

Household demand for typhoid fever vaccines in Hue, Vietnam

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The demand function for vaccines against typhoid fever was estimated using stated preference data collected from a random sample of 1065 households in Hue, Vietnam, in 2002. These are the first estimates of private willingness-to-pay (WTP) and demand functions for typhoid vaccines in a developing country. Mean respondent WTP for a single typhoid fever vaccine ranged from US\$2.30 to US\$4.80. Mean household WTP estimates (vaccinating all members of the household) ranged from US\$21 to US\$27. Demand was similar for vaccines with different degrees of effectiveness and intervals of duration. These results suggest a significant potential for private sector provision of typhoid fever vaccines in Hue.

Key words: private demand, vaccines, willingness-to-pay, typhoid fever vaccines, contingent valuation

Introduction

Asia sustains 75% of global morbidity and mortality from typhoid fever (Yang et al. 2001a,b). The bulk of this burden is borne by preschool and school-aged children (Sinha et al. 1999; Lin et al. 2000). The costs of treating typhoid fever strain both public and private resources, diverting funds from alternative investments that could improve standards of living and quality of life. The increasing prevalence of antibiotic-resistant strains increases the costs of the disease, especially in areas like Vietnam, which has some of the highest rates of multi-drug-resistant *Salmonella typhi* in the world (Pang et al. 1998).

Public health decision-makers in Vietnam have already adopted the Vi polysaccharide vaccine against typhoid fever in high-incidence areas, for children aged 3 to 10 years. In 2003, 523 000 children received free Vi vaccines in 80 districts in 29 provinces (DeRoeck and Jodar 2004), accounting for less than 4% of the nation's children in this age group. In addition, imported Vi vaccine is available through Preventive Medicine Centres, but only about 10 000 imported vaccines were sold for a price of about US\$6. The locally produced vaccine is not yet available in Preventive Medicine Centres, but is expected to be sold for about US\$1. Despite significant interest among health decision-makers in expanding typhoid fever immunization within the nation, lack of public sector resources is expected to slow the introduction of immunization programmes (DeRoeck et al. 2002). Policy initiatives that rely on private demand for typhoid vaccines could overcome

some of the financial barriers to adoption of the new vaccine. Estimates of private demand for typhoid fever vaccine can help decision-makers evaluate the potential for private sales and cost recovery, and can inform the design of targeted immunization programmes.

This article reports the results of a stated preference study of private demand for typhoid fever vaccines in Hue (Thua Thien Province), Vietnam. In July and August 2002, we interviewed respondents in 1065 randomly selected households in Hue (pop. 282 000) regarding demand for typhoid vaccines. Our results indicate significant private demand for typhoid vaccines. Mean household private benefits from typhoid immunization (vaccinating all members of the household), measured by household *ex ante* willingness to pay (WTP), ranged from US\$21 to US\$27 depending on the effectiveness and duration of the vaccine. This work is part of a series of studies measuring the private demand for typhoid fever and cholera vaccines for the Diseases of the Most Impoverished (DOMI) Program, which is administered by the International Vaccine Institute (IVI) and funded by the Bill and Melinda Gates Foundation.

Discussion below opens with a description of the typhoid fever situation in Vietnam, and specifically in Hue, then provides a brief overview of some of the vaccine policy issues that public health officials must consider. After reviewing the research questions that we posed for our study, we summarize the economic models used in our research, describe our study site and research design, and present our results and analysis.

Our conclusions address some of the implications of our findings.

Background

Because few population-based studies of typhoid fever have been conducted in Vietnam, characterization of the disease situation must rely on hospital-based data. Average annual incidence in Hue, on the central east coast, from 1995 to 1999 (at 216.6 cases per 100 000 inhabitants) is much higher than the national incidence rate (on average, 31 cases per 100 000 per year from 1995 to 1999), and higher than in other areas of the same province (115 cases per 100 000 inhabitants) (NIHE 2002). Reported cases of typhoid fever in Hue at the time of our study occurred primarily (64%) in school-aged children aged 5 to 18 years. During a typhoid fever outbreak in Hue in 1996, incidence increased by about 500%. Cases reported at that time were predominantly (87%) in urban (the most densely populated) areas of the city. The remainder (13%) were in semi-urban areas of the city.

Because these statistics are based only on reported cases, they almost certainly underestimate the incidence of typhoid fever, omitting (for example) cases treated at home with antibiotics and cases misdiagnosed due to inadequate blood culture capabilities. A population-based surveillance study in southern Vietnam, in three rural communes in the Mekong Delta, found that typhoid incidence was highest among children aged 5 to 9 years (531 cases per 100 000) (Lin et al. 2000). Incidence in preschool children was also high (358 cases per 100 000). The overall annual incidence rate in that study area was 198 per 100 000.

To our knowledge, the economic costs of typhoid fever in Vietnam have not yet been measured.¹ They are likely to be significant, owing to the prevalence of multi-drug-resistant *Salmonella typhi*. Another recent study based in the southern part of the country (Hoa et al. 1998) found that more than 70% of *S. typhi* were multi-drug-resistant. Resistance to first-line antibiotics (e.g. chloramphenicol, trimethoprim, ampicillin and tetracycline) has been reported to be between 89% and 93% (Pang et al. 1998), and 4% of isolates are resistant to nalidixic acid (a quinolone) (Hoa et al. 1998). There is some evidence that these drug-resistant strains are more virulent (Pang et al. 1998). These high rates of drug resistance make typhoid vaccination especially valuable to individuals in Vietnam, as vaccination reduces the risk of a severe case of the disease. For a somewhat comparable impoverished urban locale in New Delhi, India, average costs of illness per episode of typhoid were estimated at US\$101 in 1996 (Bahl et al. 2004). These costs increased threefold, to US\$326, in episodes caused by antibiotic-resistant strains of *S. typhi*.

These high rates of incidence and of multi-drug resistance, as well as anticipated high costs of the disease, indicate the importance of controlling typhoid fever in Vietnam.

Well-functioning water-supply and sanitation systems would help control the disease, but those are long-term investments. Immunization programmes, a short- to medium-term strategy for disease control, are recommended by the World Health Organization in 'geographical areas where typhoid fever is a recognized public health problem and areas where antibiotic-resistant *S. typhi* strains are particularly prevalent' (WHO 1998).

The Vi polysaccharide vaccine is a new-generation typhoid vaccine with a well-established safety profile and low incidence of mild side effects when administered alone or with other vaccines; it is administered in one dose, as an injection, with revaccination recommended after 3 years; in most countries it is licensed for use in children over 24 months of age, but its efficacy in very young children remains to be determined (Hessel et al. 1999). Studies in endemic areas have found that the efficacy of the Vi polysaccharide vaccine ranges from 50% to 80% (Hessel et al. 1999; Yang et al. 2001a,b).

Despite policymakers' interest in typhoid fever immunization, DeRoeck et al. (2002) expect that the introduction of the Vi vaccine into routine immunization programmes will be gradual due to a lack of public sector budgetary resources. Currently, about 61% of the costs of vaccines included in the Expanded Programme of Immunization (EPI) come from the national budget. Non-EPI vaccines, including typhoid fever, hepatitis B and Japanese encephalitis vaccines, are paid for by local and national governments. The central and local governments purchase Vi polysaccharide vaccine from Aventis-Pasteur for less than US\$0.70 per dose. Preventive Medicine Centres in some provinces, especially in urban areas, sell imported Vi polysaccharide vaccines to patients for about US\$5.50 for a single dose.

Our study has two guiding research questions. First, what is the private demand for typhoid fever vaccines and how does it respond to different vaccine characteristics, such as effectiveness and duration? This question has implications for the economic benefits of typhoid fever immunization programmes, cost recovery and the potential for private sales. Secondly, who would buy and receive the vaccine if it were widely available in the private market? The answer to this question has implications for the design and targeting of immunization programmes. To address these questions, we estimated the private demand for typhoid fever vaccines in Hue by conducting a field survey that included a contingent valuation (CV) scenario describing a hypothetical typhoid fever vaccine. The resulting data were analyzed to estimate respondents' willingness to pay (WTP) for themselves and their households for vaccines of varying effectiveness and duration over a range of prices.

Conceptual model and analysis plan

In this paper we first report the individual respondent's demand for a vaccine for herself and then report the respondent's demand for vaccines for all

household members. Our approach to modelling an individual's demand for a typhoid fever vaccine is based on a standard random utility framework (McFadden 1974; Hanemann 1984). We measured respondent (self) vaccine demand by posing a single-bounded discrete choice valuation question. A probit regression model was used to analyze the resulting data on respondent demand, and respondent WTP was computed following Cameron and James (1987).

We adopted a recently developed theoretical model (Cropper et al. 2004) for deriving household demand for preventive health care, and its concomitant procedures for estimating household demand and WTP for vaccines. In this model, the head of household maximizes household utility subject to a budget constraint and health production functions. We measured household vaccine demand asking respondents how many vaccines they would purchase for other household members. The total number of vaccines is the sum of this count data plus the discrete choice indicator of whether the respondent would purchase the vaccine for himself. Using this framework, we estimate WTP for typhoid fever vaccines for the decision-maker and other household members as the area under the demand curve. The household demand function is estimated using a count regression model.

Research design

The study was conducted in Hue, the capital of Thua Thien Province. Tourism brings significant numbers of both domestic and foreign visitors to Hue. Although water and sanitation coverage is high, it is not universal. Approximately 75% of the population has private water connections; about 70% use improved latrines or water-sealed toilets. The Huong river, the main source of drinking water in Hue, is heavily contaminated, especially during the summer. Food vending is common, and many people report eating street food regularly.

Sample

In July 2002, there were approximately 281 788 individuals living in 54 765 households in 25 communes in Hue. Twenty of these communes are classified as urban areas.² A 2001 census of the study population showed that 77% of households had children of less than 18 years of age.

Because current estimates of typhoid fever incidence indicate that children and young adults are the age groups most vulnerable to typhoid fever, we restricted our sample to households with children aged 0–18 years.³ We eliminated households headed by adults aged 60 years or more, as a pretest revealed that they often were difficult to interview and were less interested in vaccines. From the remaining eligible population, a sample of 1200 households was drawn from a sampling frame of 12 communes, 10 of which were urban. (Sample size was dictated by the CV component of our research design; see below.) The sample was drawn such that the proportion of sample

households from each commune was equivalent to the proportion of the sampling frame population from that commune. This ensured that each household with children and with parents less than 60 years of age in the sampling frame had an equal probability of being selected. A multi-stage random sampling procedure was then employed, first to select households with children and with parents less than 60 years old, then to draw the requisite number of households from that pool, and finally to determine which parent in each household would be interviewed as household head.

Questionnaire development

Our survey questionnaire had six sections: (1) demographic characteristics of the respondent and the household, (2) health-seeking behaviour, (3) perceptions and attitudes regarding typhoid fever, (4) perceptions and attitudes regarding vaccination, (5) assessment of WTP for a typhoid vaccine (CV scenario), and (6) socio-economic information. Questionnaire development was informed by local public health experts and a pretest of 146 households. The research design was approved by the institutional review board for the Vietnamese national government and the institutional review boards at the International Vaccine Institute and the University of North Carolina at Chapel Hill. All respondents provided written informed consent to participate. The interviews took an average of 43 minutes (standard deviation = 10 minutes) to complete.

Two components of the questionnaire deserve further discussion. Section 5, our contingent valuation (CV) scenario, opened with a brief tutorial and quiz to assess how well the respondent understood the concept of vaccine effectiveness. A basic understanding of the concept was essential for making reasoned answers to our two WTP questions in the CV scenario. The CV scenario itself, though brief, presented key information on vaccine demand and then posed two WTP questions.

Assessing understanding of vaccine effectiveness

Our methods for teaching and testing comprehension of the concept of vaccine effectiveness built upon previous work by Suraratdecha et al. (2005). Vaccine effectiveness was described as the joint probability of (1) being exposed to an infectious agent and (2) being protected by a vaccine. The explanation relied on pictures with blue and red figures representing persons with different levels of protection from typhoid fever (Figure 1: the red figures are those that appear darker in the figure). Each respondent's understanding of vaccine effectiveness was tested after the explanation. (The full text of the vaccine effectiveness description and test is reproduced in the Appendix.)

Contingent valuation scenario

Because typhoid fever vaccines are not widely used or available in Hue or other areas of Vietnam, we used a

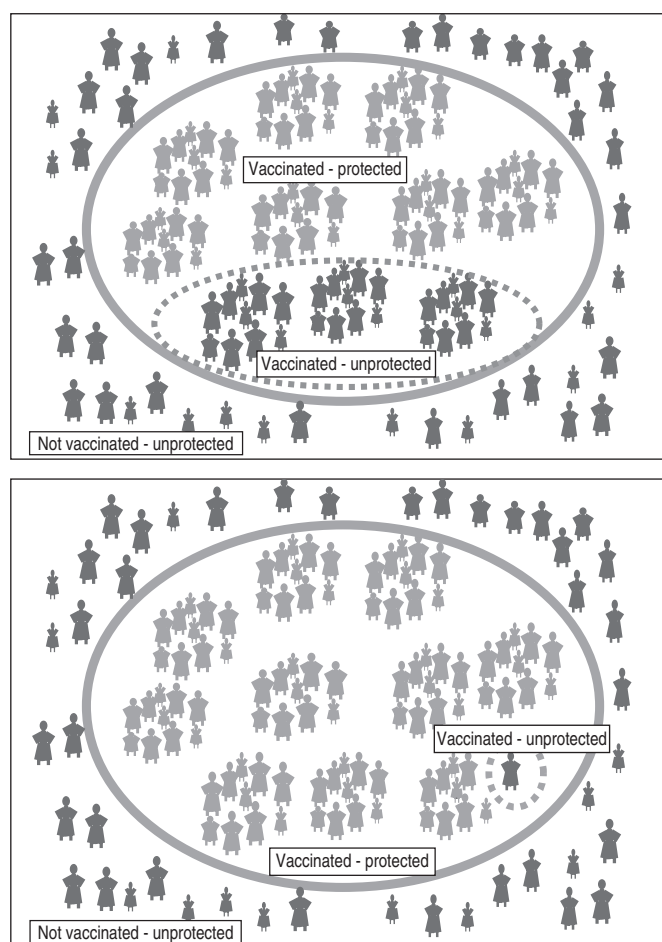


Figure 1. Diagrams used for explaining vaccine effectiveness

contingent valuation strategy to collect data on vaccine demand. This survey-based method, which measures respondents' preferences for currently unavailable goods (Mitchell and Carson 1989), is now widely used in developing countries (Whittington 1998, 2002). The CV component of our survey (reproduced in the Appendix) asked respondents about their willingness to purchase hypothetical typhoid fever vaccines of varied effectiveness and duration at a range of prices, both for themselves and for members of households.

The hypothetical vaccines were assigned four varied levels of effectiveness and duration: 70% effectiveness for 3 years, 99% effectiveness for 3 years, 70% effectiveness for 20 years and 99% effectiveness for 20 years. These levels were determined in discussions with the International Vaccine Institute and local health experts. The least effective and least durable version approximated the Vi polysaccharide vaccine actually available for public immunization. The most effective and most durable version had no real-life counterpart that would provide such levels of protection but rather represented an upper-bound estimate on the total private benefits of eliminating the risk of typhoid fever. A range of five prices – 10 000, 25 000, 50 000, 100 000, 200 000 dong (US\$0.67, US\$1.67,

TOTAL = 1065					
DURATION:	3 years (n = 530)		20 years (n = 535)		
EFFICACY:	70% (n = 265)	99% (n = 265)	70% (n = 261)	99% (n = 274)	
PRICE (US\$)	0.67	53	53	52	56
	1.7	53	54	55	54
	3.3	54	51	51	55
	6.7	52	56	50	52
	13.3	53	51	53	57

Figure 2. Distribution of respondents in sample (by price, vaccine efficacy and duration)

US\$3.3, US\$6.67, US\$13.3) – was applied to the four vaccines, yielding 20 possible combinations of price and vaccine attribute as shown in Figure 2.

Each respondent was pre-assigned only one vaccine price and one set of vaccine attributes from the array of 20. Our total original sample size of 1200 was based on a goal of approximately 50 completed interviews per experimental design point, that is, for each of the price/vaccine attribute combinations (see Figure 2). The vaccine was presented to the respondent as generic, with no reference to resemblance to any currently available typhoid fever vaccine. The respondent was then told that there would be two questions to answer. First (a single-bounded discrete choice question): Would he or she would be willing to purchase, for personal immunization, a vaccine with the designated effectiveness and duration, at the price stated? Second: How many vaccines would he or she purchase for other household members on the same terms? Taken together, replies to these two questions provide count data on the total number of vaccines that each respondent said the household would purchase.

Results

Of the 1200 individuals in our original sample, 1065 completed interviews for our survey. Sample statistics are summarized in Table 1. Respondents' average age was 41 years; 40% were male. Average household size was 5.6 persons: two school-aged children (aged 6–18), three adults (aged 19 and older), and less than one preschool child (aged 0–5) (Table 2). Four per cent of respondents had never attended school, 19% had completed primary school only, 61% had completed secondary school and 16% had completed university or postgraduate studies.

Virtually all of the respondents were employed. Most households (87%) owned televisions, 65% had a motor-bike and 44% had a telephone. Most of the sample used piped water (85%) and a flush toilet (71%). Average monthly household income was US\$77. The average household had spent US\$16 on food, rent, electricity, water service and health care during the previous month. The most recent monthly electricity bill averaged US\$4.72.

Table 1. Descriptive statistics

Variable name	Description	Mean	S.D.
Demographic and socioeconomic			
Urban	Location of respondent's commune (1 = urban, 0 = semi-urban)	0.78	0.42
Male	= 1 if respondent is male, 0 otherwise	0.40	0.49
Age	Age of respondents (continuous)	40.72	8.26
Education	Educ1 = 1 if resp never attended school, 0 otherwise	0.04	0.20
	Educ2 = 1 if resp completed primary school, 0 otherwise	0.19	0.39
	Educ3 = 1 if resp completed secondary school, 0 otherwise	0.61	0.49
	Educ4 = 1 if resp completed univ. and postgrad, 0 otherwise	0.16	0.37
hhsiz	Number of household members (continuous)	5.62	2.16
Young	Number of children aged 0–5 years in household (continuous)	0.49	0.69
School	Number of children aged 6–18 years in household (continuous)	1.82	1.18
Adult	Number of children aged 19–40 years in household (continuous)	3.31	1.73
Income	Monthly household income (continuous, US\$)	77.40	61.82
Exp	Monthly expenditures on food, rent, electricity, water, and health care (continuous, US\$)	16.23	13.19
Employ	= 1 if currently employed, 0 otherwise	1.00	0.07
Elbill	Monthly electricity bill (continuous, US\$)	4.72	4.59
Refrig	Owens refrigerator, 1 = yes, 0 = no	0.18	0.39
Tv	Owens television, 1 = yes, 0 = no	0.87	0.34
Mobike	Owens motorbike, 1 = yes, 0 = no	0.65	0.48
Sofa	Owens sofa, 1 = yes, 0 = no	0.17	0.38
Phone	Owens telephone, 1 = yes, 0 = no	0.44	0.50
Water	Owens private or shared water connection, 1 = yes, 0 = no	0.85	0.36
Pflush	Usually uses private flush toilet, 1 = yes, 0 = no	0.71	0.45
Averting behaviour			
Street 1–4	How often does your family eat food sold by street vendors?		
	Street1 = 1 if never/rarely, 0 otherwise	0.21	0.41
	Street2 = 1 if 1–2 times per week, 0 otherwise	0.34	0.47
	Street3 = 1 if 3–5 times per week, 0 otherwise	0.24	0.43
Distance	Street4 = 1 if more than 6 times per week, 0 otherwise	0.20	0.40
	Distance from house to the nearest private health facility on foot, in minutes (continuous)	46.26	42.14
Risk			
Anyrisk	= 1 if somewhat or very likely that someone in the household would contract typhoid fever sometime in the future, 0 otherwise	0.49	0.50
Common	= 1 if typhoid is common in your commune, 0 otherwise	0.04	0.21
Knowledge and experience			
Know	1 = knows someone who has had typhoid, 0 otherwise	0.18	0.39
knowty	= 1 if knows about typhoid, 0 otherwise	0.77	0.42
Effectiveness test			
Fail1	= 1 if fails first round but passes second round, 0 otherwise	0.15	0.36
Fail2	= 1 if fails both rounds, 0 otherwise	0.05	0.21
Vaccines			
99%/20yr	1 = vaccine is 99% effective for 20 years, 0 otherwise	0.26	0.44
99%/3yr	1 = vaccine is 99% effective for 3 years, 0 otherwise	0.25	0.43
70%/20yr	1 = vaccine is 70% effective for 20 years, 0 otherwise	0.24	0.43
70%/3yr	1 = vaccine is 70% effective for 3 years, 0 otherwise	0.25	0.43

Table 2. Average household composition by age

Age group	Average number of household members	Combined age groups	Average number of household members
0–2 years	0.17	} Preschool-aged children	0.49
3–5 years	0.32		
6–12 years	1.00	} School-aged children	1.82
13–18 years	0.81		
19–40 years	1.92	} Adults	3.31
Over 40 years	1.39		

Respondents' acquaintance with typhoid fever

Most respondents (77%) reported that they were familiar with the disease, but a large majority (90%) believed typhoid fever was uncommon in their commune.

A minority of respondents (19%) reported knowing someone who had had typhoid fever, and only 2% (n = 24) reported that a household member had ever had a case. Almost one-half of respondents (49%) believed that someone in their household would be somewhat

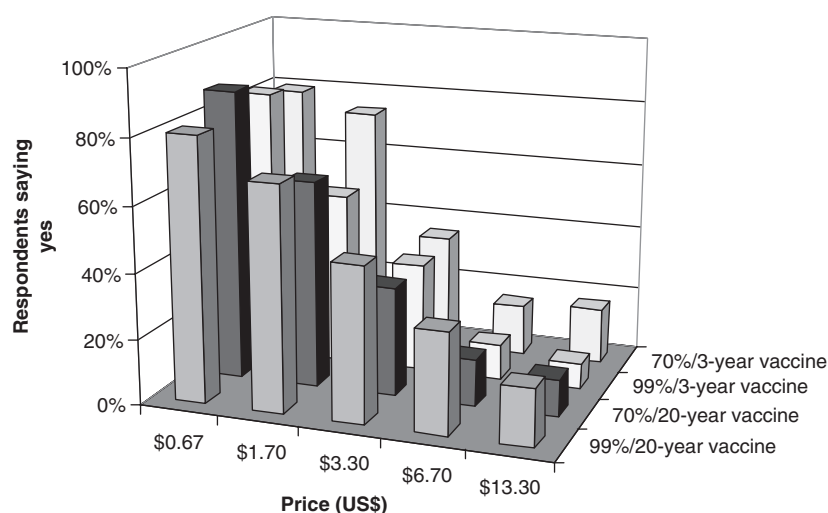


Figure 3. Respondent WTP responses: percentage of respondents willing to buy a typhoid fever vaccine, by price and vaccine characteristics

likely or very likely to contract typhoid fever in the future. Two-thirds (67%) believed that the incidence of typhoid fever had been decreasing in Hue over the past 3 years.

Respondents' experience with and attitudes about vaccines

Respondents' experience with typhoid vaccines reflects Vietnam's commitment to immunization programmes. Nearly all respondents were familiar with vaccines in general (94%) and reported that some or all of their children had received the EPI vaccinations (95%). Coverage with non-EPI vaccines was less extensive. Just over one-half (54%) had received a Japanese Encephalitis vaccine, and even fewer had been inoculated against Tetanus (17%), Rabies (24%) and Hepatitis B (30%). Most were satisfied or very satisfied with the immunization services available in their community (95% for EPI vaccines, 75% for non-EPI vaccines).

Respondent understanding of vaccine effectiveness

Our test questions showed that 85% of respondents understood the concept of vaccine effectiveness after it was explained to them once. An additional 10% understood effectiveness after it was explained a second time. Those who failed to understand the concept after two explanations tended to have lower monthly income, were more likely to perceive themselves to be at low risk and were from the city's semi-urban (less densely populated) communes. In t-tests, these differences between those who did not understand effectiveness after two explanations and the rest of the sample were statistically significant at the 5% level. Education levels were not significantly different.

Respondent demand

The percentage of respondents who were willing to purchase a single vaccine, for personal immunization,

declined as price increased (Figure 3), but that decline was not clearly responsive to variations in vaccine characteristics (either duration or effectiveness). Most respondents (86%) were very certain of their WTP response; 10% were somewhat certain; only 2% were unsure of their WTP response.⁴

A nonparametric estimate of mean respondent WTP was calculated using the Turnbull estimator (Haab and McConnell 2002). Mean respondent WTP ranged from US\$2.52 to US\$4.20, depending on the vaccine characteristics (Table 3). The bottom panel of Table 3 shows the Turnbull estimates when respondents who were 'out of the market' were excluded from the calculation. Respondents were determined to be out of the market if they said no to the first WTP question and indicated that they would not take the vaccine if it were free. With 'out of the market' respondents excluded, respondent WTP is about US\$0.30 higher.

Respondent WTP for single (self only) vaccines of the four different types did not fully conform to our expectations. We expected WTP to be lowest for the 70%/3-year vaccine and highest for the 99%/20-year vaccine; our expectations about the values of the other two vaccines (70%/20-year and 99%/3-year) were indeterminate. The Turnbull estimates show that mean WTP for the 99%/20-year vaccine is indeed higher than the WTP for the three other vaccine types, as expected. However, mean WTP for the 70%/3-year vaccine is higher than for the 99%/3-year vaccine.

As shown in Table 4, multivariate analyses of respondents' stated decisions to purchase a typhoid vaccine generally passed the standard CV construct validity tests proposed by Mitchell and Carson (1989).⁵ Table 4 presents full (column 2) and reduced model specifications (columns 3, 4 and 5). Vaccine price has a negative effect

Table 3. Turnbull estimates of mean and median respondent WTP for typhoid vaccine (US\$)

Vaccine characteristics (% effectiveness; duration)		Lower bound mean (median range)*
Most protective	99%/20-year	4.20 (1.67–3.33)
	99%/3-year	2.52 (1.67–3.33)
	70%/20-year	3.01 (1.67–3.33)
Least protective	70%/3-year	3.47 (1.67–3.33)
Excluding respondents who were out of the market:		
Most protective	99%/20-year	4.61 (3.33–6.67)
	99%/3-year	2.85 (1.67–3.33)
	70%/20-year	3.27 (1.67–3.33)
Least protective	70%/3-year	3.81 (1.67–3.33)

*Median range is the same for all four vaccines in the top panel, indicating that the WTP distributions are similar. The median range of WTP from the Turnbull estimator is the range of initial bids to which 50% of respondents said yes and 50% said no.

Table 4. Probit regression analysis of respondent demand (with *t*-statistics)

	Model			
	Full (n = 1059)	Reduced 1 (n = 1059)	Reduced 2 (n = 1059)	Reduced 3 (n = 1059)
Constant	1.0791 (2.76)***	1.320 (3.50)***	1.3269 (3.34)***	1.3217 (3.32)***
Price	−0.1654 (−14.60)***	−0.1613 (−14.49)***	−0.1612 (−14.48)***	−0.1624 (−14.47)***
Urban	−0.0707 (−0.58)	−0.0150 (−0.14)	−0.0186 (−0.17)	−0.0666 (−0.59)
Male	0.0897 (0.95)	0.0692 (0.73)	0.0677 (0.71)	0.0839 (0.88)
Nrooms	0.0563 (1.58)			
Refrig	0.2291 (1.71)*			
Tv	0.1662 (1.18)			
Mobike	0.2670 (2.44)***			
Sofa	−0.0098 (−0.07)			
Hhinc	0.0004 (0.43)	0.0016 (1.85)*	0.0015 (1.82)**	
Street2	0.0638 (0.49)			
Street3	0.1756 (1.22)			
Street4	−0.0435 (−0.29)			
Distance	−0.0003 (−0.24)	0.0001 (0.08)	0.0001 (0.07)	0.0000 (−0.03)
Educ2	0.2676 (1.04)	0.2580 (1.02)	0.2624 (1.03)	0.2563 (1.01)
Educ3	0.2897 (1.16)	0.3647 (1.48)	0.3649 (1.48)	0.3490 (1.42)
Educ4	0.5071 (1.81)*	0.7231 (2.66)***	0.7207 (2.65)***	0.6819 (2.50)***
Age	−0.0235 (−4.11)***	−0.0230 (−4.09)***	−0.0226 (−3.48)***	−0.0230 (−3.52)***
Common	−0.0625 (−0.29)			
Know	0.1162 (1.00)	0.1085 (0.96)	0.1109 (0.98)	0.1085 (0.95)
Fail1	−0.0831 (−0.64)	−0.120 (−0.94)	−0.1195 (−0.93)	−0.1042 (−0.81)
Fail2	−0.2918 (−1.33)	−0.2421 (−1.13)	−0.2452 (−1.14)	−0.2356 (−1.09)
99%/20yr	0.1517 (1.23)	0.1445 (1.20)	0.1453 (1.20)	0.1570 (1.29)
Hhsize	−0.0642 (−2.91)***	−0.0595 (−2.80)***		
99%/3yr	−0.2526 (−2.02)**	−0.2405 (−1.95)**	−0.2377 (−1.92)**	−0.2306 (−1.86)**
70%/20yr	−0.1060 (−0.84)	−0.1209 (−0.98)	−0.1225 (−0.99)	−0.1019 (−0.82)
Anyrisk		0.1118 (1.27)	0.1101 (1.25)	0.1107 (1.25)
Young			−0.0736 (−0.93)	−0.0831 (−1.05)
School			−0.0804 (−2.01)**	−0.0881 (−2.19)**
Adult			−0.0507 (−1.94)**	−0.0645 (−2.40)***
R ²	0.239	0.222	0.222	0.227

p* ≤ 0.10; *p* ≤ 0.05; ****p* ≤ 0.001.

on respondent WTP, and monthly household income has a positive but insignificant effect. Respondents who had completed a university or postgraduate education are more likely to have agreed to purchase a vaccine for themselves. Respondent's age has a negative effect on demand. Household size has a negative effect on respondent demand, but column 4 shows that household composition does matter: when household size is replaced by counts of household members in three different age groups (preschool, school-aged, adults), the number of

school-aged children and the number of adults has a negative effect on respondent demand. That is, as the number of school-aged children in the household increases, and as the number of adults increases, the probability that the respondent would purchase a single (self) vaccine declines.

The dummy variables for vaccine alternatives indicate that respondents would be less likely to purchase for themselves a 99%/3-year vaccine than any of the other

three vaccine types (the 70%/3-year vaccine is the omitted category), confirming our Turnbull WTP estimates in Table 3. Parametric estimates of mean respondent WTP for a single (self) typhoid fever vaccine range from US\$2.30 to US\$4.80 (Table 5), very close to the Turnbull estimates.

Household demand

Figure 4 presents four household demand curves (one for each of the four vaccine types) that summarize respondents' raw responses to our two WTP questions, indicating the number of vaccines they would buy for themselves and for other household members. As shown, the average number of vaccines respondents would buy for all household members (including themselves) declines as vaccine price increases. Figure 4 shows that the average stated household demand for the different vaccine types is nearly identical at low prices. At higher prices, respondents appear to discriminate between the vaccines to some extent. At our highest price (US\$13.3), household demand for the most effective and most durable (99%/20-year) vaccine exceeded that for the other three vaccine types, as expected.

Table 5. Respondent WTP estimates from probit regression models, by vaccine alternatives (US\$)

Vaccine characteristics	Full Model	Reduced Model 1	Reduced Model 2	Reduced Model 3
70%/3-year vaccine				
Mean	3.84	3.86	3.86	3.81
Standard error	0.07	0.06	0.06	0.07
99%/3-year vaccine				
Mean	3.20	2.37	2.39	2.39
Standard error	0.07	0.06	0.06	0.07
70%/20-year vaccine				
Mean	3.20	3.11	3.10	3.18
Standard error	0.07	0.06	0.06	0.07
99%/20-year vaccine				
Mean	4.76	4.76	4.76	4.77
Standard error	0.07	0.06	0.06	0.07

Data for mean and standard deviation of raw household demand for each vaccine type (Table 6) show mixed evidence of overdispersion (i.e. the standard deviation of the number of vaccines the respondent would purchase is greater than the mean). Household demand for the 99%/20-year vaccine is not overdispersed. For the other three vaccine types, raw demand tends to be overdispersed at higher prices. Results from multivariate analysis indicate that the negative binomial model, which allows for overdispersion in the data, provides the best fit. All likelihood-ratio tests reject the hypothesis that α (the common parameter of the gamma distribution) is equal to zero.

Table 7 shows household demand results from the negative binomial model. The dependent variable in this model is the total number of vaccines that the respondent would purchase for all household members (self plus others). As with the models of respondent demand, these household demand results pass standard CV construct validity tests proposed by Mitchell and Carson (1989). As expected, there are significant negative price effects and positive income effects on household demand. Demand is greater among respondents who had completed a university or postgraduate education. Respondents who believed that a member of their households would be somewhat likely or very likely to contract typhoid fever in the future agreed to purchase more vaccines. Household size is not significant, nor are variables measuring the number of preschool, school-aged and adult household members.

Estimates of mean household WTP for the four different vaccine types were calculated from this negative binomial household model (see Table 8). These WTP estimates measure the benefits the household would experience if all of its household members were vaccinated against typhoid fever. Results are similar across all four vaccine types, ranging from US\$21 for the 99%/3-year vaccine to US\$27 for the 99%/20-year vaccine. Figure 5 shows how household WTP is distributed in our sample, by vaccine type.

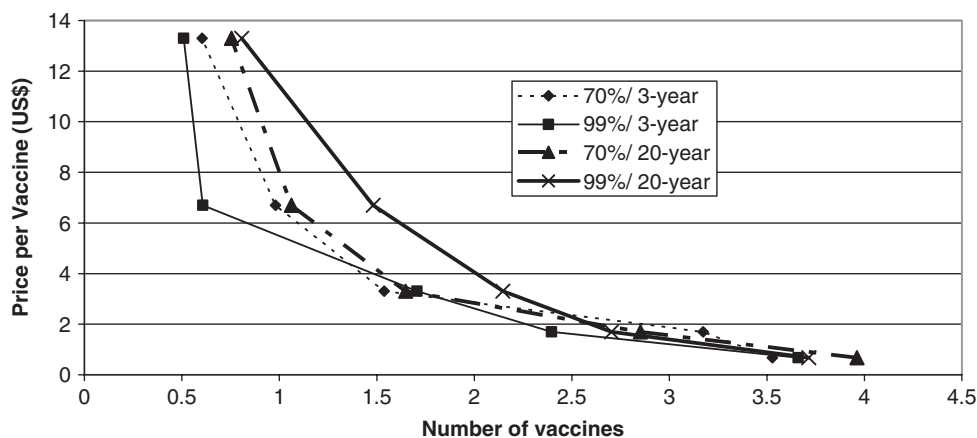


Figure 4. Household demand raw WTP responses: average number of vaccines respondent would buy, by price and vaccine characteristics

Figure 6 shows average WTP for households with different characteristics based on the parameter estimates reported in Table 7. Typical households, or households with average characteristics, were used to simulate these WTP estimates. For example, to compute average WTP for urban households, all variables were replaced with the means observed in the urban subsample. Figure 6 indicates that households in the second quartile of monthly income (mean income = US\$57) are willing to pay more for vaccines than households in the first quartile (mean income = US\$38) and the fourth (mean income = US\$161). This finding may reflect a perception among respondents with higher incomes that they face lower risks that low- and middle-income households. We also note that WTP is approximately the same for households with and without school-aged children.

The regression results were used to predict each sample household's demand for the 70%/3-year vaccine. Averages for predicted and raw demand, by price, are summarized in Figure 7. At the lowest prices, average

predicted demand is less than average raw demand. It is greater than average raw demand in the middle range of prices because of the kinks in the demand function around the prices of US\$3.3 and US\$6.67 (see Figure 7). At the highest price (US\$13.3), average predicted demand and average raw demand are similar. The comparisons of average predicted demand and raw demand are similar for the other three vaccine types used in our survey instrument.⁶

Estimates of price and income elasticities

Table 9 (Panel A) shows price elasticity of total household demand for vaccines with different characteristics. For all four vaccine types, demand is price-inelastic (−0.03 to −0.87) at the three lowest prices and very price-elastic (−3.53 to −4.56) at the highest price. Demand for less effective vaccines is more price-elastic, the most elastic being demand for the 99%/3-year vaccine.

Income elasticity of household demand for all vaccine types is inelastic (Table 9, Panel B), suggesting that

Table 6. Number of vaccines household is willing to purchase by price and vaccine characteristics

Price	70%/3-Yr vaccine		99%/3-Yr vaccine		70%/20-Yr vaccine		99%/20-Yr vaccine	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
0.67	3.53	1.94	3.66	1.94	3.96	1.74	3.71	1.85
1.67	3.17	1.98	2.40	2.12	2.85	1.84	2.70	1.83
3.3	1.54	1.60	1.71	2.16	1.65	1.71	2.15	2.01
6.67	0.98	1.36	0.61	1.09	1.06	1.96	1.48	1.79
13.3	0.60	1.18	0.51	1.19	0.75	1.39	0.81	1.51
Total	1.96	2.01	1.77	2.10	2.07	2.10	2.17	2.06

Table 7. Household demand, negative binomial model (with *t*-statistics)

	Model (n obs)			
	Model 1 (n = 1059)	Model 2 (n = 1059)	Model 3 (n = 1059)	Model 4 (n = 1059)
Price	−0.1457 (−17.05)***	−0.1453 (−17.06)***	−0.1456 (−16.96)***	−0.1452 (−16.98)***
Elbill	0.0249 (3.54)***	0.0240 (3.42)***		
Hhinc			0.0012 (2.19)**	0.0012 (2.20)**
Age	−0.0114 (−2.73)***	−0.0164 (−3.37)***	−0.0107 (−2.55)*	−0.0160 (−3.28)***
99%/20yr	0.1243 (1.42)	0.1266 (1.45)	0.1133 (1.29)	0.1156 (1.32)
99%/3yr	−0.1609 (−1.77)*	−0.1538 (−1.69)*	−0.1475 (−1.62)	−0.1413 (−1.55)
70%/20yr	0.0240 (0.27)	0.0305 (0.34)	0.0065 (0.07)	0.0138 (0.15)
Anyrisk	0.1779 (2.80)***	0.1807 (2.86)***	0.1773 (2.78)***	0.1806 (2.85)***
Educ2	0.2726 (1.41)	0.2607 (1.35)	0.2624 (1.35)	0.2492 (1.28)
Educ3	0.4346 (2.35)**	0.4325 (2.35)**	0.4393 (2.37)**	0.4351 (2.35)**
Educ4	0.6424 (3.25)***	0.6503 (3.30)*	0.6780 (3.42)***	0.6830 (3.45)*
Distance	0.0008 (0.97)	0.0009 (1.12)	0.0006 (0.83)	0.0008 (0.99)
Male	0.1178 (1.73)*	0.1305 (1.92)*	0.1116 (1.63)*	0.1257 (1.84)*
Urban	−0.0244 (−0.30)	−0.0257 (−0.32)	0.0096 (0.12)	0.0062 (0.08)
Hhsize	−0.0127 (−0.82)		−0.0169 (−1.06)	
Young		−0.0805 (−1.38)		−0.0888 (−1.51)
School		0.0344 (1.17)		0.0344 (1.16)
Adult		−0.020 (−1.06)		−0.0253 (−1.31)
Constant	1.0685 (3.88)***	1.2321 (4.21)***	1.0713 (3.87)***	1.2448 (4.23)***

* $p \leq 0.10$; ** $p \leq 0.05$; *** $p \leq 0.01$.

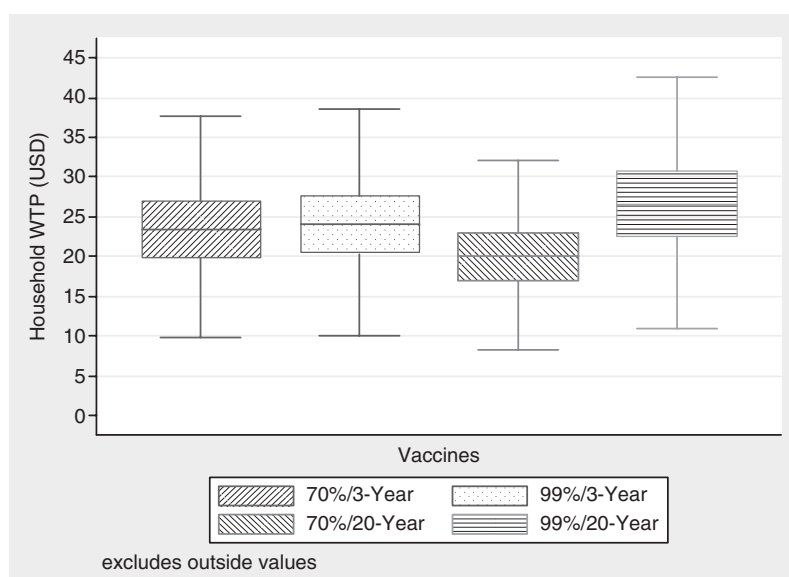
Table 8. Household WTP estimates from negative binomial regression models, by vaccine alternatives (US\$)

Vaccine characteristics	Model 1	Model 2	Model 3	Model 4
70%/3-year vaccine				
Mean	24.04	23.98	24.12	24.07
Standard error	0.15	0.15	0.15	0.15
99%/3-year vaccine				
Mean	20.47	20.56	20.81	20.89
Standard error	0.15	0.14	0.14	0.42
70%/20-year vaccine				
Mean	24.63	24.72	24.28	24.40
Standard error	0.14	0.15	0.15	0.15
99%/20-year vaccine				
Mean	27.22	27.21	27.01	27.01
Standard error	0.16	0.16	0.16	0.16

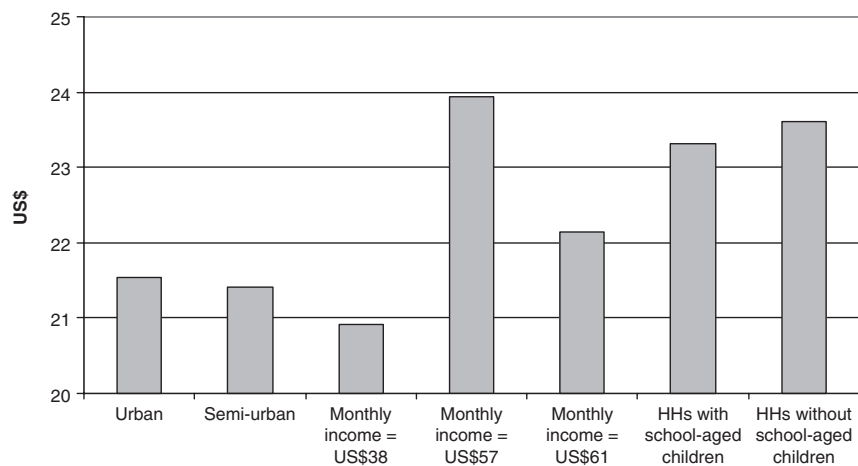
typhoid fever vaccine is not viewed as a luxury good. This result is consistent with findings (Cropper et al. 2004) on income elasticity of demand for hypothetical malaria vaccines.

Discussion

Mean respondent WTP for a single (self-only) typhoid fever vaccine ranged from US\$2.30 to US\$4.80. Mean household (self plus others) WTP for typhoid fever vaccines ranged from US\$21 to US\$27. As average monthly household income was US\$77 (see Table 1), household WTP estimates for the 3-year vaccine types are approximately 1% of household income over the period of effectiveness. While this simple calculation does



Note: The horizontal line in the centre of the box is the median, and the top and bottom of the box show the interquartile range. The whiskers indicate the range of values within 1.5 times the interquartile range.

Figure 5. Distribution of household WTP estimates**Figure 6.** Average household WTP for 70%/3-year vaccine, by household characteristics

not account for income growth or inflation, it does put these WTP estimates in perspective. This result can be interpreted to denote that the average household would be equally receptive to (1) having all of its members receive a free typhoid vaccine or (2) receiving a 1% increase in real income over 3 years.

We found that respondent (self-only) and household (self plus others) demand for vaccines was insensitive to changes in vaccine effectiveness. Several possible explanations arise for this apparent indifference to effectiveness:

- (1) Perhaps our respondents failed to understand the concept of effectiveness. Though 95% answered our questions about vaccine effectiveness correctly, it is possible that some passed the test without understanding the concept.
- (2) Perhaps respondents simply did not think degree of effectiveness was important under the terms provided in our survey.
- (3) Perhaps our methodology was insufficiently designed for detecting demand responsiveness with respect to vaccine characteristics. Yet analysis of responses to the first of our two WTP questions shows that demand for single (self) vaccines was indeed

responsive to changes in duration (though not to changes in effectiveness).

- (4) It may be that demand for typhoid fever vaccine is satiated at low prices. Thus households did not buy more of the better vaccines because, on average, 4 out of 5 household members could be vaccinated at low prices. In other words, there was a limit to how many vaccines a household needed. If a vaccine with low efficacy and a low price could be bought for everyone in the household, one would not expect a respondent to buy *more* vaccines if offered a more effective vaccine at the same low price.

As with all stated preference studies, it is impossible to test study validity in the absence of data on actual sales of vaccines offered to the community via the programme described in the contingent valuation study. Though approximately 10 000 imported Vi vaccines were sold through the Preventive Medicine Centres in 2003, these sales data are inadequate for comparison or validating our stated preference findings. A more appropriate comparator would be sales realized via a public sector immunization programme coupled with health education and vaccine promotion campaigns. Such a programme would likely provide broader access to the vaccine and may have higher vaccine uptake.

Our results have important policy implications for the expanded use of the Vi polysaccharide vaccine in Vietnam.

These findings suggest that a mass vaccination campaign against typhoid fever in Hue would be popular and would likely pass a social cost-benefit analysis, if benefits were to be measured by households' private WTP. Our results indicate that if public sector monies are insufficient to fund such an immunization programme, there is significant potential for selling vaccines through either the public or the private sector. In the past, most countries have usually provided vaccines at no charge during mass immunization campaigns. Our study in Hue indicates that it should be feasible to conduct an urban mass vaccination campaign there, with conventional publicity and social-marketing messages, in which at least part of the financial costs are covered by vaccine user charges.

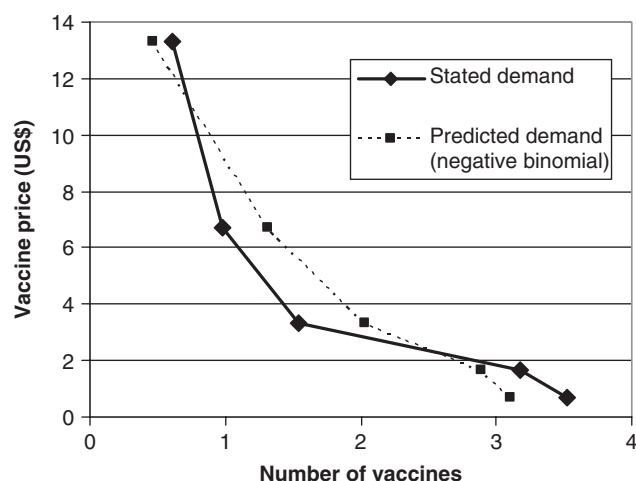


Figure 7. Predicted and stated household demand for the 70%/3-year vaccine

Table 9. Elasticity of household demand, by vaccine

Price	70%/3-year	99%/3-year	70%/20-year	99%/20-year
A. Price elasticity of household demand, by vaccine price and vaccine characteristics				
0.67	-0.03	-0.04	-0.03	-0.03
1.67	-0.09	-0.11	-0.09	-0.08
3.33	-0.23	-0.27	-0.23	-0.21
6.67	-0.75	-0.87	-0.74	-0.67
13.33	-3.96	-4.56	-3.91	-3.53
B. Income elasticity of demand, by vaccine				
Total household demand	0.01	0.01	0.01	0.01

Endnotes

¹An ongoing DOMI community-based surveillance study is collecting data on the patient costs of typhoid fever (direct and indirect costs of illness). The costs borne by health facilities are also being measured. Each commune has one Community Health Centre, and the government operates three polyclinics and six hospitals in Hue. There are 53 private health facilities in Hue.

²Urban communes are characterized by population densities of more than 5000 people per km². Semi-urban communes are characterized by population densities of less than 2000 people per km².

³Because there was a lag of 1 year between the census and our survey, we selected households whose children were listed as aged 0–17 years in the census.

⁴One per cent of respondents did not indicate how certain they were of their response.

⁵Construct validity establishes whether the measure relates to other measures as predicted by theory.

⁶Predicted demand was also compared with household size, to see if the models predicted that respondents would purchase more vaccines than household members. Predicted demand was greater than household size in only 4% of households. Thus estimation of demand functions that are truncated for household size (see Cropper et al. 2004) was not undertaken.

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Appendix: Effectiveness test and contingent valuation scenario

[The following is a lightly edited transcript of section 5 of our survey questionnaire.]

[Enumerator speaking] Next I'd like to talk with you about the transmission and prevention of typhoid. Typhoid is transmitted primarily by food and water contaminated by the faeces of people already infected. Flies can contaminate food. You can help protect yourself from typhoid by consuming only safe, clean food and water.

A type of bacteria (not a virus) causes typhoid. People can transmit the disease as long as they have the bacteria. If someone becomes infected with typhoid, taking antibiotic drugs can treat him or her. Although the patient will have to take antibiotics for about 4 weeks, he/she should feel better in 2 to 3 days. Early treatment in combination with new antibiotics is usually quite effective. Without antibiotic treatment a person with typhoid can be sick for weeks or months with a high fever, and there is a small chance of death. Typhoid is more common in children and young adults. Older adults are less likely to get typhoid than children or young adults.

1a: Do you have any questions or anything you are not clear about?

(0)_____No

(1)_____Yes

[If Yes, record the respondent's questions. If you know the answer to the questions, answer them truthfully and briefly. If you are unsure of the answers, tell the respondent that you are not sure.]

Doctors and scientists have been working for several years trying to develop new vaccines that can prevent people from getting typhoid. We'd like to know what you would do if a new typhoid vaccine were available and you could purchase it. Assume that this vaccine can only be given to individuals who don't currently have typhoid. It would not be effective if someone were already infected.

Suppose that this vaccine was safe and had no side effects (feeling sick, light fever, headaches...). Suppose that you could take the vaccine either as an injection or as a pill. Assume that only one dose of the vaccine would be required. Suppose this vaccine was [70%, 99%] effective in preventing typhoid for [3 years, 20 years].

Now I want to explain exactly what I mean when I say the vaccine would be [70%, 99%] effective.

[Show picture] Suppose that each of these little blue or red figures represents a person. [Indicate circle] The 100 figures inside this circle represent 100 persons who have got the vaccine. The figures outside the circle represent those who have not got the vaccine. The typhoid vaccine is not 100% effective. That is, the vaccine is only [70%, 99%] effective. Therefore, of the 100 people getting the vaccine in the circle, there will be [70%, 99%] of the people who get the vaccine that are protected. That is, the vaccine works for them. The vaccine protects these people from getting typhoid for a period of [3, 20] years. The blue figures inside this circle represent these people.

The rest of the people, the red ones, who have been vaccinated [30 people, 1 person], will not be protected against typhoid even though they have got the vaccine. This is because the vaccine did not work for them. These people are represented by the red figure(s) inside the circle. They will still be at risk of getting typhoid just like they were before they got the vaccine – or just like the people outside the circle who haven't received vaccines – although the symptoms will not be as severe. The people who receive the typhoid vaccine will not be able to know if the vaccine works for them. Of course, we don't know who would actually get typhoid. A person who does not get a vaccine still has relatively small risk of being infected.

Assessing understanding of vaccine effectiveness

Now we are going to ask you some questions to make sure that the information we told you is clear.

First round

[Enumerator shows picture]

1. Please point to all the people who have received the vaccine.

[Enumerator marks place indicated and records result:]

(0)_____ respondent did not give correct answer

(1)_____ respondent did give the correct answer

(98)_____ respondent did not know/not sure

2. Please point to all the people who have got the vaccine and it works for them.

[Enumerator marks those indicated and records result:]

(0)_____ respondent did not give correct answer

(1)_____ respondent did give the correct answer

(98)_____ respondent did not know/not sure

3. How many years would the typhoid vaccine work for them?

[If respondent answers incorrectly, enumerator tells respondent correct answer.]

4. How many people have already received the vaccine but can still get typhoid?

[Enumerator marks those indicated and records result:]

(0)_____ respondent did not give correct answer

(1)_____ respondent did give the correct answer

(98)_____ respondent did not know/not sure

5. If an unvaccinated person gets infected by typhoid, can the vaccine be used to cure them?

(0)_____ respondent did not give correct answer

(1)_____ respondent did give the correct answer

(98)_____ respondent did not know/not sure

[If respondent gives incorrect answer, enumerator tells respondent correct answer.]

[If the respondent gave correct answers to the effectiveness questions, enumerator proceeds to Questions on Willingness to Pay. If not, enumerator explains the efficacy of the vaccine again and re-asks questions 1, 2 and 4, marking the picture and recording the results as before:]

Second round

6. Please point to all the people who have received the vaccine.

(0)_____ respondent did not give correct answer

(1)_____ respondent did give the correct answer

(98)_____ respondent did not know/not sure

7. Please point to all the people who have got the vaccine and it works for them, i.e. they are prevented from getting typhoid by the vaccine.

(0)_____ respondent did not give correct answer

(1)_____ respondent did give the correct answer

(98)_____ respondent did not know/not sure

8. How many people have already received the vaccine but can still get typhoid?

(0)_____ respondent did not give correct answer

(1)_____ respondent did give the correct answer

(98)_____ respondent did not know/not sure

[Whether responses are correct or incorrect, proceed to next step:]

Suppose that the new typhoid vaccine was in limited supply and that those who wanted a vaccine would have to pay a fixed price for the vaccine. Everyone would pay the same price. Assume that neither the government nor your health insurance would pay for the vaccine.

Now I'd like to know whether you would buy the vaccine if it were available at a specified price. You may answer yes or no, provided it reflects your true preferences.

Keep in mind that when you give your answer about whether you would or would not buy the typhoid vaccine, please consider the following: your own income and your family's income and economic status compared with the price of the vaccine, and your risk of getting typhoid. Apart from the vaccine, remember that we can still treat typhoid with antibiotics. Also remember that the benefit of the vaccine in preventing typhoid is for [3, 20] years duration and is [70%, 99%] effective.

9. Do you have any question or anything you are not clear about?

(0) _____ No

(1) _____ Yes

[Enumerator records the respondent's questions/ comments:]

First I'm going to ask you about your willingness to purchase the vaccine for yourself. Then I am going to ask you about whether you would purchase the vaccine for other members of your household.

10. Suppose that this typhoid vaccine costs [10 000, 25 000, 50 000, 100 000, 200 000 dong]. Would you buy this vaccine for yourself?

(0)_____No

(1)_____Yes

(2) ____ Yes, if I had the money

(3) ____ Yes, but too expensive

(4) ____ Yes, but I am too old

(5) ____ Yes, but only for children

(6) ____ Yes, only if the community health staff recommends

(7) ____ Yes, only if many people around me get typhoid fever

(98) ____ Don't know/not sure

<Some text removed>

If the price of the vaccine were [10 000, 25 000, 50 000, 100 000, 200 000 dong] for adults and for children, how many vaccines would you be willing to purchase for members of your household (not including yourself)?

Number of Vaccines (ONLY FOR HOUSEHOLD MEMBERS, NOT INCLUDING YOURSELF)

Relationship	check	Age
Spouse		
mother		
father		
Child1		
Child2		
Child3		
Child4		
Child5		
Child6		
Child7		
Other adult1		
Other adult2		
Other child1		
Other child2		

[Enumerator: If respondent would pay for 0 vaccines, skip the next question]

Who would you buy this vaccine for? (Record the age of family member whom you want to get the vaccine in the blank according to their relationship with you)

[Do not include respondent on the table below]