policy implications. Firstly, the public health communication messages should put more emphasis on severities of health (from infection, and from vaccine side effects) as these are the most important predictors of vaccination demand. Many previous researches have assumed that risk is the key in vaccination choice, and have concluded that refusal to vaccinate is due to a misperception of the relative balance of risk. Our finding, on the contrary implies that risk description is less important than description of health severity. Public health messages based upon such health severity would be more effective to change attitudes and behaviour. Secondly, emotive responses can be exploited for effective intervention strategies. Government and health researchers could manipulate these in large scale interventions but also at an individual level. Health service professionals could be trained to use verbal persuasion techniques, or media messengers could use the beliefs associated with these feeling by highlighting the perils and dangers associated with missing out on the opportunity to be vaccinated. Thirdly, the finding that anticipated regrets are an important component of individual utility functions in relation to vaccination should be used for the evaluation of vaccination program, which is currently ignored.

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Appendix - Table 1: attributes and their levels

Rotavirus Vaccine

	Vaccinate	**Don't vaccinate**
Price	50, 100, 150	
Risk	**Risk of side effects**: 10 in 100000 20 in 100000 40 in 100000	**Risk of infection** 10000 in 100000 20000 in 100000 50000 in 100000
Severity	**Severity of side effects** Mild irritability (1 - 2 days) Loss of appetite (1 - 2 days) Mild irritability (3-6 days) Loss of appetite (3-6 days) Fever & fatigue (3-6 days) Bowel obstruction (requires surgery to correct)	**severity of infection** Fever & abdominal pain (1-2 days) Diarrhoea, but no dehydration (loss of body fluids) (1-2 days) Fever & abdominal pain (3–5 days) Vomiting and diarrhoea, leading to moderate dehydration (loss of body fluids) (3-5 days) Fever & abdominal pain (6-9 days) Vomiting and diarrhoea leading to severe dehydration (loss of body fluids) (6-9 days)

Non-invasive Pneumococcal Vaccine

	Vaccinate	**Don't vaccinate**
Price	50, 100, 150	

Risk	**Risk of side effects**: 100 in 100000 200 in 100000 400 in 100000	**Risk of infection** 500 in 100000 1000 in 100000 2000 in 100000
Severity	**Severity of side effects** Mild irritability, redness and swelling at the site of injection Mild irritability, redness and swelling (1-2 days) Muscle pain and swelling of joints (1-2 days) Mild fever (1-2 days) Swelling of face, lips, and tongue (3-6 days) Rashes, itching, and skin swellings (3-6 days) Muscle pain and swelling of joints (3-6 days) Mild fever (3-6 days) Breathlessness (3-6 days)	**severity of infection** Mild cold and fever (1-2 days) Breathing difficulties (1-2 days) Heavy cold and fever (3-4 days) Breathing difficulties (3-4 days) Ear infection (ear discharge) (3-4 days) Heavy cold and high fever (5 - 7 days) Breathing difficulties (5 - 7 days) Severe chest infection (5 - 7 days) Ear infection (ear discharge) (5 - 7 days)

Invasive Pneumococcal Vaccine

	Vaccinate	**Don't vaccinate**
Price	50, 100, 150	
Risk	**Risk of side effects**: 100 in 100000 200 in 100000 400 in 100000	**Risk of infection** 20 in 100000 40 in 100000 60 in 100000
Severity	**Severity of side effects** Mild irritability, redness and swelling at the site of injection Mild irritability, redness and swelling (1-2 days) Muscle pain and swelling of joints (1-2 days) Mild fever (1-2 days) Swelling of face, lips, and tongue (3-6 days) Rashes, itching, and skin swellings (3-6 days) Muscle pain and swelling of joints (3-6 days) Mild fever (3-6 days) Breathlessness (3-6 days)	**severity of infection** High fever Blood poisoning High fever Blood poisoning Brain damage (permanent disability) Deafness (permanent disability) Loss of vision (permanent disability) High fever and brain damage leading to Death