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# The health benefits of reduced air pollution: value and trade-offs

## Introduction

This study was performed in several steps. The first was a survey to obtain population values of the amount people were willing to pay to avoid respiratory symptoms and their perceptions of the impact of air pollution. This survey also identified a suitable population for the further studies. Second, a qualitative survey was then carried out to obtain suggestions about factors affecting health to use as attributes in a subsequent conjoint analysis. Finally, we validated locally an estimate for the value of a life saved (or death avoided).

## Methods and results

### *Survey on perceptions of air pollution and willingness to pay to avoid respiratory symptoms*

A random household telephone survey was performed during August to November 2001. The objectives were to estimate the willingness to pay (WTP) to avoid respiratory symptoms, to obtain data on factors which may confound the relationship between WTP and exposure to air pollution, and to obtain other relevant data on perceptions of air pollution.

The survey questionnaire included as many previously validated questions as possible and was extensively piloted on the local population.<sup>1,2</sup> All interviews were conducted in Cantonese. Air pollution was not mentioned until after the monetary valuation had been done; thus, we estimated non-contextual values. We used a closed-ended question format to elicit people's WTP for avoiding 1 day of each symptom. We collected double-bounded (DB) data, that is, the respondents were asked about two bid amounts. In the first pilot study, we used an open-ended question format to elicit eight starting bid levels for the eight symptoms (coughing, shortness of breath, sinus congestion, congested throat, itching and smarting eyes, fever, headache, and acute bronchitis) to be valued. The second bid was conditional on the respondent's response to the first bid: half the first bid if the first response was 'no' and double the first bid if it was 'yes'. The initial bid amounts were assigned randomly to respondents. Willingness to pay was estimated using interval regression analysis.

## Survey results

The prevalence of self-reported symptoms was high and two thirds of the sample thought air pollution affected their health. Most common problems perceived to be related to air pollution were breathing and throat problems. The mean number of hours per week spent near busy roads was 12, which accounted for 46% of the mean time spent outdoors. In their own residential districts, 11% thought the air quality was poor and almost half thought it was only fair. In Kowloon, those who lived closer to ground level considered their air quality poorer than those living at higher levels.

The unweighted estimate of median WTP to avoid 1 day of each symptom was similar to the weighted estimate, where weighting was based on the age and sex structure of the population. Therefore, to avoid any bias created from the weighting process, we recommend using the unweighted median WTP. Respondents were willing to pay most to avoid 1 day of shortness of breath, followed by itching eyes, fever, coughing, congested throat, and sinus congestion. The WTP values ranged from HK\$265 for shortness of breath to \$212 for itching

## Key Messages

1. The majority of respondents considered that air pollution was affecting their health and were willing to pay to avoid respiratory symptoms and more serious illness.
2. Willingness-to-pay values yielded a range of \$139 to \$235 to avoid a day of respiratory symptoms and \$4089 to \$4855 to avoid an episode of serious cardiorespiratory disease.
3. Based on the data collected in 2001, a life in Hong Kong can be valued at least as high as HK\$10 million.

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and smarting of eyes down to \$139 for sinus congestion. The ranking of WTP was consistent with the stated ranking of disutility of symptoms, thus supporting their validity.

These estimates were affected by the characteristics of correspondents. As expected, the wealthier and better educated respondents tended to give higher WTP values, providing support for construct validity. A 1% increase in income resulted in a 0.2% increase in WTP to avoid a 1-day episode of coughing, implying that symptom avoidance is a relatively inelastic desire. Smokers, women, people having poor self-assessed health status and those who perceived the air quality to be poor, gave lower WTP values to avoid 1 day of a symptom than the rest of the sample, but the differences were not statistically significant. People who claimed that their health status has been affected by air pollution were willing to pay more than others. These data give a range of estimates of the value for the relatively minor adverse health consequences of air pollution.

### **Survey data validity**

Compared to the general population, the survey respondents were less likely to be young, male, high-income earners, highly educated, professional, and living in a single person household. However, in our sample only the proportion in the lowest-income group differed from the population by more than 10%, and most of the differences were quite small. To test the reliability of the questionnaire, we randomly selected 311 out of 1385 respondents to call back; 268 were successfully asked eight of the questionnaire items. The test-retest reliability was good for those items which would not be expected to change, ie the questionnaire showed good reliability. The reliability of the WTP question was lower, as would be expected, but two thirds did not change their valuation at all.

The WTP estimates did not change dramatically from those using only the first bid result when the follow-up responses were added. Responses for the symptoms of sinus congestion, congested throat, and fever did not change at all and those for coughing, shortness of breath and itching and smarting of eyes only changed a little.

We compared the results for WTP in this study with those reported in similar studies for Norway and the United States.<sup>1,2</sup> Median values for the United States and Norway are both lower than those for Hong Kong. It is unlikely that differences across the three studies are solely due to differences in survey methodologies, since these were similar. The differences could well be due to real economic or cultural effects, and further studies are necessary to confirm this possibility. We also conducted a further small survey to estimate WTP to avoid 3 or 7 days of the same symptom. We found that, to avoid 3 days of symptoms, respondents are willing to pay three times the value of avoiding 1 day of symptoms. However, there is a declining marginal value of a symptom day as the number of symptom days increases, because the value for avoiding 7 days is less than seven

times 1 day and is nearer five times the 1-day value.

### **Pilot study on roadside workers**

A sample of those who work regularly at the side of polluted roads was carried out to determine how different their perceptions would be from those of the general public. This was done only as a pilot study and aimed to include a range of roadside worker, rather than being a random sample. The results show that roadside workers experience poorer health than the members of the random population sample and also perceive air quality in their living district to be poorer. They were, as expected, a different group in terms of demographic and socio-economic characteristics from the general population and the population sample used for the WTP estimates. They had a higher rate of declared heart and respiratory disease than the population sample (15% vs 5%) and poorer self-perceived health; 75% being fair or poor compared with 44% in the population sample. They are more inclined to complain of throat symptoms than breathing problems, but this may reflect a 'survivor effect', ie those who had breathing problems no longer work at the roadside. The survivor effect is also supported by the finding that 42% of the roadside workers said they have no problem related to air pollution compared with only 31% in the general population. They spend far more time outdoors and near busy roads than the population sample, and are more inclined to rate the air quality in the district they live in as only fair or poor (88% vs 57%) although the same proportion (11-12%) rate their air quality as poor. We did not ask for the WTP values because the small sample precluded this analysis.

### **Qualitative study on perceptions of health**

In the second sub-study, focus groups were used to explore what people felt affected their health and where air pollution stood in relation to other factors. A convenience sample of persons with respiratory diseases from two general out-patient clinics in Shatin, New Territories and Ap Lei Chau, Hong Kong Island gave their perceptions of the disadvantages of having respiratory disease, the impact of air pollution on their problem and how they tried to minimise such impact. The subjects regarded the impact of air pollution as an adverse effect on their health. The qualitative information obtained from the focus group was used to construct the questions for the quantitative conjoint analysis. With appropriate, detailed explanation, even elderly people were willing to participate in the trade-off question (WTP exercise).

### **Conjoint analysis on trade-offs and willingness to pay to avoid serious morbidity**

Thirdly, a conjoint analysis study was undertaken to estimate trade-offs between air pollution, factors affecting air pollution, cost, and health. A group of 245 randomly selected respondents to the household survey participated in a conjoint analysis to estimate the value of reducing risks of serious respiratory and cardiovascular disease. Each person was presented with scenarios in which the risk of a serious

exacerbation of either cardiovascular or respiratory disease which would result in admission to hospital was varied along with other attributes such as travel, convenience, and cost.

### Conjoint analysis results

Using a random effects probit model, the value of this diminished quality of life due to cardiovascular and respiratory disease was estimated to be HK\$4089 and HK\$4855 respectively for a period of 12 months. The findings suggest that convenience and cost are important qualifiers when considering the health impact of air pollution.

### Conjoint analysis data validity

The conjoint analysis can only focus on a limited number of attributes in a scenario, for which health impact was restricted to the diminished quality of life associated with the morbidity. The questionnaire was deliberately structured to lead the respondents to think about the degradation of life quality; the valuation may therefore exclude loss of productivity and cost of medications. The medical costs were not an explicit attribute in the decision. Another limitation is the linearity assumption imposed when 100% risk reductions were computed, although we have no evidence that this is not a reasonable assumption. Only two discrete increments were built into the choice sets (2% and 10% reduction). This was for practical reasons since one more increment would have increased the final choice set by 20 additional scenarios. Another caveat is the estimation method. Many standard packages do not have pre-programmed ordered probit routines that can accommodate observations correlated at the subject level. We therefore carried out the sensitivity analysis to test the impact of including or excluding those who were indifferent towards the choice offered. The magnitude of the coefficients changed, but the directions of the impacts stayed the same. Finally, since many respondents stated that they were also thinking of the risks to others when they made their valuation, this gives a conservative estimate for the value of an individual's own reduction in risk.

A complementary contingent valuation study using closed-ended bids returned an estimate of the same order of magnitude (HK\$4792 and HK\$3227) which, along with sensitivity analyses, led us to conclude that the WTP estimates were reasonably robust. It is quite normal for a survey of this kind to under-sample households with higher corresponding incomes but those with higher incomes are usually willing to pay more. This is further support for the belief that our estimates are probably conservative.

### Validation of value of statistical life

Finally, a validation of an estimate of a value of statistical life was carried out by survey. Based on a World Health Organization estimate of 1.4 million euros (HK\$10 million) as a middle estimate worldwide for the value of a life, it was estimated that 100 000 people would need to pay HK\$100 each to save one life. We tested the willingness of the local population to pay this amount.

### Value of statistical life results

Approximately 81% of respondents agreed to be one of 100 000 willing to donate \$100, ie they agreed to a total value of \$10 million for one life (\$100 x 100 000 people = \$10 000 000). The sample differs from the population in terms of sex distribution, the age distribution of females, and occupation. However, if we accept that this sample is reasonably representative, then these figures imply that a life in Hong Kong can be valued at least as high as HK\$10 million.

### Conclusions

We found that the majority of respondents considered that air pollution was affecting their health and were willing to pay to avoid respiratory symptoms and more serious illness. This study has yielded estimates for some non-monetary costs of air pollution which can be used in local costing studies. The WTP values were found to be reasonably robust in our validity estimations and yielded a range of \$139 to \$235 to avoid a day of respiratory symptoms and \$4089 to \$4855 to avoid an episode of serious cardiorespiratory disease. While the validation we carried out implies that these estimates may be conservative, the estimates for the symptoms are a little higher than those noted overseas and so further exploration appears warranted. The value of \$10 million for the statistical value of life was acceptable to the local population.

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