# DEPARTMENT OF COMMUNITY MEDICINE 

 THE UNIVERSITY OF HONG KONGFINAL REPORT

## FOR

# THE PROVISION OF SERVICE FOR STUDY OF 

## SHORT TERM HEALTH IMPACT AND COSTS

## DUE TO ROAD TRAFFIC-RELATED AIR POLLUTION

## ENVIRONMENTAL PROTECTION DEPARTMENT

TENDER REF. AS 00-378

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## Study of short term health impact and costs due to road traffic-related air pollution

## Executive Summary

1. Background: In Hong Kong a large proportion of ambient air pollution is attributable to air pollutant emissions from road traffic. Methods for assessing the proportion of air pollution attributable to road traffic have already been established and from these data an assessment of the health impact and economic cost of traffic-related air pollution can be estimated for use by policy makers.
2. Methods: Using study methods in line with those of Air Pollution and Health: a European Approach (APHEA) and Poisson regression on daily time-series data for years 1995-2000, we estimated the health effects for each of four criteria pollutants, nitrogen dioxide $\left(\mathrm{NO}_{2}\right)$, sulphur dioxide $\left(\mathrm{SO}_{2}\right)$, respirable suspended particulates (RSP), and ozone $\left(\mathrm{O}_{3}\right)$.
3. The health outcomes were: (i) all causes (non-accidental) daily mortality, and mortality due to all respiratory diseases, chronic obstructive pulmonary diseases, all cardiovascular, cardiac and ischaemic heart diseases, for all ages; and (ii) hospital admissions, due to respiratory disease for 65+ and for all ages; asthma for 15-64; all cardiovascular, cardiac and ischaemic heart diseases for all ages.
4. Economic valuation was carried out by calculating cost of illness (direct cost of health service utilization and productivity losses) and estimating the full economic value using willingness to pay value estimates for the avoidance of mortality and morbidity. Willingness to pay was estimated using contingent valuation and conjoint analysis on data obtained through telephone interviewing. Effects of fine suspended particulates (partially accounted for by its correlation with respirable suspended particulates) and carbon monoxide, with data available only from one monitoring station and for three years, were also assessed, but these results were not included in the economic valuation.
5. Results: The estimates of excess daily mortality risks, in all ages, show that an increase of 10 $\mu \mathrm{g} / \mathrm{m}^{3}$ concentration of pollutants was associated with a $0.6 \%$ to $2.1 \%$ increase across all disease categories for $\mathrm{NO}_{2} ; 1.4 \%$ to $3.9 \%$ increase across all disease categories for $\mathrm{SO}_{2} ; 0.2 \%$ increase in all non-accidental causes and $0.9 \%$ increase in chronic obstructive pulmonary disease for RSP and with $0.6 \%$ increase in respiratory disease for $\mathrm{O}_{3}$.
6. The results for hospital admissions show that, except for asthma, all the criteria pollutants under study were associated with increased admissions across all the disease categories. For an increase of $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ concentration, there was a $0.5 \%$ to $1.9 \%$ increase for $\mathrm{NO}_{2} ; 0.5 \%$ to $2.4 \%$ increase for $\mathrm{SO}_{2} ; 0.4 \%$ to $1.0 \%$ increase for RSP; and $0.2 \%$ to $0.6 \%$ increase for $\mathrm{O}_{3}$.
7. According to the excess risk of each pollutant estimated from the database for the period 1995-2000, the number of cardiorespiratory deaths attributable to a $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ change in concentration of the pollutant which produced the greatest effect, would be 243 deaths a year (based on $\mathrm{SO}_{2}$ ) and that for the fraction due to traffic-related air pollution would be 83 deaths a year (based on $\mathrm{NO}_{2}$ ). The corresponding numbers of cardiorespiratory admissions would be 1917 (based on $\mathrm{SO}_{2}$ ) and 821 (based on $\mathrm{NO}_{2}$ ) respectively. When mean concentrations for the year 2000 were used (i.e. $\mathrm{NO}_{2} 58.3, \mathrm{SO}_{2} 17.8$, RSP 50.4 and $\mathrm{O}_{3} 34.3 \mu \mathrm{~g} / \mathrm{m}^{3}$ ), the corresponding numbers attributable to a single pollutant would be 783 and 485 deaths (based
on $\mathrm{NO}_{2}$ ); and 7737 and 4789 admissions (based on $\mathrm{NO}_{2}$ ) a year. The $95 \%$ confidence upper bound estimates would be 1244 and 770 deaths; and 10911 and 6753 admissions correspondingly.
8. Based on the results for respiratory and cardiovascular diseases in this analysis, and using results of another EPD study on the effects of air pollution on general practitioner visits we estimate that the direct cost of illness, in the year 2000, would be at least $\$ 227.3$ million for a $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ change in pollutant concentration in total air pollution and $\$ 289.7$ million with productivity losses included; and at least $\$ 140.7$ million and 179.3 million respectively for the fraction due to traffic-related air pollution.
9. The most complete estimation using the willingness to pay estimates for the monetary value of morbidity and mortality and including the cost of public hospital care, in the year 2000, would be at least $\$ 2.8$ billion for a change of $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ concentration in the total air pollution; and at least $\$ 1.2$ billion for the fraction due to traffic-related air pollution.
10. Conclusions: When mean concentrations in the year 2000 were used, an estimate of the monetary value of the effects of air pollution on cardiorespiratory diseases in Hong Kong would be at least $\$ 11.1$ billion for total air pollution; and at least $\$ 6.9$ billion for the fraction due to traffic-related air pollution; and for direct cost of illness would be at least 1.3 billion and 0.8 billion respectively.

Economic valuation (in HK\$ billion) for health effects of air pollution in year 2000
\(\left.$$
\begin{array}{ccc}\hline & \text { Billion } \mathrm{HK} \$ & \text { Remarks } \\
\hline \begin{array}{c}\text { Direct cost of illness } \\
\text { a. } 10 \mu \mathrm{~g} / \mathrm{m}^{3} \text { change in pollutant concentration } \\
\text { i. total air pollution }\end{array} & 0.2 & \begin{array}{c}\text { Based on } \mathrm{NO}_{2} \text { only } \\
\text { Based on } \mathrm{NO}_{2} \text { only } \\
\text { (includes productivity loss) } \\
\text { Based on } \mathrm{NO}_{2} \text { only } \\
\text { Based on } \mathrm{NO}_{2} \text { only }\end{array}
$$ <br>

ii. fraction due to traffic-related air pollution \& 0.3 \& 0.1\end{array} $$
\begin{array}{c}\text { (includes productivity loss) }\end{array}
$$\right]\)| b. mean pollutant concentration in year 2000 |
| :---: |
| i. total air pollution |

Monetary value to avoid mortality/morbidity
a. $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ change in pollutant concentration
i. total air pollution
2.8
Based on $\mathrm{SO}_{2}$ only
ii. fraction due to traffic-related air pollution
1.2
Based on $\mathrm{NO}_{2}$ only
b. mean pollutant concentration in year 2000 i. total air pollution $\quad 11.1 \quad$ Based on $\mathrm{NO}_{2}$ only
ii. fraction due to traffic-related air pollution 6.9

Based on $\mathrm{NO}_{2}$ only

## 1. Background

Recently, three European countries, namely Austria, France and Switzerland, co-operated in a tri-lateral project which aimed to quantify the road-traffic-related health cost due to respirable suspended particulate matters i.e. $\mathrm{PM}_{10} .^{1}$ The research project was based on an interdisciplinary co-operation in the fields of air pollution, epidemiology and economics, and provide input to the World Health Organization (WHO) Ministerial Conference in June 1999. A similar study for Hong Kong is deemed necessary to help assess the effectiveness of air pollution control policies.

The Hong Kong Environmental Protection Department (EPD) has commissioned a number of studies ${ }^{2-6}$ on the short-term health effects of air pollutants on daily hospital admissions and daily mortality due to cardiorespiratory diseases and in the current year, another study ${ }^{7}$ on the effects of air pollution on daily general practitioner visits for cardiorespiratory problems. Results from these studies would allow the quantification of the exposure-response effects of ambient air pollution on general practitioner visits, hospital admissions and mortality, and serve as a basis for calculation of the associated direct and indirect costs and also the costs which individuals are willing to pay to prevent a certain level of the health effects.

In Hong Kong, a large proportion of ambient air pollution may be attributable to air pollutant emissions from road traffic. ${ }^{8}$ Parameters other than respirable suspended particulates should also be considered. Methods for assessing the proportion of road traffic-related air pollution have already been established. With such information, the avoidable health costs due to road traffic-related air pollution could be estimated for use by policy makers in the assessment of the benefits which would be gained by the implementation of clean air policies.

## 2. Objectives

In order to investigate the short-term effects of air pollution on morbidity and total mortality, as well as to assess the direct and indirect costs, together with the costs which individuals are willing to pay to prevent health effects of air pollution, the following will be evaluated:
2.1 the exposure-response relationship between air pollution and health outcomes, and the road traffic-related exposure, based on the estimated proportions of ambient and roadside air pollution and the exposed population,
2.2 the total health impact, the road traffic-related health impact of air pollution and their monetary value

## 3. Data and methods

### 3.1 Health impact of air pollution

Air pollutant data: Hourly concentration records of air pollutants including Nitrogen Dioxide $\left(\mathrm{NO}_{2}\right)$, Sulphur Dioxide ( $\mathrm{SO}_{2}$ ), Respirable Suspended Particulates (RSP), Ozone $\left(\mathrm{O}_{3}\right)$, Fine Suspended Particulates (FSP) and Carbon Monoxide (CO) were extracted for the years 1995 to 2000 for each of eight monitoring stations. The stations included Central and Western (CW), Kwai Chung (KC), Tai Po (TP), Kwun Tong (KT), Shamshuipo (SSP), Sha Tin (ST), Tsuen Wan (TW) and Yuen Long (YL). The data for Tung Chung and Hong Kong Eastern were not included in the study because these two stations started to operate only recently and have data for only 2-3 years. Those stations with data during the study period chosen are indicated by an asterisk (*) in Table 3.1.

For gaseous pollutants the Opsis instrument was used to measure the concentrations, in addition to or in replacement of the usual Point Analyzer instrument, in some stations as indicated by \# in the Table 3.1. For stations CW 1995-97 and KC 1995-96 both Opsis and Point Analyzer methods were used. The correlations between the two methods were high ( 0.84 - 0.97) (Table 3.2). From March 1999 onwards concentrations for $\mathrm{NO}_{2}, \mathrm{SO}_{2}$ and $\mathrm{O}_{3}$ were measured by the Opsis instrument in TP and YL stations. Thus the concentrations measured by Opsis have been used for the analysis for these pollutants in the two stations.

Hourly data were summarized into 8-hour (9:00-17:00 hours) daily means for $\mathrm{O}_{3}$ and into 24-hour daily means for the other pollutants. The daily data were regarded as valid if there were more than 6 hourly data for $\mathrm{O}_{3}$ and more than 18 hourly data for the other pollutants. Only valid data were used to summarize the set into daily data. The percentages of valid data are indicated in Table 3.3. Only those stations with more than three quarters of their data valid in each year were included for further analysis.

In checking for validity, the daily concentrations were summarized into monthly means and were compared with those published in the EPD Air Quality in Hong Kong reports for $1995,1996,1997,1998,1999$ and 2000. The monthly data which deviated more than $2 \mu \mathrm{~g} / \mathrm{m}^{3}$ from those published were checked to determine whether the deviations were due to mistakes in data manipulation or in extraction of data. After correction for mistakes, the original daily data were accepted for data analysis. Correlations between stations were high (Table 3.4). For each pollutant in each year, daily data for all stations, subject to the above restriction, were pooled up.

The procedures for summarizing all available stations into daily data were set according to studies ${ }^{9-10}$ using the Air Pollution and Health: a European Approach (APHEA) Phase II guidelines as outlined in Box 1 below:

## Box 1

1. Estimate the annual mean concentration of each pollutant in each monitoring station.
2. Subtract this annual mean from the daily concentrations of the corresponding station and year. The resulting series is regarded as centered.
3. Take the arithmetic mean over all monitoring stations of these centered series day by day.
4. Finally add the annual mean of all stations to the series obtained from step 3. The series for each health outcome is used for the analysis.

The distributions and summary statistics for each of the pollutants are presented in Table 3.5 .

Meteorological data: Daily means of relative humidity and temperature for 1995-2000 were obtained from the Hong Kong Observatory. Their distributions are summarized in Table 3.6.

Mortality data: Daily mortality data for the years 1995-2000 were available from the Census \& Statistics Department. The total numbers of deaths in each disease category under study for the years 1995-2000 are shown in Table 3.7. They were summarized into daily counts for the analysis.

Hospital admission data: Hospital records for patients discharged between 1.1.1995 and 30.06.2001 were retrieved from the data provided from the Hospital Authority (HA) via the EPD. The data were checked and discrepancies between years were identified. Corrections were made after receiving advice from the HA Information Technology Department.

Daily hospital admissions for health outcomes from 1.1.1995 to 31.12.2000 were derived. The data were extracted from 12 major HA hospitals, which include Kwong Wah Hospital, Our Lady of Mary Knoll Hospital, Pok Oi Hospital, Princess Margaret Hospital, Prince of Wales Hospital, Pamela Youde Nethersole Eastern Hospital, Queen Elizabeth Hospital, Queen Mary Hospital, Ruttonjee Hospital, Tuen Mun Hospital, United Christian Hospital and Yan Chai Hospital. A summary of total numbers for some health outcomes is presented in Table 3.8.

Statistical methods: We used Poisson regression modeling to develop core models with daily counts of mortality and hospital admissions as the outcome variable ${ }^{11}$. The explanatory variables included were nonparametric smoothing (Loess function) ${ }^{12}$ terms for trend on days, seasonality, temperature, relative humidity, and dummy variables for days of the week, holidays, and influenza epidemics defined as the weeks with number of hospital admissions due to influenza being in the upper quartile in each year. Residuals (i.e. observed minus expected counts) of each core model were examined to check whether there were discernible patterns (indication of confounding effects by unobserved variables) and autocorrelation (due to effects of uncontrolled variables which might have affected variations in successive days) by means of residual plots and partial autocorrelation
function (PACF) plots. When there were overdispersions and autocorrelations in the residuals, they were adjusted for in the model.

We then added the daily pollutant concentration of each current day up to the previous three days for a pollutant, into the core model as an independent variable. Relative risks were then estimated. An estimate which was associated with the most significant result within 0-3 lag days was adopted. The estimates obtained in this study were compared with similar estimates from other Hong Kong studies ${ }^{9-10}$ for the period 1995-97 for validity and reliability checking.

All effect estimates were converted to excess risks per $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ increase in pollutant concentration which is assumed to be linearly related to the risk estimate. An excess risk is the proportional increase in risk for those exposed to $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ concentration higher relative to those exposed to the lower level. Excess risk is derived from the corresponding relative risk minus one.

For comparison with previous studies, relative risks for a change of pollutant concentrations from $10^{\text {th }}$ percentile to $90^{\text {th }}$ percentile, i.e. risk ratio at the upper $90 \%$ of the concentration relative to that at the lower $10 \%$, were also used on some occasions.

Number of deaths and hospital admissions which would be attributed to air pollution were estimated by multiplying the total numbers in the year 2000 with the corresponding excess risks.

### 3.2 Health cost of air pollution

Cost of illness: A range of health services, due to respiratory and cardiovascular diseases were included in the analysis. Admission to hospital; visits to accident and emergency departments, specialty and general outpatient clinics and private general practitioners were used for the calculation of direct health care costs. The average bed-day costs obtained from the Hospital Authority included investigations, procedures and drug costs. The computation methods and the assumptions used are specified in Box 2 below.

## Box 2: Computation and assumptions

(I) Cost per episode/visit (Refer to column A of Table 4.7)
(a) HA hospital admissions: Mean lengths of stay (LOS) in number of bed-days for an episode of stay, for admission due to respiratory and cardiovascular diseases in acute general ( $\mathrm{n}=15$ ), chronic infirmary ( $\mathrm{n}=19$ ) and coronary care unit ( $\mathrm{n}=3$ ) hospitals for females and males were obtained from the HA Inpatient database for the year 2000. Each mean value was computed after truncating the $10 \%$ highest values of LOS to avoid distortion of the mean by the extremely high values which were skewed from a normal distribution. Average costs for each bed-day were analyzed separately for acute general (\$3132), chronic infirmary (\$2735) and coronary care unit (\$5188) hospitals, but were assumed to be the same for both genders and for both diseases, and were obtained from HA ${ }^{13}$. Cost per episode was obtained by multiplying cost per bed-day with LOS.
(b) Private hospital admissions: The mean LOS in private hospitals were assumed to be the same as for HA acute general hospitals for respiratory and cardiovascular diseases. Cost per bed-day was taken to be that of HA acute general hospitals.
(c) Accident \& Emergency $(A \& E)$ visits: Average cost per visit (\$571), obtained from $\mathrm{HA}^{13}$, was used for all categories of diseases and both genders.
(d) Specialty Outpatient Clinic (SOPC) visits: Average cost per visit (\$660) was obtained from $\mathrm{HA}^{13}$ and was applied to all visits in Medicine and Surgery SOPCs. The cost was assumed to be the same for all categories of diseases and for both genders.
(e) General Outpatient Clinic (GOPC) visits: The cost per visit was obtained from HA $(\$ 302)^{13}$ and Department of Health (\$219) ${ }^{14}$. It was assumed to be the same for all categories of diseases and for both genders.
(f) Private General Practitioners (GP): The mean consultation fee for a visit to a private doctor was obtained from a Household Survey carried out in $1998{ }^{15}$ adjusted for deflation in 2000 and assumed to be the same for all reasons for consultation.
(II) Frequency of episodes/visits per year (Refer to column B of Table 4.7)
(a) HA hospital admissions: The annual numbers of episodes in the year 2000, for respiratory and cardiovascular diseases, in females and males, and in each of acute general, chronic infirmary hospitals and coronary care unit (CCU), were derived from HA inpatient databases.
(b) Private hospital admissions: The total number of hospital admissions for respiratory and cardiovascular diagnoses in the past 12 months in HA and private hospitals were estimated from the Annual Digest of Statistics (2000) ${ }^{16}$ (respiratory 151,330; cardiovascular 110,877)

Total numbers from HA hospitals were derived from HA inpatient databases (respiratory 120,018; cardiovascular 93,629); and the numbers from private hospitals were obtained by taking the difference between the two sets of two numbers.
(c) $A \& E$ visits: The total number of visits in the year 2000 was obtained from $\mathrm{HA}^{13}$. The proportions due to respiratory and cardiovascular diseases were assumed to be the same as for HA inpatient admissions (acute general and chronic infirmary hospitals).
(d) SOPC visits: The total numbers of visits in Departments of Medicine and Surgery of all SOPCs under the HA, were obtained from HA ${ }^{13}$. The proportions due to respiratory and cardiovascular diseases were assumed to be the same as for HA inpatient admissions (acute general and chronic infirmary hospitals).
(e) GOPC visits: The total numbers of visits to GOPCs under Department of Health were obtained ${ }^{13}$. The proportions due to respiratory and cardiovascular diseases were taken to be the same as for HA inpatient admissions (acute general and chronic infirmary hospitals).
(f) Private GP visits: In Wong (2001) ${ }^{17}$, the average numbers of visits per GP for respiratory and cardiovascular complaints were estimated to be 6203 and 395 respectively, for 11 GPs in the study (data for 7 GPs for the whole year 2000 and for 4 GPs for first nine months of the year, adjusted to yearly data, were used). In Wong (2001) ${ }^{17}$, it was estimated that there was a total of 4202 GPs (range 3173-5231) in practice in Hong Kong. The total numbers of GP visits for the two categories of complaint were then estimated by multiplication between total number of GPs and average number of visits per GP.
(III) Direct medical cost due to traffic-related air pollutants
(Refer to columns C and D of Table 4.7)
(a)-(d) Excess risks for respiratory and cardiovascular diseases per $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ change in each pollutant $\left(\mathrm{NO}_{2}, \mathrm{SO}_{2}, \mathrm{RSP}\right.$ and $\left.\mathrm{O}_{3}\right)$ were derived from daily time-series analysis of HA hospital admission data 1995-2000. The proportions of traffic-related pollutants in the ambient air were estimated to be $61.9 \%$ for $\mathrm{NO}_{2}, 9.0 \%$ for $\mathrm{SO}_{2}$ and $38.8 \%$ for RSP according to statistics from emission inventories for each pollutant ${ }^{18}$. As $\mathrm{O}_{3}$ is not directly emitted from vehicles, the proportion could not be estimated. Multiplying each of these proportions to the excess risks due to pollutants in the ambient air gives estimates of excess risks due to traffic-related air pollutants. Multiplying each of them to the cost per episode/visit and number of episodes/visits per year gave costs due to trafficrelated air pollution per $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ change, for each air pollutant, for the utilization of each health service.
(e)-(f): Excess risks for private GP consultations for respiratory problems were obtained from Wong (2001) ${ }^{17}$. They were $2.98 \%$ for $\mathrm{NO}_{2}, 1.55 \%$ for $\mathrm{SO}_{2}, 1.42 \%$ for RSP and $2.4 \%$ for $\mathrm{O}_{3}$. As described above, we multiplied each of them to the traffic-related proportions to obtain excess risks due to $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ change in traffic-related air pollutants, assuming the same in both respiratory and cardiovascular diseases. The health cost for the traffic-related air pollutants was estimated in a similar way as for III (a)-(d) above.
(IV) Indirect cost of morbidity and mortality

Productivity loss: (Refer to Table 4.8)
(a) Productivity loss due to admissions: Because admission to hospital and premature death have effects on productivity, these can be considered a cost of the illness associated with air pollution. The loss in productivity applies only to people aged from 15 to 64 years old. This productivity loss is calculated from the multiplication of mean lengths of stay, and number of episodes for patients aged from 15 to 64 and the median monthly income in Hong Kong. ${ }^{19}$ The number of episodes was multiplied by the labour force rate and the employment rate in the year 2000 from Census and Statistics Department ${ }^{16}$. The cost due to admission to hospital is separated into two parts: public hospitals and private hospitals. The mean lengths of stay and numbers of episodes for public hospitals were obtained from the HA inpatient database while the data for private hospitals were estimated by the same methods as stated in II (a-b).
(b) Productivity loss due to private GP consultations: Doctor consultations for respiratory and cardiovascular disease in the primary care sector might have been accompanied by time off work and therefore productivity loss would have been incurred. Data on sick leave was taken from a study based on twelve local general practitioners performed in $2001^{20}$. Productivity loss resulting from sick leave granted for each disease
attributable to a $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ increase in concentrations of each pollutant was calculated as follows:

The corresponding excess risk x mean number of sick leave days per consultation x total annual consultations for the disease in 2000 x labour force rate x employment rate x median income per day.

The relative risk for each pollutant (all air pollution and traffic-related air pollution) and the total annual number of consultations in Hong Kong were the same as those used previously in the calculations of direct private doctor consultation costs ${ }^{19}$. The mean number of days of sick leave granted by the sample of twelve GPs was 0.17 per consultation for all diseases (range is 0.06 to 0.24 ) and was applied to both consultations for respiratory and cardiovascular diseases in the calculation. According to the Census and Statistics Department, the labour force and unemployment rates were $61.4 \%$ and $4.9 \%$ in 2000 respectively ${ }^{16}$. The median income per day of $\$ 328.77$ ( $10,000 \times 12 / 365$ ) was derived by translating the median monthly income to a daily rate ${ }^{19}$.

The waiting time for each consultation with a private GP was taken as the average waiting time found in the 1998 Household Survey ${ }^{15}$. Similarly, the travel time per consultation was taken as the average travel time found in that survey. These times were then valued in the same way as the sick leave days.
(c) The productivity loss due to premature deaths: The productivity loss value was obtained by multiplying person-years of life lost for those died at 15-64 years of age with median annual incomes for males and females respectively. Person-years of life lost were obtained by subtracting age at death from 65 for each death.

In summary, calculations on productivity loss were based on those incurred from hospital admissions, private doctor consultations, and premature death. It was assumed that people attending the GOPC, SOPC and A\&E were mainly elderly people and thus productivity loss was not calculated for these calculations.

These costs for productivity loss, time and travel can be added to the direct costs of illness to produce a further estimate of cost of illness which takes the reduction in productivity into account.

Mild symptoms: A questionnaire was designed ${ }^{21}$ to enquire whether respondents have experienced cough, sinus congestion, congested throat, itching and smarting eyes, shortness of breath and fever in the past 12 months and how much they are willing to pay to avoid one day of such symptoms. The method of enquiry is known as contingent valuation ${ }^{22}$. Telephone interviews were carried out on a population sample. Data on possible confounding factors and perceptions of air pollution was collected. The survey methods and findings on perceptions of air pollution are in Annex $1^{23}$. When asking a value of their willingness to pay (WTP) to avoid each symptom, closed-end questions (i.e. fixed amounts) were used. If a respondent had accepted an amount, a higher value was next asked. But if he/she refused, a lower value was asked. Both single bid and double
bid (i.e. one level and two levels higher or lower) were asked. Log-linear statistical methods were used in the estimation. Eventually, the symptom of cough was taken as the representative symptom since it is a common symptom of upper respiratory tract infection (URTI) and the WTP to avoid a day of cough was intermediate between WTP values for other symptoms. The WTP value for avoidance of a day's cough (i.e. \$183.67) multiplied by 4 (which is slightly less than an a priori estimate of 5 days for duration of an URTI episode) was used to give an estimate of value for avoiding an episode of cough. The frequency of URTI episodes per year in the whole of Hong Kong was estimated to be the number of new GP visits for URTI inflated by $20 \%$ to take into account those who did not visit a GP even with URTI symptoms. Excess risks for URTI per $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ of a pollutant were taken from Wong (2001) ${ }^{17}$.

The calculation of the value of avoiding mild respiratory symptoms was

| Value to avoid 1 day's cough | 4 days | x | Estimated no. of URTI visits in Hong Kong |  | $120 \%$ for inflation |  | Excess risk of URTI visit $/ 10 \mu \mathrm{~g} / \mathrm{m}^{3}$ of pollutants |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |

Serious morbidity: A sample of subjects was recruited from the previously mentioned telephone survey for participation in a choice set experiment ${ }^{21}$. The choice set contained two scenarios for the subjects to choose between. Each scenario has four items: 1/ probability to contract a disease; $2 /$ convenience between commuting; $3 /$ time spent on commuting; and 4/ additional expenses to be spent for transport/fuel. The first scenario represented the current situation of the respondent which did not require additional expenses for transport/fuel; and the other option represented a reduction in the probability of contracting a disease together with some additional expenses for transport/fuel which would be associated with a reduction in air pollution. Focus group meetings were carried out to obtain the information for designing the choice sets. The willingness to pay to avoid a day of serious morbidity was calculated from the responses to the choice sets. There was a total of 9 or 10 choice sets in each questionnaire sent to two groups of respondents with differing probabilities to contract cardiovascular and respiratory diseases. These probabilities were taken from the risk of admission to hospital due to air pollution. Within two to three weeks of receiving the mailed questionnaires, the respondents were called for telephone interview to answer the choice set questions.

As detailed in Working Paper AP02-02-003 ${ }^{24}$ (Annex 3), the value obtained for the avoidance of an admission to hospital and other associated impacts of having serious disease was $\$ 4,100$ for cardiovascular disease and $\$ 4,900$ for respiratory disease. These values were then multiplied by the relevant risks of admission to obtain the monetary value of avoiding these serious cases of disease.

Another sample of road-side workers, including those who work in petroleum-filling stations and news kiosks, were recruited and interviewed face-to-face to obtain their perceptions of roadside pollution. This survey is described in more detail in Appendix 1.

Mortality: The value of each avoided death is taken as that used in the WHO report on the impact assessment project of Austria, France and Switzerland. This estimate is 1.4 million Euros ${ }^{1}$ (HK $\$ 10,000,000$ at $\mathrm{HK} \$ 7.00$ per Euro) at 1999 prices and has not yet been
updated to 2000 values. This figure was chosen as being a reasonable value for this valuation, according to most international evidence to date, being a middle estimate, not the lowest and not the highest. The excess risks for mortality are taken from Table 4.5. Using these and the numbers of respiratory and cardiovascular deaths in 2000, we calculate the potential number of deaths avoidable per $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ reduction in the individual pollutants. This calculation is carried out for all air pollution and traffic-related pollution fractions.

The value of a whole life has been used rather than costing number of life years lost. This is the current approach in other countries and has some justification in that a premature death has value even if the person is relatively old. An age-related valuation or one based on life years lost may be preferable but the data to allow this is not yet available. The final calculation for the value of deaths avoided by reducing air pollution is

$$
\mathrm{f}_{\text {resp }} \times \mathrm{ER}_{\text {resp }} \times \mathrm{HK} \$ 10,000,000+\mathrm{f}_{\text {cardio }} \times \mathrm{ER}_{\text {cardio }} \times \operatorname{HK} \$ 10,000,000
$$

where, $f_{\text {resp }}$ and $f_{\text {cardio }}$ are the number of deaths due to respiratory and cardiovascular diseases, respectively in the year $2000 ; \mathrm{ER}_{\text {resp }}$ and $\mathrm{ER}_{\text {cardio }}$ are the excess risks of death per $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ of a specific pollutant, respectively for respiratory and cardiovascular, due to all air pollution or traffic-related air pollution.

To validate this estimate in Hong Kong, we carried out a contingent valuation study using bid levels based on the value of HK $\$ 10$ million. The bid was designed so that, if the respondent answered 'yes' to the bid, he or she would be valuing a statistical life at HK $\$ 10$ million. A random population sample was used for the telephone interview asking for responses to the bid levels. This survey is described in Appendix 2.

Economic evaluation of health effects of air pollution: The cost of illness and the complete estimation for monetary value of morbidity and mortality, including WTP estimation and cost of public hospital care, were estimated for each of the criteria pollutants under study. The maximum value among the pollutants was used as an 'at least' estimate as in the WHO study. ${ }^{1}$

Sensitivity analysis: The validity and reliability of the estimates of the health effects of each air pollutant were assessed by varying the effect estimates for the overall population and roadside population with pollutant concentrations from general level monitoring stations. The sensitivity analyses for cost of illness were carried out by using different values in some selected variables relating to ratios of respiratory and cardiovascular diseases, GP consultations and fraction of air pollution related to traffic.

## 4. Findings

### 4.1 Health impact of air pollution

Mortality: The residual plots show that there were no discernible patterns in the core model (Appendix 3). Autocorrelations between successive mortality counts after fitting the core model were small with coefficients all within $\pm 0.1$ (Appendix 3 ). In all the three outcomes under study, the excess risk estimates were comparable to those obtained from a previous study ${ }^{9}$ for 1995-97 (Table 4.1).

Table 4.2 shows that $\mathrm{NO}_{2}$ and $\mathrm{SO}_{2}$ were associated with all of the causes of mortality under study. The excess risks per $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ increase in concentration were, in general, higher for $\mathrm{SO}_{2}$ than $\mathrm{NO}_{2}$. Those for RSP were smaller, and were significant for chronic obstructive pulmonary disease (COPD) and for all non-accidental causes, but only marginally significant for cardiovascular and respiratory diseases. $\mathrm{O}_{3}$ shows a significant association only with respiratory disease.

Hospital admissions: The residual plots show that there were no discernible patterns for all the outcomes under study for (Appendix 3). Some autocorrelations with coefficients ranging from 0.1-0.3 were found between successive hospital admission counts after fitting the core model but were eventually adjusted for (Appendix 3). A small degree of auto-regression for respiratory diseases is allowed in order to avoid over fitting of the model and the subsequent divergence of estimates. The predicted numbers from the core models and the observed numbers for years 1995-2000 were close to each other (Appendix 4). The discrepancies between the observed number in January - March 2001 and those predicted from 1995-2000 model are shown in Appendix 5.

Table 4.3 shows that the effects on hospital admissions estimated from this study were comparable with those from a previous study ${ }^{10}$, in that both studies did not show any effects for asthma (age 15-64), and also showed significant effects, with $95 \%$ confidence intervals overlapping in the two studies, for respiratory (65+), cardiac (all ages) and ischaemic heart diseases (IHD) (all ages).

Table 4.4 shows that, except for asthma, $\mathrm{NO}_{2}, \mathrm{SO}_{2}, \mathrm{RSP}$ and $\mathrm{O}_{3}$ were associated with all the outcomes under study. The excess risks for admissions were in general the highest for association with $\mathrm{SO}_{2}$ in all the outcomes under study, except for IHD where $\mathrm{NO}_{2}$ showed the highest effect.

FSP and CO preliminary study: The estimated effects of FSP and CO based on data only from one station in Tsuen Wan and for a shorter period of three years, were not reliable (Appendix 6). Further analysis should be performed on more complete data when available.

Excess risks due to ambient air pollution for general levels and in relation to road traffic: Table 4.5(a) shows the excess risks, for respiratory and cardiovascular mortality as well as hospital admissions, per $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ change in each of the pollutants under study. Except for $\mathrm{O}_{3}$, all the excess risks were significant and were comparatively higher in the 65 and older age group than all ages group.

The fractions of the pollutant concentrations due to road traffic were $\mathrm{NO}_{2} 61.9 \%, \mathrm{SO}_{2}$ $9.0 \%$ and RSP $38.8 \%$. The excess risks due to traffic-related air pollution were the greatest for $\mathrm{NO}_{2}$, smaller for RSP and the smallest for $\mathrm{SO}_{2}$, for all health outcomes under study (Table 4.5 (b)).

Number of deaths and hospital admissions due to air pollution: Based on the excess risk estimates, the number of deaths and hospital admissions due to total pollutants and due to traffic related pollutants are derived and the results are shown in Table 4.6. The minimum number of cardiorespiratory deaths attributable to a $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ change in pollutant concentration, would be 243 deaths ( $95 \%$ confidence interval/upper limit 369) a year and that for the fraction due to traffic-related air pollution would be 83 (133) deaths a year. The corresponding minimum numbers of cardiorespiratory admissions would be 1917 (2755) and 821 (1159) respectively.

For the effects due to mean pollutant concentrations in the year $2000\left(\mathrm{NO}_{2} 58.3, \mathrm{SO}_{2} 17.8\right.$, RSP 50.4 and $\mathrm{O}_{3} 34.3 \mu \mathrm{~g} / \mathrm{m}^{3}$ ), the corresponding minimum numbers of deaths from cardiorespiratory disease were $783(1,244)$ and $485(770)$; and those for hospital admissions were 7737 (10911) and 4789 (6753) respectively.

### 4.2 Cost of health service utilization due to traffic-related air pollution

## Cost of illness due to traffic-related air pollution:

(a) Direct costs: The annual costs of illness and frequencies in utilizing each category of health services are shown in Table 4.7 columns A and B respectively. The corresponding annual cost, due to all pollution and traffic-related air pollution, for a $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ change in each air pollutant, are shown, respectively, in columns C and D of Table 4.7. The total cost associated with $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ change in the pollutant $\left(\mathrm{NO}_{2}\right)$ related to traffic amounted to $\$ 141$ million, with contribution from private GP visits of $\$ 118$ million, hospital admissions $\$ 14$ million, general outpatient clinic visits $\$ 6.3$ million, and specialty outpatient clinic visits and accident and emergency visits each about $\$ 1$ million.
(b) Productivity loss: The costs of lost productivity due to all pollution and traffic-related air pollution are shown in Table 4.8. The costs of lost productivity due to trafficrelated pollutants were $\$ 38.7$ million for $\mathrm{NO}_{2}, \$ 5.8$ million for $\mathrm{SO}_{2}$ and $\$ 11.0$ million for RSP. These productivity losses can be added to the direct costs to produce two estimates of cost of illness, excluding and including productivity losses. For example, for $\mathrm{NO}_{2}$ these costs are 227.3 million (excluding productivity loss) and 289.7 million (including productivity loss).

Willingness to pay to avoid death, and serious and minor morbidity:Table 4.9 shows the willingness to pay (WTP) to avoid death or episode of serious or minor illness and number of deaths or morbidity episodes in a year, in columns A and B respectively. A value of statistical life (VSL) of HK $\$ 10$ million was adopted. The survey to validate the estimate of VSL used, obtained 108 responses with $59 \%$ response rate and showed that $81 \%$ of respondents would estimate a VSL of, at least, $\mathrm{HK} \$ 10$ million (Appendix 2). Hence this is considered a conservative value for the local population. Column D shows
the monetary values in a year in association with traffic-related pollution for a $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ change in pollutant concentration.

Economic valuation of health effects of air pollution: The monetary value for the health effect of air pollution for a change of $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ pollutant concentration would amount to at least (a) for total air pollution, $\$ 2.8$ billion; and (b) for the part related to road traffic, $\$ 1.2$ billion (Table 4.10). When the annual mean pollutant concentrations were used as an overall estimate for Hong Kong in the year 2000, the corresponding estimates for economic valuation were at least (a) for total air pollution, $\$ 11.1$ billion; (b) for the part related to road traffic, $\$ 6.9$ billion, and for the direct cost of illness the estimates were at least $\$ 1.3$ billion and $\$ 0.8$ billion respectively.

The corresponding estimates per one million population are shown in the last column of Table 4.10, which allows extrapolation of the monetary valuation to other years with different populations and different mean pollutant concentrations.

### 4.3 Perceptions of air pollution: general population and roadside workers

Working paper AP 02-02-001 in Annex $1^{23}$ gives the full report on the general population survey of perceptions of air pollution and Appendix 1 gives the findings for the roadside workers. The roadside workers are a different socio-economic and demographic group from the population sample. They will also be a survivor group, the most severely affected by the pollution probably having moved into other occupations. In both groups, more than half think they suffer from health problems due to air pollution (58\% of roadside workers, $69 \%$ of general population). These problems are principally breathing and throat problems. The roadside workers estimate they spend an average of 40 hours a week near busy roads, while the general population spends 12 hours a week. Regarding the air quality in their own district, $88 \%$ and $57 \%$ of the roadside workers and the general population respectively consider the air quality as only fair or poor. It was found that those whose home was nearer ground level in Kowloon, were more likely to rate the air quality as poor. (Annex 1)

## 5. Sensitivity analysis

### 5.1 Health impact of air pollution

Mortality: Table 5.1 compares effects of air pollution on respiratory and cardiovascular mortality for the whole of Hong Kong with those for the sub-population residing in roadside areas most exposed to traffic-related air pollution (TRAP). The estimates for the two populations were consistent with each other when pollutant concentrations were derived from all monitoring stations.

Hospital admissions: Table 5.2 compares the effects of air pollution, on respiratory and cardiovascular admissions, for the whole of Hong Kong with those for the sub-population residing in roadside areas most exposed to TRAP. The estimates were consistent with each other, for the two populations.

### 5.2 Direct cost of illness due to traffic-related air pollution

Table 5.3 shows the sensitivity of using different values in some selected variables on the direct cost of illness due to traffic-related air pollution. For the effects of $\mathrm{NO}_{2}$ (the one with the strongest effect among all pollutants), the greatest variations were from variables relating to GP consultation, in that the deviation in the cost may be up to $30 \%$ of the original estimate. For the other variables the deviations were limited to about $10 \%$.

Part (E) in table 5.3 is an assessment of an estimate of number of consultations with private GPs in Hong Kong in one year. We calculated this variable using a totally different data set (McGhee et al 1998) ${ }^{15}$ and came up with a figure which is very close to that originally estimated using Wong (2001) ${ }^{17}$. We are therefore satisfied that total numbers of consultations in Hong Kong using data from Wong (2001) ${ }^{17}$ is probably valid. Furthermore, in part (F) we used proportional differences between roadside and general levels of air pollutants as fractions of traffic-related air pollutant to obtain the cost estimates, and compared with those based on emission proportions. The results are also close to each other, suggesting that the use of emission proportion is also probably valid.

## 6. Discussion

### 6.1 Strengths of this study

Considering $\mathrm{NO}_{2}, \mathrm{SO}_{2}, \mathrm{RSP}$ and $\mathrm{O}_{3}$ together: Most studies of economic evaluation of the health effects of air pollution used, in an a priori approach, only a single indicator of air pollution, namely, RSP. In this study, we assessed four pollutants and used a conservative "at least" approach, in that the one pollutant which produced the largest value was selected for an "at least" estimate. For total air pollution level the pollutant which produced the biggest economic value per $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ change of the concentration was $\mathrm{SO}_{2}$, and for traffic related pollution $\mathrm{NO}_{2}$. A similar approach has been used by the WHO European study, ${ }^{1}$ for which the single pollutant, RSP, was chosen a priori.

Using local estimates for effects of air pollution: All the health effect estimates were derived from local studies performed by the principal investigators of this report. Most of the health outcomes, including mortality, ${ }^{9}$ hospital admissions ${ }^{10}$ and GP visits, ${ }^{25}$ have been published in peer reviewed international journals.

Using local valuations of value of avoiding health effects: All of the estimates used to put a monetary value on avoiding health effects were derived or, in the case of mortality, validated, locally. Most studies overseas transfer values from elsewhere with little validation being possible. These local studies were rigorous and had adequate power to produce fairly precise estimates.

Using multiple approaches in data collection: In this study, several methods of data collection were used. We used telephone interviews to acquire willingness to pay (WTP) values; a conjoint analysis using choice set experiments in obtaining the WTP values for serious morbidity from a sub-sample of the consenting respondents to the telephone survey and focus group meetings to obtain information for the design of the choice set options of the experiment.

The largest local study of health effects of air pollution: The examination of health effects of air pollution carried out in this study is the largest study of its kind in the Asia Pacific region. It used six years of data while the other studies used about three years data. Thus the estimates obtained from this study are likely to be highly reliable.

### 6.2 Limitations of this study

Effects due to short term exposure: The health effects estimated in this study can only be regarded as those due to short term exposure of daily air pollution. The study does not estimate long term exposure effects. But short term exposure may produce long term effects. In order to estimate long term exposure effects, much more organisationally difficult and expensive longer term prospective studies are required. Another potential drawback of short term daily time-series studies for mortality arises from the possibility of mortality displacement or "harvesting". That is the phenomenon due to elimination of susceptible subjects after the exposure, so that persistent effects cannot be observed even though high levels of air pollution continue. However recent studies have shown, that after correction for the effects due to harvesting, continuing effects could be observed and that the advancement of deaths could extend over a period of many months or may be longer. ${ }^{26,27}$

Unavailability of private hospital data: There are about 7\% of hospital inpatients utilizing private hospitals. Private hospital clients belong to higher socioeconomic groups of the community. Our use of estimates of health effects and health care costs based on public hospitals may be subject to some bias because of this selection factor. But the biases, if there are any, should be small.

Crude estimates of GP visits in Hong Kong: The total number of GPs in Hong Kong, estimated to be around 4000, was based on a recent local study ${ }^{17}$. The effects on GP visits were obtained from a small study of 11 GPs only. Thus the number of GP visits in Hong Kong, derived from these two estimates, could be subject to biases. However, the validation of the number of visits to private GP as shown in Table 5.3, shows that the estimate of visits is probably valid.

Lack of more precise cost data for health service utilization: Due to a lack of this type of data, the cost estimates of health service utilization are not very detailed. For example, unit costs for different age groups, between public and private hospitals and for different disease categories, were assigned the same values.

Using proxy estimates of morbidity: Again due to a lack of data, episodes and risk estimates of minor and serious morbidity were based on proxy estimates of health service utilization effects. For example, numbers and effects of GP visits and hospital admissions were used for morbidity prevalence and effect estimates, in the economic evaluation of this study.

Small data sets for FSP and CO: The pollutant concentration data for FSP and CO were only derived from one monitoring station in three years. Results for these two pollutants should be interpreted cautiously and should be validated when more data are available. Thus, the health effects of these two pollutants were not considered in the economic
evaluation of this study. However, FSP is highly correlated with RSP and, a major part of its effect should have been taken account of by RSP.

Effect on asthma admissions: From the literature, the role of air pollution in the causation of asthma is unclear. For example, it was frequently found that asthma was insensitive to episodes of air pollution, e.g. the lack of effect on asthmatics in the famous London smog (Fry 1953) ${ }^{28}$, European smog (Wichmann 1989) ${ }^{29}$ and high levels of $\mathrm{NO}_{2}$ in London in 1991. ${ }^{30}$ Some epidemics of asthma in Barcelona, Spain, were apparently related to $\mathrm{NO}_{2}$ but the real cause was due to soy-bean allergens which were trapped by weather conditions in the atmosphere when ships were unloading their cargoes in the harbour (Ussetti 1983). ${ }^{31}$

In Hong Kong, $\mathrm{SO}_{2}$ was related to a potential patho-physiological precursor of asthma in children, bronchial hyperresponsiveness ${ }^{32}$. But bronchial hyperresponsiveness in children was associated with $\mathrm{NO}_{2}$ only when they also had atopy and/or a high concentration of $\operatorname{IgE} .{ }^{33}$ In a recent prospective cohort study, it was shown for the first time that ozone may be a cause of increased incidence of asthma in children, but only when they also increased their ventilatory rate by participating in high activity sports. ${ }^{34}$ Thus the relationships between air pollution and asthma are not clear and may be related to complex interactions with other social and environmental factors in different regions. In addition, there may be important differences in the pollutant mixtures between these different geographical settings. In this Hong Kong daily time-series study, no relationships between air pollution and asthmatic admissions were found and no associated costs were therefore included. Further studies are warranted.

Effects on road-side workers: In the survey of roadside workers, this sample is not directly comparable with the population sample because of differing socio-demographic characteristics. However, the results are shown side by side in section 5 of Appendix 1 for information. Roadside workers spend about twice as much time outdoors and over three times as much time near busy roads than the general population. It appears that roadside workers consider their health to be poorer, with more respiratory and heart problems. Fewer apparently consider that they have health problems related to air pollution and, for those who do, fewer reported breathing problems. Signs of good air quality are similar in both groups.

### 6.3 Comparison with similar studies

Health impact on mortality: For mortality outcomes, we found relatively stronger associations and a greater magnitude of effect for $\mathrm{SO}_{2}$ (its correlations with others were the lowest when compared with other pollutants) and $\mathrm{NO}_{2}$ than for RSP. In the studies of 20 US cities for relationships between air pollution and mortality, the focus was on RSP (Samet 2000). ${ }^{35}$ However, the analysis for the wider grouping of 90 cities showed that effects of $\mathrm{SO}_{2}$ and $\mathrm{NO}_{2}$ were strong. ${ }^{36}$ For studies in Europe (combining 5 western and 4 central European countries) ${ }^{37}$ and Asia Pacific regions, ${ }^{38-42}$ strong effects for gaseous pollutants were also found. Thus independent effects of gaseous pollutants should be further investigated with control for effects of particulates and other pollutants.

Health impact on hospital admissions: For hospital admissions we found significant effects on all categories of diseases under study except asthma, for all the four criteria pollutants. The results are in line with many other studies. ${ }^{43}$ As in the case of mortality, $\mathrm{SO}_{2}$ and $\mathrm{NO}_{2}$ exhibited the strongest effects per unit of pollutant concentration in both cardiovascular and respiratory admissions.

Direct cost for health service utilization: The approach used in this study included only those costs which were spent directly on utilization of health services and an estimate of costs of productivity loss due to admissions and for premature deaths. These approaches have been used in other studies. Intangible costs were not included, and this approach is known to provide an under-estimate of the total cost of illness. However, an estimate including loss in productivity, for duration of stay in hospital due to respiratory and cardiovascular diseases for the 15-64 age groups, showed that the cost was relatively small.

Economic valuation of morbidity: In this study willingness to pay (WTP) costs for avoidance of minor morbidity were assessed by contingent valuation; and for avoidance of serious morbidity by conjoint analysis using choice sets. In Hong Kong most people utilize public hospital services for treatment of serious morbidity. They usually could not locate a reference dollar value in hypothetical contingent valuation while a choice-set survey provides the respondents a discrete choice format, mimicking the decision-making process in the real life situation and was considered more suitable for valuation of serious morbidity in Hong Kong. In most other similar studies, costs of morbidity were assessed by the direct costs of health service utilization and productivity loss plus another part for avoidance of specific pain and suffering derived by a survey method. ${ }^{1,5,44,45}$

Economic valuation of mortality: In this study, the value of avoiding of mortality was first estimated by adopting a value ( 1.4 million Euro or $\mathrm{HK} \$ 10$ million) for preventing a statistical fatality which was based on a sophisticated study design ${ }^{46}$ and validating this value locally. This value is the one used in the WHO European study as a middle and feasible estimate according to international evidence to date. We further validated this estimate in Hong Kong using the contingent-valuation survey method already adopted in this study. Our validation exercise showed that this estimate is a conservative value for Hong Kong.

Comparison of our results with other local studies: There are two principal, previous studies to compare with this one - the Friends of the Earth report ${ }^{44}$ (FOE) and that by EHS Consultants Ltd. ${ }^{5}$ The value used by EHS for the VSL was HK $\$ 5$ million, based on a very small sample and the median of an open-ended question, which is not an accepted method for deriving such a value. We used a value of $\mathrm{HK} \$ 10$ million and have justified and validated this estimate for use in Hong Kong. The EHS report estimated that the cost of illness due to air pollution was $\mathrm{HK} \$ 170$ million for each $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ change in $\mathrm{NO}_{2}$. We find a cost of illness of $\mathrm{HK} \$ 227$ million for a $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ change in $\mathrm{NO}_{2}$. It is well known that cost of illness studies often under-estimate the true value of health impact since they only include direct costs of health care and lost productivity due to serious illness. The FOE study says that they used data reported in a 1995 report in the $U^{47}$ and states that the value of ill health associated with air pollution in the Hong Kong population could be HK $\$ 208$ million per unit of RSP. They also discuss the quantification of other costs to
business, tourism and personal and vegetation costs. We have not tried to quantify these latter costs. Our estimate for the health costs is based on local data and is a little higher than their estimate but of a similar magnitude.

For the sake of comparison, using the most complete valuation per $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ change in a pollutant per one million population, the monetary cost estimate was 397.8 million by FOE, 157.7 million by EHS and 423.7 million by this study. Thus our estimate lies much closer to the FOE value and can be regarded as valid and reliable.

Variations in number of deaths/admissions due to air pollution: Using the "at least" approach, the estimate only represents the effect of a single pollutant which was found to produce the greatest effect among the four pollutants under study. When the effects of the four pollutants are assumed to be independent of each other, we can obtain a figure for health effect using the total sum of the effects of the four pollutants as an indicator. Another source of variation arises from using different periods of the database and different assumptions based on the mean or the upper bound of the confidence interval in estimating the excess risk. The following box summarizes these possible variations

Box 3: Variations in number of deaths and hospital admissions due to air pollution


### 6.4 Summary

Pollution and health: This further analysis consolidates the Hong Kong evidence on the adverse health effects of all of the four criteria pollutants. It demonstrates that radical interventions are needed to reduce the ambient levels of pollutants, resulting from the combustion of fossil fuels, to a point well below the present Air Quality Objectives.

Economic: Polluted air is costly. It causes premature death, serious illness, an epidemic of more minor health problems and impairment of quality of life. Everyone is exposed. Individuals have few or no means of protecting themselves against this hazard. For these reasons, the current air pollution levels in Hong Kong are a serious economic problem as reflected in the mean value of $\$ 11.1$ billion which is the Hong Kong population's willingness to pay to eliminate the health impacts.

Even in terms only of the direct medical costs, the amount spent on dealing with the excess health problems due to the annual average air pollution level amounts to $\$ 1.3$ billion spending on health care in the year 2000. Eliminating this pollution would save much or all of this cost and the re-allocation of these scarce health care resources would allow them to be put to better use in improving and maintaining the population's health.

Tables
Table 3.1: Air pollutant concentration data available from the EPD

|  |  | Rooftop stations |  |  |  |  |  |  |  | Roadside stations |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | CW | KC | KT | SSP | ST | TP | TW | YL | CL | CB | MK |
| $\mathrm{NO}_{2}$ | 1995 | *\# | *\# | * | * | * | * | * | * | - | - | * |
|  | 1996 | *\# | *\# | * | * | * | * | * | * | - | - | * |
|  | 1997 | *\# | * | * | * | * | * | * | * | - | - | * |
|  | 1998 | * | * | * | * | * | * | * | * | - | * | * |
|  | 1999 | * | * | * | * | * | (*)\# | * | (*)\# | * | * | * |
|  | 2000 | * | * | * | * | * | \# | * | \# | * | * | [*] |
| $\mathrm{SO}_{2}$ | 1995 | *\# | *\# | * | * | * | - | * | * | - | - | * |
|  | 1996 | *\# | *\# | * | * | * | - | * | * | - | - | * |
|  | 1997 | *\# | * | * | * | * | * | * | * | - | - | * |
|  | 1998 | * | * | * | * | * | * | * | * | - | * | * |
|  | 1999 | * | * | * | * | * | (*)\# | * | (*)\# | * | * | * |
|  | 2000 | * | * | * | * | * | \# | * | \# | * | * | [*] |
| $\mathrm{O}_{3}$ | 1995 | *\# | *\# | - | - | - | - | - | * | - | - | - |
|  | 1996 | *\# | *\# | - | - | - | - | - | * | - | - | - |
|  | 1997 | *\# | * | * | - | * | * | * | * | - | - | - |
|  | 1998 | * | * | * | * | * | * | * | * | - | - | - |
|  | 1999 | * | * | * | * | * | (*)\# | * | (*)\# | - | - | - |
|  | 2000 | * | * | * | * | * | \# | * | \# | - | - | - |
| RSP | 1995 | * | * | * | - | * | - | * | * | - | - | - |
|  | 1996 | * | * | * | - | * | - | * | * | - | - | * |
|  | 1997 | * | * | * | * | , | * | * | * | - | - | * |
|  | 1998 | * | * | * | * | * | * | * | * | - | * | * |
|  | 1999 | * | * | * | * | * | * |  | * | * | * | * |
|  | 2000 | * | * | * | * | * | * | * | * | * | * | [*] |
| FSP | 1995 | - | - | - | - | - | - | - | - | - | - | - |
|  | 1996 | - | - | - | - | - | - | - | - | - | - | - |
|  | 1997 | - | - | - | - | - | - | * | - | - | - | - |
|  | 1998 | - | - | - | - | - | - | * | - | - | * | - |
|  | 1999 | - | - | - | - | - | - | * | - | * | - | - |
|  | 2000 | - | - | - | - | - | - | * | - | - | - | - |
| CO | 1995 | - | - | - | - | - | - | - | - | - | - | * |
|  | 1996 | - | * | - | - | - | - | - | - | - | - | * |
|  | 1997 | - | * | - | - | - | - | * | - | - | - | * |
|  | 1998 | - | - | - | - | - | - | * | - | - | * | * |
|  | 1999 | - | - | - | - | - | - |  | - | * | * | * |
|  | 2000 | - | - | - | - | - | - | * | - | * | * | [*] |

( ) Recorded only in January - February;

* : data recorded by usual Point Analyzer instrument;
\# : data recorded by Opsis instrument;
- : no data;
[ ] : data recorded January - September.

Table 3.2: Correlations between data measured by the usual Point Analyzer instrument and by the Opsis instrument

| $\mathrm{NO}_{2}$ | 1995 | CW | 0.93 |
| :--- | :--- | :--- | :--- |
|  |  | KC | 0.96 |
|  | 1996 | CW | 0.95 |
|  |  | KC | 0.91 |
|  | 1997 | CW | 0.89 |
| $\mathrm{SO}_{2}$ | 1995 | CW | 0.94 |
|  |  | KC | 0.92 |
|  | 1996 | CW | 0.85 |
|  |  | KC | 0.97 |
|  | 1997 | CW | 0.97 |
| $\mathrm{O}_{3}$ | 1995 | CW | 0.84 |
|  |  | KC | 0.88 |
|  | 1996 | CW | 0.95 |
|  |  | KC | 0.97 |
|  | 1997 | CW | 0.88 |

Table 3.3: Percentage of valid measures of air pollutants in each monitoring stations
Note: Valid data less than $75 \%$ were excluded, except those for roadside station.

|  |  | Rooftop stations |  |  |  |  |  |  |  | Roadside stations |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | CW | KC | KT | SSPO | ST | TP | TW | YL | CL | CB | MK |
| $\mathrm{NO}_{2}$ | 1995 | 93 | 92 | 96 | 89 | 97 | 97 | 95 | - | - | - | 86 |
|  | 1996 | 93 | 96 | 96 | 90 | 96 | 95 | 93 | 96 | - | - | 92 |
|  | 1997 | 91 | 90 | 87 | 98 | 93 | 89 | 85 | 84 | - | - | 79 |
|  | 1998 | 98 | 97 | 84 | 91 | 98 | 98 | 97 | 97 | - | 93 | 94 |
|  | 1999 | 98 | 98 | 93 | 96 | 98 | (81) | 98 | (83) | 98 | 97 | 93 |
|  | 2000 | 96 | 98 | 76 | 98 | 99 | (83) | 98 | (90) | 97 | 97 | [72] |
| $\mathrm{SO}_{2}$ | 1995 | 98 | 97 | 97 | 93 | 99 | - | 95 | - | - | - | 94 |
|  | 1996 | 98 | 95 | 98 | 89 | 99 | - | 98 | 96 | - | - | 97 |
|  | 1997 | 92 | 93 | 93 | 97 | 94 | - | 82 | 85 | - | - | 74 |
|  | 1998 | 95 | 98 | 84 | 91 | 98 | 99 | 96 | 97 | - | 96 | 95 |
|  | 1999 | 98 | 99 | 95 | 97 | 98 | (81) | 99 | (83) | 96 | 98 | 93 |
|  | 2000 | 95 | 99 | 76 | 98 | 99 | (83) | 99 | (90) | 95 | 98 | [71] |
| $\mathrm{O}_{3}$ | 1995 | 94 | 93 | - | - | - | - | - | - | - | - | - |
|  | 1996 | 92 | 95 | - | - | - | - | - | 91 | - | - | - |
|  | 1997 | 87 | 90 | - | - | - | - | - | 80 | - | - | - |
|  | 1998 | 94 | 95 | 81 | 88 | 94 | 95 | 93 | 91 | - | - | - |
|  | 1999 | 93 | 90 | 90 | 91 | 92 | (77) | 93 | (79) | - | - | - |
|  | 2000 | 92 | 97 | - | 94 | 96 | (81) | 93 | (86) | - | - | - |
| RSP | 1995 | 85 | 95 | 79 | - | 87 | - | 94 | - | - | - | - |
|  | 1996 | 99 | 98 | 92 | - | 87 | - | 86 | 89 | - | - | 42 |
|  | 1997 | 90 | 92 | 85 | - | 91 | - | 90 | 88 | - | - | 81 |
|  | 1998 | 99 | 96 | 81 | 91 | 97 | 99 | 95 | 96 | - | 96 | 96 |
|  | 1999 | 98 | 97 | 96 | 98 | 99 | 94 | 98 | 97 | 96 | 97 | 94 |
|  | 2000 | 99 | 100 | 96 | 100 | 99 | 85 | 100 | 96 | 95 | 95 | [73] |
| FSP | 1998 | - | - | - | - | - | - | 97 | - | - | 94 | - |
|  | 1999 | - | - | - | - | - | - | 99 | - | 94 | - | - |
|  | 2000 | - | - | - | - | - | - | 100 | - | - | - | - |
| CO | 1995 | - | - | - | - | - | - | - | - | - | - | 94 |
|  | 1996 | - | - | - | - | - | - | - | - | - | - | 97 |
|  | 1997 | - | - | - | - | - | - | - | - | - | - | 78 |
|  | 1998 | - | - | - | - | - | - | 96 | - | - | 95 | 94 |
|  | 1999 | - | - | - | - | - | - | 99 | - | 96 | 97 | 91 |
|  | 2000 | - | - | - | - | - | - | 99 | - | 96 | 98 | [71] |

( ) Measured by Point Analyzer method in January 1999 and by Opsis instrument afterwards.
[ ] Data documented in January - September.

Table 3.4: Correlations between stations for daily concentrations of pollutant

|  |  |  | KC | KT | SSP | ST | TP | TW | YL |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\mathrm{NO}_{2}$ | 1995 | CW | 0.70 | 0.89 | 0.83 | 0.78 | 0.82 | 0.87 | 0.76 |
|  |  | KC | - | 0.61 | 0.70 | 0.78 | 0.70 | 0.72 | 0.76 |
|  |  | KT |  | - | 0.83 | 0.72 | 0.84 | 0.85 | 0.74 |
|  |  | SSP |  |  | - | 0.71 | 0.80 | 0.85 | 0.70 |
|  |  | ST |  |  |  | - | 0.84 | 0.75 | 0.76 |
|  |  | TP |  |  |  |  | - | 0.81 | 0.77 |
|  |  | TW |  |  |  |  |  | - | 0.68 |
|  | 1996 | CW | 0.69 | 0.85 | 0.83 | 0.74 | 0.76 | 0.81 | 0.82 |
|  |  | KC | - | 0.75 | 0.75 | 0.86 | 0.81 | 0.77 | 0.70 |
|  |  | KT |  | - | 0.90 | 0.78 | 0.82 | 0.87 | 0.78 |
|  |  | SSP |  |  | - | 0.79 | 0.83 | 0.93 | 0.83 |
|  |  | ST |  |  |  | - | 0.89 | 0.76 | 0.73 |
|  |  | TP |  |  |  |  | - | 0.81 | 0.79 |
|  |  | TW |  |  |  |  |  | - | 0.76 |
|  | 1997 | CW | 0.67 | 0.83 | 0.88 | 0.76 | 0.68 | 0.82 | 0.87 |
|  |  | KC | - | 0.68 | 0.63 | 0.82 | 0.70 | 0.70 | 0.72 |
|  |  | KT |  | - | 0.90 | 0.78 | 0.74 | 0.88 | 0.76 |
|  |  | SSP |  |  | - | 0.74 | 0.74 | 0.92 | 0.83 |
|  |  | ST |  |  |  | - | 0.84 | 0.75 | 0.74 |
|  |  | TP |  |  |  |  | - | 0.69 | 0.69 |
|  |  | TW |  |  |  |  |  | - | 0.83 |
|  | 1998 | CW | 0.67 | 0.82 | 0.84 | 0.77 | 0.77 | 0.78 | 0.84 |
|  |  | KC | - | 0.53 | 0.63 | 0.77 | 0.64 | 0.67 | 0.68 |
|  |  | KT |  | - | 0.92 | 0.72 | 0.80 | 0.88 | 0.85 |
|  |  | SSP |  |  | - | 0.77 | 0.78 | 0.94 | 0.90 |
|  |  | ST |  |  |  | - | 0.87 | 0.77 | 0.82 |
|  |  | TP |  |  |  |  | - | 0.75 | 0.83 |
|  |  | TW |  |  |  |  |  | - | 0.89 |
|  | 1999 | CW | 0.80 | 0.85 | 0.87 | 0.84 | 0.80 | 0.81 | 0.85 |
|  |  | KC | - | 0.79 | 0.78 | 0.81 | 0.76 | 0.82 | 0.81 |
|  |  | KT |  | - | 0.92 | 0.78 | 0.76 | 0.89 | 0.84 |
|  |  | SSP |  |  | - | 0.78 | 0.75 | 0.93 | 0.87 |
|  |  | ST |  |  |  | - | 0.89 | 0.78 | 0.85 |
|  |  | TP |  |  |  |  | - | 0.75 | 0.84 |
|  |  | TW |  |  |  |  |  | - | 0.89 |
|  | 2000 | CW | 0.76 | 0.82 | 0.83 | 0.75 | 0.73 | 0.79 | 0.86 |
|  |  | KC | - | 0.74 | 0.76 | 0.80 | 0.78 | 0.76 | 0.76 |
|  |  | KT |  | - | 0.91 | 0.66 | 0.73 | 0.90 | 0.81 |
|  |  | SSP |  |  | - | 0.65 | 0.64 | 0.88 | 0.85 |
|  |  | ST |  |  |  | - | 0.82 | 0.68 | 0.77 |
|  |  | TP |  |  |  |  | - | 0.72 | 0.77 |
|  |  | TW |  |  |  |  |  | - | 0.85 |


|  |  |  | KC | KT | SSP | ST | TP | TW | YL |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\mathrm{SO}_{2}$ | 1995 | CW | 0.69 | 0.49 | 0.66 | 0.77 | - | 0.51 | 0.60 |
|  |  | KC | - | 0.37 | 0.61 | 0.76 | - | 0.73 | 0.63 |
|  |  | KT |  | - | 0.51 | 0.60 | - | 0.26 | 0.49 |
|  |  | SSP |  |  | - | 0.74 | - | 0.64 | 0.63 |
|  |  | ST |  |  |  | - | - | 0.58 | 0.62 |
|  |  | TP |  |  |  |  | - | - | - |
|  |  | TW |  |  |  |  |  | - | 0.63 |
|  | 1996 | CW | 0.49 | 0.62 | 0.73 | 0.65 | - | 0.42 | 0.56 |
|  |  | KC | - | 0.60 | 0.74 | 0.75 | - | 0.85 | 0.46 |
|  |  | KT |  | - | 0.74 | 0.69 | - | 0.45 | 0.56 |
|  |  | SSP |  |  | - | 0.84 | - | 0.69 | 0.61 |
|  |  | ST |  |  |  | - | - | 0.70 | 0.60 |
|  |  | TP |  |  |  |  | - | - | - |
|  |  | TW |  |  |  |  |  | - | 0.50 |
|  | 1997 | CW | 0.70 | 0.69 | 0.79 | 0.75 | 0.73 | 0.59 | 0.63 |
|  |  | KC | - | 0.69 | 0.77 | 0.81 | 0.70 | 0.87 | 0.57 |
|  |  | KT |  | - | 0.74 | 0.79 | 0.85 | 0.65 | 0.52 |
|  |  | SSP |  |  | - | 0.83 | 0.75 | 0.75 | 0.65 |
|  |  | ST |  |  |  | - | 0.86 | 0.74 | 0.54 |
|  |  | TP |  |  |  |  | - | 0.66 | 0.65 |
|  |  | TW |  |  |  |  |  | - | 0.55 |
|  | 1998 | CW | 0.60 | 0.65 | 0.75 | 0.72 | 0.65 | 0.60 | 0.43 |
|  |  | KC | - | 0.61 | 0.84 | 0.80 | 0.54 | 0.78 | 0.31 |
|  |  | KT |  | - | 0.65 | 0.68 | 0.66 | 0.53 | 0.42 |
|  |  | SSP |  |  | - | 0.88 | 0.66 | 0.74 | 0.41 |
|  |  | ST |  |  |  | - | 0.78 | 0.70 | 0.47 |
|  |  | TP |  |  |  |  | - | 0.61 | 0.64 |
|  |  | TW |  |  |  |  |  | - | 0.52 |
|  | 1999 | CW | 0.56 | 0.62 | 0.79 | 0.59 | 0.36 | 0.51 | 0.54 |
|  |  | KC | - | 0.47 | 0.79 | 0.70 | 0.33 | 0.84 | 0.29 |
|  |  | KT |  | - | 0.58 | 0.48 | 0.23 | 0.39 | 0.40 |
|  |  | SSP |  |  | - | 0.74 | 0.38 | 0.75 | 0.45 |
|  |  | ST |  |  |  | - | 0.30 | 0.65 | 0.34 |
|  |  | TP |  |  |  |  | - | 0.31 | 0.60 |
|  |  | TW |  |  |  |  |  | - | 0.37 |
|  | 2000 | CW | 0.60 | 0.61 | 0.70 | 0.49 | 0.54 | 0.63 | 0.51 |
|  |  | KC | - | 0.61 | 0.84 | 0.68 | 0.54 | 0.76 | 0.37 |
|  |  | KT |  | - | 0.67 | 0.58 | 0.56 | 0.65 | 0.56 |
|  |  | SSP |  |  | - | 0.65 | 0.55 | 0.83 | 0.38 |
|  |  | ST |  |  |  | - | 0.52 | 0.51 | 0.28 |
|  |  | TP |  |  |  |  | - | 0.60 | 0.58 |
|  |  | TW |  |  |  |  |  | - | 0.55 |


|  |  |  | KC | KT | SSP | ST | TP | TW | YL |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\mathrm{O}_{3}$ | 1995 | CW | 0.82 | - | - | - | - | - | 0.59 |
|  |  | KC | - | - | - | - | - | - | 0.50 |
|  |  | KT |  | - | - | - | - | - | - |
|  |  | SSP |  |  | - | - | - | - | - |
|  |  | ST |  |  |  | - | - | - | - |
|  |  | TP |  |  |  |  | - | - | - |
|  |  | TW |  |  |  |  |  | - | - |
|  | 1996 | CW | 0.79 | - | - | - | - | - | 0.71 |
|  |  | KC | - | - | - | - | - | - | 0.69 |
|  |  | KT |  | - | - | - | - | - | - |
|  |  | SSP |  |  | - | - | - | - | - |
|  |  | ST |  |  |  | - | - | - | - |
|  |  | TP |  |  |  |  | - | - | - |
|  |  | TW |  |  |  |  |  | - | - |
|  | 1997 | CW | 0.79 | 0.75 | - | 0.77 | 0.84 | 0.86 | 0.86 |
|  |  | KC | - | 0.80 | - | 0.85 | 0.83 | 0.90 | 0.79 |
|  |  | KT |  | - | - | 0.75 | 0.84 | 0.80 | 0.76 |
|  |  | SSP |  |  | - | - | - | - | - |
|  |  | ST |  |  |  | - | 0.93 | 0.79 | 0.73 |
|  |  | TP |  |  |  |  | - | 0.76 | 0.86 |
|  |  | TW |  |  |  |  |  | - | 0.84 |
|  | 1998 | CW | 0.80 | 0.80 | 0.86 | 0.86 | 0.84 | 0.82 | 0.85 |
|  |  | KC | - | 0.84 | 0.87 | 0.89 | 0.83 | 0.89 | 0.80 |
|  |  | KT |  | - | 0.86 | 0.86 | 0.84 | 0.79 | 0.83 |
|  |  | SSP |  |  | - | 0.89 | 0.85 | 0.90 | 0.86 |
|  |  | ST |  |  |  | - | 0.93 | 0.87 | 0.88 |
|  |  | TP |  |  |  |  | - | 0.83 | 0.89 |
|  |  | TW |  |  |  |  |  | - | 0.88 |
|  | 1999 | CW | 0.84 | 0.83 | 0.86 | 0.86 | 0.64 | 0.81 | 0.69 |
|  |  | KC | - | 0.81 | 0.84 | 0.84 | 0.60 | 0.85 | 0.57 |
|  |  | KT |  | - | 0.83 | 0.87 | 0.79 | 0.84 | 0.72 |
|  |  | SSP |  |  | - | 0.83 | 0.67 | 0.88 | 0.73 |
|  |  | ST |  |  |  | - | 0.86 | 0.82 | 0.79 |
|  |  | TP |  |  |  |  | - | 0.70 | 0.85 |
|  |  | TW |  |  |  |  |  | - | 0.71 |
|  | 2000 | CW | 0.84 | 0.83 | 0.87 | 0.87 | 0.82 | 0.85 | 0.73 |
|  |  | KC | - | 0.83 | 0.86 | 0.86 | 0.75 | 0.89 | 0.60 |
|  |  | KT |  | - | 0.88 | 0.88 | 0.83 | 0.83 | 0.66 |
|  |  | SSP |  |  | - | 0.87 | 0.84 | 0.92 | 0.75 |
|  |  | ST |  |  |  | - | 0.84 | 0.87 | 0.65 |
|  |  | TP |  |  |  |  | - | 0.79 | 0.80 |
|  |  | TW |  |  |  |  |  | - | 0.73 |


|  |  |  | KC | KT | SSP | ST | TP | TW | YL |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| RSP | 1995 | CW | 0.95 | 0.93 | - | 0.95 | - | 0.95 | 0.81 |
|  |  | KC | - | 0.95 | - | 0.97 | - | 0.98 | 0.88 |
|  |  | KT |  | - | - | 0.93 | - | 0.92 | 0.81 |
|  |  | SSP |  |  | - | - | - | - | - |
|  |  | ST |  |  |  | - | - | 0.95 | 0.88 |
|  |  | TP |  |  |  |  | - | - | - |
|  |  | TW |  |  |  |  |  | - | 0.89 |
|  | 1996 | CW | 0.95 | 0.93 | - | 0.94 | - | 0.95 | 0.94 |
|  |  | KC | - | 0.94 | - | 0.95 | - | 0.98 | 0.95 |
|  |  | KT |  | - | - | 0.94 | - | 0.93 | 0.89 |
|  |  | SSP |  |  | - | - | - | - | - |
|  |  | ST |  |  |  | - | - | 0.96 | 0.92 |
|  |  | TP |  |  |  |  | - | - | - |
|  |  | TW |  |  |  |  |  | - | 0.95 |
|  | 1997 | CW | 0.94 | 0.93 | 0.97 | 0.95 | 0.91 | 0.95 | 0.92 |
|  |  | KC | - | 0.94 | 0.97 | 0.95 | 0.95 | 0.97 | 0.91 |
|  |  | KT |  | - | 0.96 | 0.95 | 0.94 | 0.93 | 0.86 |
|  |  | SSP |  |  | - | 0.97 | 0.92 | 0.96 | 0.87 |
|  |  | ST |  |  |  | - | 0.96 | 0.95 | 0.90 |
|  |  | TP |  |  |  |  | - | 0.93 | 0.90 |
|  |  | TW |  |  |  |  |  | - | 0.92 |
|  | 1998 | CW | 0.91 | 0.92 | 0.95 | 0.94 | 0.91 | 0.93 | 0.92 |
|  |  | KC | - | 0.91 | 0.95 | 0.93 | 0.90 | 0.96 | 0.89 |
|  |  | KT |  | - | 0.95 | 0.90 | 0.88 | 0.91 | 0.86 |
|  |  | SSP |  |  | - | 0.95 | 0.92 | 0.96 | 0.92 |
|  |  | ST |  |  |  | - | 0.95 | 0.92 | 0.93 |
|  |  | TP |  |  |  |  | - | 0.89 | 0.93 |
|  |  | TW |  |  |  |  |  | - | 0.91 |
|  | 1999 | CW | 0.90 | 0.97 | 0.97 | 0.96 | 0.94 | 0.96 | 0.93 |
|  |  | KC | - | 0.90 | 0.93 | 0.92 | 0.90 | 0.94 | 0.88 |
|  |  | KT |  | - | 0.97 | 0.96 | 0.93 | 0.95 | 0.89 |
|  |  | SSP |  |  | - | 0.97 | 0.93 | 0.97 | 0.90 |
|  |  | ST |  |  |  | - | 0.95 | 0.97 | 0.93 |
|  |  | TP |  |  |  |  | - | 0.94 | 0.93 |
|  |  | TW |  |  |  |  |  | - | 0.95 |
|  | 2000 | CW | 0.90 | 0.95 | 0.96 | 0.96 | 0.92 | 0.94 | 0.92 |
|  |  | KC | - | 0.92 | 0.94 | 0.93 | 0.91 | 0.95 | 0.85 |
|  |  | KT |  | - | 0.96 | 0.96 | 0.93 | 0.94 | 0.88 |
|  |  | SSP |  |  | - | 0.96 | 0.92 | 0.97 | 0.90 |
|  |  | ST |  |  |  | - | 0.96 | 0.96 | 0.93 |
|  |  | TP |  |  |  |  | - | 0.93 | 0.93 |
|  |  | TW |  |  |  |  |  | - | 0.92 |

Table 3.5: Summary statistics of daily concentrations of pollutants ( $\mu \mathrm{g} / \mathrm{m}^{\mathbf{3}}$ )

| A. General Level |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Whole year | Min. | 1st Qu. | Median | Mean | 3rd Qu. | Max. |
| $\mathrm{NO}_{2}$ | 1995 | 17.2 | 40.6 | 51.4 | 53.3 | 65.1 | 123.2 |
|  | 1996 | 17.0 | 39.7 | 52.4 | 54.5 | 66.6 | 122.7 |
|  | 1997 | 15.6 | 46.1 | 57.1 | 59.8 | 71.7 | 146.6 |
|  | 1998 | 20.8 | 43.8 | 54.8 | 55.5 | 66.2 | 125.6 |
|  | 1999 | 10.3 | 44.6 | 60.9 | 62.6 | 75.0 | 157.8 |
|  | 2000 | 20.0 | 46.1 | 55.9 | 58.3 | 67.8 | 167.3 |
| $\mathrm{SO}_{2}$ | 1995 | 2.3 | 10.1 | 15.1 | 17.7 | 22.2 | 63.6 |
|  | 1996 | 3.5 | 10.4 | 15.5 | 18.6 | 23.9 | 75.8 |
|  | 1997 | 2.2 | 8.0 | 13.6 | 17.4 | 21.6 | 88.8 |
|  | 1998 | 1.6 | 7.3 | 11.9 | 13.3 | 16.7 | 45.9 |
|  | 1999 | 4.9 | 13.0 | 18.0 | 20.3 | 23.7 | 75.5 |
|  | 2000 | 4.4 | 10.1 | 14.6 | 17.8 | 23.4 | 77.8 |
| $\mathrm{O}_{3}$ | 1995 | 0.0 | 12.5 | 25.2 | 29.1 | 43.5 | 99.6 |
|  | 1996 | 0.9 | 18.0 | 32.1 | 37.2 | 53.4 | 170.7 |
|  | 1997 | 0.8 | 17.6 | 28.2 | 34.2 | 47.3 | 124.9 |
|  | 1998 | 3.9 | 15.6 | 25.4 | 32.1 | 44.3 | 125.8 |
|  | 1999 | 6.1 | 19.4 | 34.2 | 35.3 | 48.5 | 123.8 |
|  | 2000 | 3.0 | 19.2 | 30.3 | 34.3 | 47.3 | 106.9 |
| RSP | 1995 | 14.1 | 30.2 | 47.3 | 51.5 | 66.6 | 156.6 |
|  | 1996 | 14.5 | 31.4 | 46.2 | 53.9 | 71.3 | 166.3 |
|  | 1997 | 12.7 | 34.1 | 48.2 | 52.2 | 67.0 | 154.2 |
|  | 1998 | 15.5 | 28.8 | 42.1 | 48.1 | 63.8 | 140.5 |
|  | 1999 | 15.0 | 34.0 | 50.2 | 54.8 | 69.7 | 188.4 |
|  | 2000 | 15.2 | 33.4 | 43.4 | 50.4 | 65.1 | 177.5 |
| FSP | 1998 | 10.5 | 24.7 | 33.8 | 37.7 | 49.8 | 120.3 |
|  | 1999 | 8.3 | 22.3 | 33.3 | 36.7 | 47.5 | 118.6 |
|  | 2000 | 8.9 | 21.2 | 29.1 | 33.2 | 43.2 | 104.2 |
| CO | 1998 | 17.6 | 52.7 | 69.2 | 71.8 | 89.3 | 214.1 |
|  | 1999 | 48.1 | 86.6 | 110.2 | 117.7 | 139.0 | 388.8 |
|  | 2000 | 1.0 | 72.8 | 89.3 | 91.9 | 110.7 | 212.2 |

B. Roadside level

|  | Whole year | Min. | 1st Qu. | Median | Mean | 3rd Qu. | Max. |
| :--- | :--- | ---: | ---: | ---: | ---: | ---: | ---: |
| $\mathrm{NO}_{2}$ | 1995 | 7.8 | 65.1 | 86.3 | 83.9 | 102.7 | 179.3 |
|  | 1996 | 21.7 | 57.1 | 82.6 | 80.4 | 102.1 | 172.0 |
|  | 1997 | 27.9 | 67.9 | 86.2 | 86.9 | 102.9 | 185.0 |
|  | 1998 | 36.5 | 70.8 | 93.6 | 93.0 | 114.5 | 186.8 |
|  | 1999 | 12.6 | 65.2 | 98.4 | 94.3 | 116.3 | 192.5 |
|  | 2000 | 40.4 | 74.5 | 93.6 | 93.1 | 110.7 | 216.4 |
| $\mathrm{SO}_{2}$ | 1995 | 3.3 | 21.2 | 28.8 | 33.0 | 41.4 | 120.7 |
|  | 1996 | 5.1 | 19.7 | 26.0 | 30.8 | 36.6 | 122.4 |
|  | 1997 | 0.6 | 9.1 | 14.0 | 18.7 | 22.2 | 102.6 |
|  | 1998 | 1.6 | 12.1 | 17.0 | 19.0 | 23.7 | 62.3 |
|  | 1999 | 3.8 | 18.2 | 22.7 | 26.0 | 31.1 | 100.0 |
|  | 2000 | 9.3 | 18.8 | 22.9 | 25.5 | 29.8 | 82.7 |
| RSP | 1996 | 40.6 | 56.7 | 67.8 | 72.1 | 81.4 | 163.9 |
|  | 1997 | 11.2 | 42.0 | 56.4 | 58.4 | 70.7 | 177.2 |
|  | 1998 | 34.9 | 69.8 | 83.7 | 84.9 | 95.8 | 190.3 |
|  | 1999 | 25.4 | 64.2 | 79.5 | 82.8 | 96.7 | 240.6 |
|  | 2000 | 24.6 | 61.0 | 73.7 | 77.0 | 88.5 | 195.9 |
| FSP | 1998 | 29.4 | 62.0 | 74.5 | 74.3 | 85.8 | 132.9 |
|  | 1999 | 14.5 | 39.6 | 50.0 | 53.6 | 63.8 | 205.9 |
| CO | 1995 | 57.7 | 98.4 | 116.7 | 122.0 | 142.9 | 239.5 |
|  | 1996 | 46.5 | 92.0 | 109.1 | 111.8 | 130.9 | 223.1 |
|  | 1997 | 23.1 | 90.5 | 110.5 | 110.5 | 131.3 | 192.1 |
|  | 1998 | 50.2 | 94.7 | 111.1 | 114.4 | 132.7 | 209.8 |
|  | 1999 | 60.7 | 93.5 | 114.3 | 120.5 | 136.6 | 352.7 |
|  | 2000 | 53.2 | 102.4 | 121.0 | 125.8 | 146.8 | 248.8 |

Table 3.6: Daily means of relative humidity and temperature for 1995-2000

|  | Whole year | Min. | 1st Qu. | Median | Mean | 3rd Qu. | Max. |
| :--- | :--- | ---: | :---: | :---: | :---: | :---: | :---: |
| Humidity | 1995 | 31.0 | 73.0 | 79.0 | 77.4 | 86.0 | 96.0 |
| $(\%)$ | 1996 | 37.0 | 71.0 | 77.0 | 76.4 | 83.0 | 96.0 |
|  | 1997 | 36.0 | 76.0 | 81.0 | 79.3 | 85.0 | 97.0 |
|  | 1998 | 38.0 | 75.0 | 80.0 | 79.2 | 86.0 | 96.0 |
|  | 1999 | 27.0 | 72.0 | 78.0 | 75.4 | 82.0 | 93.0 |
|  | 2000 | 39.0 | 74.0 | 79.0 | 78.1 | 84.0 | 97.0 |
| Temperature | 1995 | 12.0 | 18.0 | 24.3 | 22.8 | 27.4 | 30.3 |
| $\left({ }^{\circ} \mathrm{C}\right)$ | 1996 | 6.9 | 19.0 | 24.4 | 23.3 | 27.9 | 30.9 |
|  | 1997 | 11.5 | 20.1 | 24.0 | 23.4 | 27.2 | 30.5 |
|  | 1998 | 9.8 | 20.4 | 25.2 | 24.0 | 28.0 | 31.3 |
|  | 1999 | 8.5 | 19.9 | 24.8 | 23.8 | 28.1 | 30.5 |
|  | 2000 | 9.8 | 19.7 | 24.1 | 23.4 | 27.9 | 30.4 |

Table 3.7: Number of deaths ${ }^{\#}$ (known deaths) - all ages

|  | Year |  |  |  |  |  |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: |
| Diseases (ICD9) | 1995 | 1996 | 1997 | 998 | 1999 | 2000 |
| Non accidental (ICD9 001-799) | 29640 | 30123 | 29733 | 30802 | 31275 | 31872 |
| Respiratory (ICD9 460-519) | 5843 | 6564 | 6400 | 6135 | 5662 | 5564 |
| COPD (ICD9 490-496 excluding 493) ${ }^{@}$ | 2013 | 2113 | 1964 | 1990 | 2234 | 2078 |
| Asthma (ICD9 493) | 73 | 98 | 70 | 96 | 98 | 101 |
| Cardiovascular (ICD9 390-459) | 8720 | 8317 | 8080 | 8855 | 9144 | 9480 |
| Cardiac (ICD9 390-429) | 5002 | 4812 | 4679 | 5065 | 5224 | 5482 |
| IHD (ICD9 410-414) | 3322 | 3282 | 3190 | 3323 | 3291 | 3565 |

Notes: \# The number included all data with and without a date of death.
${ }^{@}$ COPD Chronic Obstructive Pulmonary Disease; IHD Ischaemic Heart Disease.

Table 3.8: Number of hospital admissions extracted from 12 major HA hospitals

|  | Year |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Diseases (ICD9) | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
| Respiratory |  |  |  |  |  |  |
| (ICD9 460-519) |  |  |  |  |  |  |
| All ages | 66495 | 77815 | 80062 | 88518 | 86723 | 89797 |
| Age 0-14 | 23421 | 25551 | 25307 | 28500 | 23241 | 21850 |
| Age 15-64 | 15171 | 16735 | 16766 | 18866 | 18929 | 19628 |
| Age 65+ | 27636 | 35289 | 37276 | 41145 | 44550 | 48317 |
| COPD |  |  |  |  |  |  |
| (ICD9 490-496 |  |  |  |  |  |  |
| excluding 493) |  |  |  |  |  |  |
| All ages | 16648 | 18673 | 18316 | 19192 | 21192 | 22479 |
| Age 0-14 | 466 | 308 | 316 | 227 | 179 | 150 |
| Age 15-64 | 3430 | 3538 | 3238 | 3428 | 3348 | 3589 |
| Age 65+ | 12709 | 14804 | 14516 | 15535 | 17664 | 18739 |
| Asthma |  |  |  |  |  |  |
| (ICD9 493) |  |  |  |  |  |  |
| All ages | 8682 | 9672 | 8794 | 8652 | 8554 | 7860 |
| Age 0-14 | 4437 | 5156 | 4385 | 4330 | 3949 | 3383 |
| Age 15-64 | 2855 | 2929 | 2734 | 2600 | 2757 | 2540 |
| Age 65+ | 1381 | 1586 | 1590 | 1722 | 1848 | 1937 |
| Cardiovasculary |  |  |  |  |  |  |
| (ICD9 390-459) |  |  |  |  |  |  |
| All ages | 54054 | 59472 | 59342 | 61590 | 65860 | 69003 |
| Age 0-14 | 1120 | 1208 | 923 | 883 | 957 | 913 |
| Age 15-64 | 20198 | 21866 | 20182 | 21382 | 22434 | 23688 |
| Age 65+ | 32561 | 36250 | 37453 | 39321 | 42464 | 44400 |
| Cardiac |  |  |  |  |  |  |
| (ICD9 390-429) |  |  |  |  |  |  |
| All ages | 34066 | 37545 | 37027 | 38921 | 41268 | 43407 |
| Age 0-14 | 515 | 470 | 376 | 368 | 344 | 368 |
| Age 15-64 | 12195 | 13052 | 11606 | 12723 | 13066 | 13782 |
| Age 65+ | 21228 | 23923 | 24540 | 25829 | 27855 | 29257 |
| IHD |  |  |  |  |  |  |
| (ICD9 410-414) |  |  |  |  |  |  |
| All ages | 12281 | 13745 | 13632 | 14911 | 15315 | 16162 |
| Age 0-14 | 23 | 16 | 144 | 4 | 6 | 9 |
| Age 15-64 | 4553 | 5080 | 4436 | 5293 | 5231 | 5645 |
| Age 65+ | 7681 | 8636 | 8940 | 9613 | 10077 | 10508 |
|  |  |  |  |  |  |  |

Table 4.1: Comparison of relative risks (RR) and $\mathbf{9 5 \%}$ confidence intervals (CI) of the best single lagged-day effects by linear extrapolation for a $10^{\text {th }}-\mathbf{9 0} \mathbf{0}^{\text {th }}$ percentile change in pollutant concentration - for mortality at all ages

| Pollutant Cause of mortality | Lag day | $\begin{gathered} \text { EPD project } \\ (1995-2000) \\ \text { RR }(95 \% \mathrm{CI}) \\ \hline \end{gathered}$ | p -value | Lag day | $\begin{aligned} & \text { from Wong CM } \\ & (1995-1997) \\ & \text { RR }(95 \% \mathrm{CI}) \\ & \hline \end{aligned}$ | et al ${ }^{9}$ <br> p -value |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\mathrm{NO}_{2}$ |  |  |  |  |  |  |
| Non accidental | 1 | 1.03 (1.02-1.05) | 0.000 | 1 | 1.04 (1.01-1.05) | 0.001 |
| Respiratory | 0 | 1.04 (1.01-1.07) | 0.006 | 0 | 1.08 (1.03-1.13) | 0.003 |
| Cardiovascular | 2 | 1.05 (1.02-1.07) | 0.000 | 2 | 1.06 (1.03-1.10) | 0.001 |
| $\mathrm{SO}_{2}$ |  |  |  |  |  |  |
| Non accidental | 1 | 1.03 (1.02-1.04) | 0.000 | 1 | 1.03 (1.03-1.05) | 0.000 |
| Respiratory | 0 | 1.04 (1.02-1.06) | 0.000 | 0 | 1.04 (1.01-1.08) | 0.010 |
| Cardiovascular | 2 | 1.04 (1.02-1.06) | 0.000 | 1 | 1.05 (1.02-1.08) | 0.001 |
| RSP |  |  |  |  |  |  |
| Non accidental | 1 | 1.01 (1.00-1.03) | 0.037 | 1 | 1.02 (1.00-1.04) | 0.102 |
| Respiratory | 1 | 1.02 (1.00-1.05) | 0.080 | 1 | 1.06 (1.01-1.11) | 0.024 |
| Cardiovascular | 2 | 1.02 (1.00-1.05) | 0.068 | 2 | 1.03 (0.99-1.06) | 0.165 |
| $\mathrm{O}_{3}$ |  |  |  |  |  |  |
| Non accidental | 1 | 0.99 (0.98-1.01) | 0.432 | 5 | 1.01 (0.99-1.03) | 0.224 |
| Respiratory | 2 | 1.03 (1.00-1.06) | 0.023 | 4 | 1.04 (1.00-1.08) | 0.078 |
| Cardiovascular | 0 | 0.99 (0.97-1.02) | 0.524 | 3 | 1.01 (0.98-1.05) | 0.479 |

Table 4.2: Excess risks (ER) (\%) and $95 \%$ confidence interval (CI) for a $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ change in pollutant concentration for the best single lag day for each category of mortality from 1995 to 2000

1995-2000 pollutant concentration data

| Mortality, age (ICD9) | Lag | ER (95\% CI) | p-value |
| :--- | :---: | :---: | :---: |
| Non-accidental, all ages <br> (ICD9 001-799) |  |  |  |
| $\quad \mathrm{NO}_{2}$ | 1 | $0.64(0.36,0.91)$ | 0.000 |
| $\mathrm{SO}_{2}$ | 1 | $1.36(0.93,1.78)$ | 0.000 |
| $\mathrm{RSP}^{\mathrm{O}}$ | 1 | $0.24(0.01,0.46)$ | 0.037 |
| $\mathrm{O}_{3}$ | 1 | $-0.11(-0.37,0.16)$ | 0.432 |

Respiratory, all ages
(ICD9 460-519)

| $\mathrm{NO}_{2}$ | 0 | $0.81(0.24,1.38)$ | 0.006 |
| :--- | :--- | :--- | :--- |
| $\mathrm{SO}_{2}$ | 0 | $1.62(0.77,2.48)$ | 0.000 |
| RSP | 1 | $0.40(-0.05,0.85)$ | 0.080 |
| $\mathrm{O}_{3}$ | 2 | $0.62(0.09,1.16)$ | 0.023 |

COPD, all ages
(ICD9 490-496 excluding 493)

| $\mathrm{NO}_{2}$ | 2 | $1.07(0.00,2.15)$ | 0.050 |
| :--- | :--- | :--- | :--- |
| $\mathrm{SO}_{2}$ | 2 | $2.47(0.74,4.24)$ | 0.005 |
| RSP | 2 | $0.87(0.00,1.74)$ | 0.050 |
| $\mathrm{O}_{3}$ | 2 | $0.81(-0.26,1.89)$ | 0.137 |

Cardiovascular, all ages
(ICD9 390-459)

| $\mathrm{NO}_{2}$ | 2 | $0.94(0.44,1.44)$ | 0.000 |
| :--- | :--- | :---: | :--- |
| $\mathrm{SO}_{2}$ | 2 | $1.61(0.78,2.44)$ | 0.000 |
| RSP | 2 | $0.37(-0.03,0.77)$ | 0.068 |
| $\mathrm{O}_{3}$ | 0 | $-0.16(-0.65,0.33)$ | 0.524 |

Cardiac, all ages
(ICD9 390-429)

| $\mathrm{NO}_{2}$ | 1 | $1.34(0.65,2.04)$ | 0.000 |
| :--- | :--- | :---: | :--- |
| $\mathrm{SO}_{2}$ | 1 | $3.12(2.03,4.23)$ | 0.000 |
| RSP | 1 | $0.17(-0.39,0.72)$ | 0.554 |
| $\mathrm{O}_{3}$ | 1 | $-0.19(-0.88,0.50)$ | 0.585 |

IHD, all ages
(ICD9 410-414)

| $\mathrm{NO}_{2}$ | 1 | $2.09(1.31,2.88)$ | 0.000 |
| :--- | :--- | :---: | :--- |
| $\mathrm{SO}_{2}$ | 1 | $3.89(2.61,5.19)$ | 0.000 |
| RSP | 1 | $0.33(-0.31,0.97)$ | 0.309 |
| $\mathrm{O}_{3}$ | 1 | $-0.48(-1.28,0.31)$ | 0.235 |

Table 4.3: Comparison of excess risk (ER) (\%) and 95\% confidence interval (CI) of the best single lagged-day effects for a $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ change in pollutant concentration for hospital admissions

| Hospital admission, age | From this project$(1995-2000)$ |  | $\begin{aligned} & \text { From Wong CM et al } 2002^{10} \\ & (1995-1997) \end{aligned}$ |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Lag | ER (95\% CI) | Lag | ER (95\%CI) |
| Respiratory, |  |  |  |  |
| $65+$ |  |  |  |  |
| $\mathrm{NO}_{2}$ | 0 | 1.9 (1.6,2.2) | 0 | 1.3 (0.8,1.8) |
| $\mathrm{SO}_{2}$ | 0 | 2.4 (1.9,2.9) | 0 | 1.7 (1.0,2.4) |
| RSP | 0 | $1.0(0.8,1.3)$ | 0 | 0.7 (0.3,1.0) |
| $\mathrm{O}_{3}$ | 1 | 0.5 (0.2,0.8) | 1 | 0.6 (0.2,1.0) |
| Asthma, |  |  |  |  |
| 15-64 years |  |  |  |  |
| $\mathrm{NO}_{2}$ | 2 | 0.8 (-0.1, 1.7) | 1 | -1.3 (-2.6,0.1) |
| $\mathrm{SO}_{2}$ | 0 | 0.5 (-0.9,1.9) | 2 | -1.5 (-3.4,0.5) |
| RSP | 0 | -0.5 (-1.2,0.2) | 0 | -1.1 (-2.1,0.0) |
| $\mathrm{O}_{3}$ | 1 | 0.5 (-0.3,1.4) | 2 | $1.2(0.0,2.4)$ |
| Cardiac, all ages |  |  |  |  |
| $\mathrm{NO}_{2}$ | 0 | 1.1 (0.8,1.4) | 0 | 1.2 (0.7,1.7) |
| $\mathrm{SO}_{2}$ | 0 | 1.5 (1.1,2.0) | 0 | 1.6 (1.0,2.2) |
| RSP | 0 | 0.5 (0.3,0.7) | 0 | 0.5 (0.2,0.9) |
| $\mathrm{O}_{3}$ | 2 | 0.3 (0.1,0.6) | 2 | 0.5 (0.1,0.8) |
| IHD, <br> all ages |  |  |  |  |
| $\mathrm{NO}_{2}$ | 1 | 0.8 (0.4,1.2) | 3 | 0.7 (0.1, 1.4) |
| $\mathrm{SO}_{2}$ | 1 | 0.6 (-0.1, 1.3) | 2 | 0.4 (-0.5, 1.4) |
| RSP | 0 | 0.6 (0.2, 0.9) | 2 | 0.5 (-0.1, 1.0) |
| $\mathrm{O}_{3}$ |  | 0.6 (0.2, 1.0) | 3 | 0.5 (0.0, 1.0) |

Table 4.4: Excess risks (ER) (\%) and $95 \%$ confidence interval (CI) for a $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ change in pollutant concentration for the best single lag day for each category of hospital admissions from 1995-2000

1995-2000 pollutant concentration data

| Hospital admission, age (ICD9) | Lag | ER $(95 \% \mathrm{CI})$ | p-value |
| :--- | :---: | :---: | :---: |
| Respiratory, all ages <br> (ICD9 460-519) |  |  |  |
| $\quad \mathrm{NO}_{2}$ | 0 | $0.54(0.27,0.80)$ | 0.000 |
| $\mathrm{SO}_{2}$ | 0 | $0.76(0.34,1.18)$ | 0.000 |
| $\mathrm{RSP}^{\mathrm{O}}$ | 0 | $0.50(0.28,0.71)$ | 0.000 |
| $\mathrm{O}_{3}$ | 1 | $0.55(0.31,0.79)$ | 0.000 |

Respiratory, 65+
(ICD9 460-519)

| $\mathrm{NO}_{2}$ | 0 | $1.91(1.59,2.23)$ | 0.000 |
| :--- | :--- | :--- | :--- |
| $\mathrm{SO}_{2}$ | 0 | $2.42(1.92,2.93)$ | 0.000 |
| RSP | 0 | $1.04(0.78,1.30)$ | 0.000 |
| $\mathrm{O}_{3}$ | 1 | $0.49(0.18,0.80)$ | 0.002 |

Asthma, 15-64 years
(ICD9 493)

| $\mathrm{NO}_{2}$ | 2 | $0.77(-0.10,1.65)$ | 0.082 |
| :--- | :--- | ---: | :--- |
| $\mathrm{SO}_{2}$ | 0 | $0.52(-0.88,1.94)$ | 0.468 |
| RSP | 0 | $-0.51(-1.23,0.22)$ | 0.172 |
| $\mathrm{O}_{3}$ | 1 | $0.54(-0.33,1.43)$ | 0.226 |

Cardiovascular, all ages
(ICD9 390-459)

| $\mathrm{NO}_{2}$ | 0 | $0.73(0.48,0.98)$ | 0.000 |
| :--- | :--- | :--- | :--- |
| $\mathrm{SO}_{2}$ | 0 | $1.08(0.72,1.44)$ | 0.000 |
| RSP | 0 | $0.37(0.18,0.57)$ | 0.000 |
| $\mathrm{O}_{3}$ | 1 | $0.24(0.01,0.47)$ | 0.040 |

Cardiac, all ages
(ICD9 390-429)

| $\mathrm{NO}_{2}$ | 0 | $1.12(0.84,1.40)$ | 0.000 |
| :--- | :--- | :--- | :--- |
| $\mathrm{SO}_{2}$ | 0 | $1.54(1.11,1.97)$ | 0.000 |
| RSP | 0 | $0.49(0.27,0.72)$ | 0.000 |
| $\mathrm{O}_{3}$ | 2 | $0.34(0.07,0.61)$ | 0.012 |

IHD, all ages

| (ICD9 410-414) |  |  |  |
| :--- | :--- | :--- | :--- |
| $\mathrm{NO}_{2}$ | 1 | $0.78(0.35,1.21)$ | 0.000 |
| $\mathrm{SO}_{2}$ | 1 | $0.60(-0.08,1.29)$ | 0.083 |
| RSP | 0 | $0.57(0.22,0.93)$ | 0.002 |
| $\mathrm{O}_{3}$ | 2 | $0.57(0.15,1.00)$ | 0.008 |

Table 4.5: Excess risks (ER) (\%) and $95 \%$ confidence interval (CI) for a $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ change in pollutant concentration for mortality and hospital admission due to respiratory and cardiovascular diseases
(a) Total air pollution

|  | $\mathrm{ER}(95 \% \mathrm{CI})$ per $10 \mu \mathrm{gg} / \mathrm{m}^{3}$ |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\mathrm{NO}_{2}$ | RSP | $\mathrm{SO}_{2}$ | $\mathrm{O}_{3}$ |  |
| Mortality <br> Respiratory |  |  |  |  |  |
| All ages | $0.81(0.24,1.38)$ | $0.40(-0.05,0.85)$ | $1.62(0.77,2.48)$ | $0.62(0.09,1.16)$ |  |
| 65+ | $0.86(0.22,1.51)$ | $0.40(-0.11,0.91)$ | $1.71(0.66,2.78)$ | $0.24(-0.33,0.81)$ |  |
| Cardiovascular |  |  |  |  |  |
| All ages | $0.94(0.44,1.44)$ | $0.37(-0.03,0.77)$ | $1.61(0.78,2.44)$ | $-0.16(-0.65,0.33)$ |  |
| 65+ | $1.37(0.81,1.93)$ | $0.45(0.01,0.90)$ | $1.78(0.87,2.70)$ | $0.41(-0.11,0.92)$ |  |

## Hospital

admissions
Respiratory
All ages $\quad 0.54(0.27,0.80) \quad 0.50(0.28,0.71) \quad 0.76(0.34,1.18) \quad 0.55(0.31,0.79)$
$65+\quad 1.91(1.59,2.23) \quad 1.04(0.78,1.30) \quad 2.42(1.92,2.93) \quad 0.49(0.18,0.80)$
Cardiovascular
All ages $\quad 0.73(0.48,0.98) \quad 0.37(0.18,0.57) \quad 1.08(0.72,1.44) \quad 0.24(0.01,0.47)$
$65+\quad 0.90(0.61,1.19) \quad 0.57(0.33,0.80) \quad 1.45(1.02,1.88) \quad 0.26(-0.01,0.52)$
(b) Traffic-related pollution ${ }^{@}$

|  | Traffic-related ER (95\% CI) per $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ |  |  |
| :---: | :---: | :---: | :---: |
|  | $\mathrm{NO}_{2}$ | $\mathrm{SO}_{2}$ |  |

## Mortality

Respiratory
All ages
$0.50(0.15,0.85)$
0.16 (-0.02,0.33)
0.15 (0.07,0.22)
$65+\quad 0.53(0.13,0.93) \quad 0.15(-0.04,0.35) \quad 0.15(0.06,0.25)$
Cardiovascular All ages
0.58 (0.27,0.89)
0.14 (-0.01,0.30)
0.14 (0.07,0.22)

65+
$0.85(0.50,1.19)$
0.18 ( $0.00,0.35$ )
0.16 (0.08,0.24)

## Hospital

 admissionsRespiratory

All ages
65+
Cardiovascular All ages 65+

| $0.33(0.17,0.50)$ | $0.19(0.11,0.27)$ | $0.07(0.03,0.11)$ |
| :--- | :--- | :--- |
| $1.18(0.99,1.38)$ | $0.40(0.30,0.50)$ | $0.22(0.17,0.26)$ |
|  |  |  |
| $0.45(0.30,0.61)$ | $0.15(0.07,0.22)$ | $0.10(0.06,0.13)$ |
| $0.56(0.38,0.73)$ | $0.22(0.13,0.31)$ | $0.13(0.09,0.17)$ |

@ Obtained by multiplying \% of motor vehicle fraction to total pollution level: $\mathrm{NO}_{2}=$ $61.9 \% ; \mathrm{SO}_{2}=9.0 \% ; \mathrm{RSP}=38.8 \%$; for $\mathrm{O}_{3}$, no data are available.

Table 4.6: Estimated number of deaths and number of admissions ( $95 \%$ confidence interval) ${ }^{\#}$ for respiratory and cardiovascular diseases due to a change in pollutant concentration in total air pollution, and in the fraction related to road traffic

|  | Due to total pollutants |  |  |  | Due to traffic related pollutants ${ }^{\wedge}$ |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\mathrm{NO}_{2}$ | RSP | $\mathrm{SO}_{2}$ | $\mathrm{O}_{3}$ | $\mathrm{NO}_{2}$ | RSP | $\mathrm{SO}_{2}$ |
| (a) Due to $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ change |  |  |  |  |  |  |  |
| Deaths |  |  |  |  |  |  |  |
| Respiratory | $45(13,77)$ | $22(0,47)^{@}$ | $90(43,138)$ | $34(5,65)$ | $28(8,48)$ | $9(0,18){ }^{\text {@ }}$ | $8(4,12)$ |
| Cardiovascular | $89(42,137)$ | $35(0,73)^{@}$ | $153(74,231)$ | $0(0,31)^{\text {@ }}$ | $55(26,85)$ | $14(0,28){ }^{\text {@ }}$ | $14(7,21)$ |
| Admissions to public hospitals |  |  |  |  |  |  |  |
| Respiratory | $646(323,957)$ | $598(335,850)$ | $910(407,1412)$ | $658(371,946)$ | $400(200,593)$ | $232(130,330)$ | $82(37,127)$ |
| Cardiovascular | $681(488,914)$ | $345(168,532)$ | 1007 (672, 1343) | $224(9,438)$ | $421(277,566)$ | $134(65,206)$ | $91(60,121)$ |

(b) Due to mean pollutant concentration* in year 2000

Deaths

| Respiratory | $263(78,448)$ | $112(0,238)^{@}$ | $160(76,246)$ | $118(17,221)$ | $163(48,277)$ | $44(0,92)^{@}$ | $14(7,22)$ |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Cardiovascular | $520(243,796)$ | $177(0,368)^{@}$ | $272(132,412)$ | $0(0,107)^{@}$ | $322(151,493)$ | $69(0,143)^{@}$ | $24(12,37)$ |

Admissions to public hospitals~
Respiratory $3768(1884,5582) 3016(1689,4283) 1619(724,2514) 2258(1273,3243) 2332(1166,3455) 1170(655,1662) 146(65,226)$
Cardiovascular $3969(2610,5329) \quad 1739(846,2679) \quad 1793(1195,2391) \quad 768(32,1504) \quad 2457(1616,3298) \quad 675(328,1040) \quad 161(108,215)$

Note: ${ }^{\#}$ Calculated by multiplication of excess risk and number of deaths/admissions due to specific diseases in year 2000.
^Number due to traffic-related air pollutants is obtained by multiplying the number due to total pollutants with fraction of pollution due to motor vehicles: $\mathrm{NO}_{2}=61.9 \% ; \mathrm{SO}_{2}=9.0 \% ; \mathrm{RSP}=38.8 \%$; for $\mathrm{O}_{3}$, no data are available.
${ }^{@}$ Lower limit of excess risk (ER) was assumed to be zero.
~ For all Hospital Authority hospitals except psychiatric.

* Mean pollutant concentrations in the year $2000\left(\mathrm{NO}_{2} 58.3, \mathrm{SO}_{2} 17.8\right.$, RSP 50.4 and $\left.\mathrm{O}_{3} 34.3 \mu \mathrm{~g} / \mathrm{m}^{3}\right)$

Table 4.7: Estimates of unit cost, frequency of health service utilization in year 2000, and total direct health care cost per $10 \mu \mathrm{~g} / \mathrm{m}^{\mathbf{3}}$ change in each air pollutant

|  | Cost (HK\$) per episode/ visit A | Total no. of episodes/ visits per year ${ }^{\text {\# }}$ <br> B | Direct health care cost (HK\$) per year due to total air pollution for each pollutants |  |  |  | Direct health care cost (HK\$) per year due to traffic-related air pollution for each pollutants |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | $\mathrm{NO}_{2}$ | RSP $\mathrm{C}=\mathrm{A}^{*}$ | * ${ }^{\text {ER }} \mathrm{SO}_{2}$ | $\mathrm{O}_{3}$ |  | D=A*B*Traffic-related ER |  |
| (a) Hospital admissions - Public |  |  |  |  |  |  |  |  |  |
| Respiratory |  |  | ( $\mathrm{A} * \mathrm{~B} * 0.54 \%)$ | ( $\mathrm{A} * \mathrm{~B} * 0.50 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.76 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.55 \%$ ) | (A*B * $0.33 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.19 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.07 \%$ ) |
| 1. Acute General |  |  |  |  |  |  |  |  |  |
| F \$3,132 x 3.639 (LOS) | 11,397.35 | 42,759 | 2,631,632 | 2,436,696 | 3,703,778 | 2,680,366 | 1,628,980 | 945,438 | 333,340 |
| M $\$ 3,132 \times 3.477$ (LOS) | 10,889.96 | 62,420 | 3,670,658 | 3,398,758 | 5,166,112 | 3,738,634 | 2,272,138 | 1,318,718 | 464,950 |
| 2. CR Infirmary |  |  |  |  |  |  |  |  |  |
| F $\quad \$ 2,735 \times 9.712$ (LOS) | 26,562.32 | 5,058 | 725,502 | 671,761 | 1,021,077 | 738,937 | 449,086 | 260,643 | 91,897 |
| M \$2,735 x 9.095 (LOS) | 24,874.83 | 9,447 | 1,268,959 | 1,174,962 | 1,785,943 | 1,292,459 | 785,486 | 455,885 | 160,735 |
| 3. Coronary Care Unit |  |  |  |  |  |  |  |  |  |
| F $\$ 5,188 \times 3.33$ (LOS) | 17,276.04 | 565 | 52,709 | 48,805 | 74,183 | 53,685 | 32,627 | 18,936 | 6,677 |
| M $\$ 5,188 \times 3.10$ (LOS) | 16,082.80 | 771 | 66,959 | 61,999 | 94,239 | 68,199 | 41,448 | 24,056 | 8,481 |
| Cardiovascular |  |  | ( $\mathrm{A} * \mathrm{~B} * 0.73 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.37 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 1.08 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.24 \%$ ) | (A*B * $0.45 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.15 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.10 \%$ ) |
| 1. Acute General |  |  |  |  |  |  |  |  |  |
| F \$3,132 x 4.016 (LOS) | 12,578.11 | 39,323 | 3,610,646 | 1,830,054 | 5,341,778 | 1,187,062 | 2,234,990 | 710,061 | 480,760 |
| M $\$ 3,132 \times 3.855$ (LOS) | 12,073.86 | 43,429 | 3,827,796 | 1,940,116 | 5,663,041 | 1,258,454 | 2,369,406 | 752,765 | 509,674 |
| 2. CR Infirmary |  |  |  |  |  |  |  |  |  |
| F $\$ 2,735 \times 13.55$ (LOS) | 37,059.25 | 5,715 | 1,546,093 | 783,636 | 2,287,371 | 508,305 | 957,032 | 304,051 | 205,863 |
| M $\$ 2,735 \times 14.04$ (LOS) | 38,399.40 | 4,799 | 1,345,235 | 681,831 | 1,990,210 | 442,269 | 832,700 | 264,551 | 179,119 |
| 3. Coronary Care Unit |  |  |  |  |  |  |  |  |  |
| F $\$ 5,188 \times 3.74$ (LOS) | 19,403.12 | 615 | 87,110 | 44,152 | 128,876 | 28,639 | 53,921 | 17,131 | 11,599 |
| M $\$ 5,188 \times 3.48$ (LOS) | 18,054.24 | 711 | 93,707 | 47,495 | 138,635 | 30,808 | 58,005 | 18,428 | 12,477 |
| Cost for item (a): |  |  | 18,927,008 | 13,120,266 | 27,395,243 | 12,027,815 | 11,715,818 | 5,090,663 | 2,465,572 |


|  | Cost (HK\$) pe episode/ visit <br> A | Total no. of episodes/ visits per year ${ }^{\text {\# }}$ $\qquad$ <br> B | Direct health care cost (HK\$) per year due to total air pollution for each pollutants |  |  |  | Direct health care cost (HK\$) per year due to traffic-related air pollution for each pollutants |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | $\mathrm{NO}_{2}$ | C= A*B*ER |  |  | $\mathrm{NO}_{2}$ D=A | D=A*B*Traffic-related ER |  |
| (b) Hospital admissions - Private Respiratory |  |  | ( $\mathrm{A} * \mathrm{~B} * 0.54 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.50 \%$ ) | ( A * ${ }^{\text {* }} 0.76 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.55 \%$ ) | ( A * $\mathrm{B}^{*} 0.33 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.19 \%$ ) | ( $\mathrm{A} * \mathrm{~B}$ * $0.07 \%$ ) |
| $\$ 3,132 \times 3.543 \text { (LOS) }$ <br> Cardiovascular | 11,096.68 | 31,312 | $\begin{gathered} 1,876,279 \\ (\mathrm{~A} * \mathrm{~B} * 0.73 \%) \end{gathered}$ | $\begin{aligned} & 1,737,296 \\ & (\mathrm{~A} * \mathrm{~B} * 0.37 \%) \end{aligned}$ | $\begin{gathered} 2,640,689 \\ (\mathrm{~A} * \mathrm{~B} * 1.08 \%) \end{gathered}$ | $\begin{gathered} 1,911,025 \\ (\mathrm{~A} * \mathrm{~B} * 0.24 \%) \end{gathered}$ | $\begin{gathered} 1,161,417 \\ (\mathrm{~A} * \mathrm{~B} * 0.45 \%) \end{gathered}$ | $\begin{gathered} 674,071 \\ (\mathrm{~A} * \mathrm{~B} * 0.15 \%) \end{gathered}$ | $\begin{array}{r} 237,662 \\ (\mathrm{~A} * \mathrm{~B} * 0.10 \%) \end{array}$ |
| \$3,132 x 3.931 (LOS) | 12,311.8 | 17,248 | 1,550,195 | 785,715 | 2,293,440 | 509,653 | 959,571 | 304,858 | 206,410 |
|  | Cost for item (b): |  | 3,426,474 | 2,523,011 | 4,934,129 | 2,420,678 | 2,120,988 | 978,928 | 444,072 |
| (c) Accident \& Emergency Visit |  |  |  |  |  |  |  |  |  |
|  | 571.00 | 318,635 | $\begin{gathered} 982,479 \\ (\mathrm{~A} * \mathrm{~B} * 0.73 \%) \end{gathered}$ | $\begin{aligned} & 909,703 \\ & (\mathrm{~A} * \mathrm{~B} * 0.37 \%) \end{aligned}$ | $\begin{aligned} & 1,382,748 \\ & (\mathrm{~A} * \mathrm{~B} * 1.08 \%) \end{aligned}$ | $\begin{gathered} 1,000,673 \\ (\mathrm{~A} * \mathrm{~B} * 0.24 \%) \end{gathered}$ | $\begin{array}{r} 608,154 \\ (\mathrm{~A} * \mathrm{~B} * 0.45 \%) \end{array}$ | $\begin{array}{r} 352,965 \\ (\mathrm{~A} * \mathrm{~B} * 0.15 \%) \end{array}$ | $\begin{array}{r} 124,447 \\ (\mathrm{~A} * \mathrm{~B} * 0.10 \%) \end{array}$ |
| Cardiovascular | 571.00 | 238,673 | 994,862 | 504,245 | 1,471,850 | 327,078 | 615,819 | 195,647 | 132,467 |
|  | Cost for item (c): |  | 1,977,341 | 1,413,948 | 2,854,598 | 1,327,751 | 1,223,974 | 548,612 | 256,914 |
| (d) Specialty Outpatient Clinic Visit |  |  |  |  |  |  |  |  |  |
| Cardiovascular | 660.00 | 298,256 | $\begin{gathered} 1,062,986 \\ (\mathrm{~A} * \mathrm{~B} * 0.73 \%) \end{gathered}$ | $\begin{array}{r} 984,246 \\ (\mathrm{~A} * \mathrm{~B} * 0.37 \%) \end{array}$ | $\begin{gathered} 1,496,054 \\ (\mathrm{~A} * \mathrm{~B} * 1.08 \%) \end{gathered}$ | $\begin{gathered} 1,082,671 \\ (\mathrm{~A} * \mathrm{~B} * 0.24 \%) \end{gathered}$ | $\begin{array}{r} 657,988 \\ (\mathrm{~A} * \mathrm{~B} * 0.45 \%) \end{array}$ | $\begin{array}{r} 381,888 \\ (\mathrm{~A} * \mathrm{~B} * 0.15 \%) \end{array}$ | $\begin{array}{r} 134,645 \\ (\mathrm{~A} * \mathrm{~B} * 0.10 \%) \end{array}$ |
|  | 660.00 | 223,409 | 1,076,384 | 545,564 | 1,592,458 | 353,880 | 666,282 | 211,679 | 143,321 |
|  | Cost for item (d): |  | 2,139,370 | 1,529,811 | 3,088,513 | 1,436,551 | 1,324,270 | 593,567 | 277,966 |



[^0]Table 4.8: Productivity loss (PL) due to air pollution per $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ change in each air pollutant

|  | PL (HK\$) per episode <br> A | Total no. of episodes/ per year <br> B | Productivity loss (HK\$) per year due to total air pollution for each pollutants |  |  |  | Productivity loss (HK\$) per year due to traffic-related air pollution for each pollutants |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | $\mathrm{C}=\mathrm{A} * \mathrm{~B}^{*} \mathrm{ER}$ |  |  |  | $\mathrm{NO}_{2} \underset{\mathbf{D}=\mathbf{A}}{ }$ | RSP <br> *B* Traffic-relate | ${ }_{\text {ER }} \mathrm{SO}_{2}$ |
| (a) Hospital admissions - Public |  |  |  |  |  |  |  |  |  |
| Respiratory |  |  | ( $\mathrm{A} * \mathrm{~B} * 0.54 \%)$ | ( $\mathrm{A} * \mathrm{~B} * 0.50 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.76 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.55 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.33 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.19 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.07 \%$ ) |
| 1. Acute General |  |  |  |  |  |  |  |  |  |
| F | 714.08 ${ }^{\text {\# }}$ | 4,407 ${ }^{\text { }}$ | 16,995 | 15,736 | 23,919 | 17,310 | 10,520 | 6,106 | 2,153 |
| M | 1,121.62 ${ }^{\text {\# }}$ | 11,292^ | 68,391 | 63,325 | 96,254 | 69,658 | 42,334 | 24,570 | 8,663 |
| 2. CR Infirmary ${ }^{\text {a }}$ |  |  |  |  |  |  |  |  |  |
| F | 1,372.93 ${ }^{\text {\# }}$ | $338{ }^{\wedge}$ | 2,504 | 2,319 | 3,524 | 2,551 | 1,550 | 900 | 317 |
| M | 2,511.12 ${ }^{\text {\# }}$ | $1,467{ }^{\wedge}$ | 19,890 | 18,416 | 27,993 | 20,258 | 12,312 | 7,146 | 2,519 |
| 3. Coronary Care Unit |  |  |  |  |  |  |  |  |  |
| F | $781.15{ }^{\text {\# }}$ | $61^{\wedge}$ | 258 | 239 | 363 | 262 | 159 | 93 | 33 |
| M | 1,270.36 ${ }^{\text {\# }}$ | $146 \wedge$ | 1,001 | 927 | 1,409 | 1,020 | 620 | 360 | 127 |
| Cardiovascular |  |  | ( $\mathrm{A} * \mathrm{~B} * 0.73 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.37 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 1.08 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.24 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.45 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.15 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.10 \%$ ) |
| 1. Acute General |  |  |  |  |  |  |  |  |  |
| F | $719.08{ }^{\text {\# }}$ | 6,122 ${ }^{\wedge}$ | 32,137 | 16,289 | 47,545 | 10,566 | 19,893 | 6,320 | 4,279 |
| M | 1,200.92 ${ }^{\text {\# }}$ | 14,032^ | 123,016 | 62,351 | 181,997 | 40,444 | 76,147 | 24,192 | 16,380 |
| 2. CR Infirmary |  |  |  |  |  |  |  |  |  |
| F | 2,441.56 ${ }^{\text {\# }}$ | 498^ | 8,872 | 4,497 | 13,125 | 2,917 | 5,492 | 1,745 | 1,181 |
| M | 4,568.55* | $1,034^{\wedge}$ | 34,470 | 17,471 | 50,997 | 11,333 | 21,337 | 6,779 | 4,590 |
| 3. Coronary Care Unit |  |  |  |  |  |  |  |  |  |
| F | $799.56{ }^{\text {\# }}$ | $83^{\wedge}$ | 486 | 246 | 719 | 160 | 301 | 96 | 65 |
| M | 1,226.96 ${ }^{\text {\# }}$ | $214 \wedge$ | 1,919 | 973 | 2,839 | 631 | 1,188 | 377 | 256 |
| Productivity loss: |  |  | 309,939 | 202,788 | 450,684 | 177,108 | 191,852 | 78,682 | 40,562 |


|  | PL (HK\$) <br> per episode <br> A | Total no. of episodes/ per year <br> B | Productivity loss (HK\$) per year due to total air pollution for each pollutants |  |  |  | Productivity loss (HK\$) per year due to traffic-related air pollution for each pollutants |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | C=A*B*ER |  |  |  | D=A*B*Traffic-related ER |  |  |
| (b) Hospital admissions - Private Respiratory |  |  | ( $\mathrm{A} * \mathrm{~B}$ *0.54\%) | ( $\mathrm{A} * \mathrm{~B} * 0.50 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.76 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.55 \%$ ) | ( A * ${ }^{\text {\% }} 0.33 \%$ ) | ( A * ${ }^{\text {* }} 0.19 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.07 \%$ ) |
| Cardiovascular | $919.46{ }^{\text {\# }}$ | 14,885 ${ }^{\wedge}$ | $\begin{array}{r} 73,907 \\ (\mathrm{~A} * \mathrm{~B} * 0.73 \%) \end{array}$ | $\begin{gathered} 68,432 \\ (\mathrm{~A} * \mathrm{~B} * 0.37 \%) \end{gathered}$ | $\begin{aligned} & 104,017 \\ & (\mathrm{~A} * \mathrm{~B} * 1.08 \%) \end{aligned}$ | $\begin{aligned} & \quad 75,275 \\ & (\mathrm{~A} * \mathrm{~B} * 0.24 \%) \end{aligned}$ | $\begin{array}{r} 45,748 \\ (\mathrm{~A} * \mathrm{~B} * 0.45 \%) \end{array}$ | $\begin{array}{r} \begin{array}{r} 26,552 \\ (\mathrm{~A} * \mathrm{~B} * 0.15 \%) \end{array} \end{array}$ | $\begin{array}{r} 9,362 \\ (\mathrm{~A} * \mathrm{~B} * 0.10 \%) \end{array}$ |
|  | 961.24 ${ }^{\text {\# }}$ | 8,199 ${ }^{\wedge}$ | 57,536 | 29,162 | 85,122 | 18,916 | 35,615 | 11,315 | 7,661 |
|  | Productivity loss: |  | 131,443 | 97,594 | 189,139 | 94,191 | 81,363 | 37,867 | 17,022 |
| (c) Private General Practitioner Visit |  |  |  |  |  |  |  |  |  |
| Respiratory |  |  | ( $\mathrm{A} * \mathrm{~B}^{*} 2.98 \%$ ) | (A*B*1.42\%) | (A*B*1.55\%) | (A*B*2.40\%) | ( ${ }^{*}{ }^{\text {B }}$ *1.845\%) | ( $\mathrm{A} * \mathrm{~B} * 0.551 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.140 \%$ ) |
| 1. Sick leave | $55.89{ }^{\text {@ }}$ | 15,220,317 ${ }^{+}$ | 25,349,959 | 12,079,511 | 13,185,381 | 20,416,074 | 15,691,624 | 4,686,850 | 1,186,684 |
| 2. Waiting \& travelling time | $20.55{ }^{\sim}$ | 15,220,317 ${ }^{+}$ | 9,319,838 | 4,440,997 | 4,847,567 | 7,505,910 | 5,768,980 | 1,723,107 | 436,281 |
| Cardiovascular |  |  | ( $\mathrm{A} * \mathrm{~B}^{*} 2.98 \%$ ) | ( $\mathrm{A} * \mathrm{~B}^{*} 1.42 \%$ ) | ( $\mathrm{A} * \mathrm{~B}^{*} 1.55 \%$ ) | (A*B*2.40\%) | ( $\mathrm{A} * \mathrm{~B} * 1.845 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.551 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.140 \%$ ) |
| 1. Sick leave | $55.89{ }^{\text {@ }}$ | 970,067 ${ }^{+}$ | 1,615,680 | 769,888 | 840,370 | 1,301,218 | 1,000,106 | 298,716 | 75,633 |
| 2. Waiting \& travelling time | 20.55 | 970,067 ${ }^{+}$ | 594,000 | 283,047 | 308,960 | 478,389 | 367,686 | 109,822 | 27,806 |
| Productivity loss : |  |  | 36,879,476 | 17,573,442 | 19,182,278 | 29,701,591 | 22,828,396 | 6,818,495 | 1,726,405 |


|  | PL (HK\$) <br> per person <br> A | Total personyears of life loss | Productivity loss (HK\$) per year due to total air pollution for each pollutants |  |  |  | Productivity loss (HK\$) per year due to traffic-related air pollution for each pollutants |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | C=A*B*ER |  |  |  | D=A*B* Traffic-related ER |  |  |
| (d) Premature death |  |  |  |  |  |  |  |  |  |
| Respiratory |  |  | ( $\mathrm{A} * \mathrm{~B} * 0.81 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.40 \%$ ) | (A*B*1.62\%) | ( $\mathrm{A} * \mathrm{~B} * 0.62 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.50 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.16 \%)$ | ( $\mathrm{A} * \mathrm{~B} * 0.15 \%)$ |
| F | 96,000.00 $=$ | 1,403 ${ }^{\text {> }}$ | 1,090,973 | 538,752 | 2,181,946 | 835,066 | 675,312 | 209,036 | 196,375 |
| M | $144,000.00=$ | 4,118 ${ }^{\text {> }}$ | 4,803,235 | 2,371,968 | 9,606,470 | 3,676,550 | 2,973,203 | 920,324 | 864,582 |
| Cardiovascular |  |  | ( ${ }^{*}{ }^{\text {B }}{ }^{*} 0.94 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.37 \%$ ) | ( $\mathrm{A} * \mathrm{~B}^{*} 1.61 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.58 \%)$ | ( $\mathrm{A} * \mathrm{~B} * 0.14 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.14 \%$ ) |
| F | 96,000.00 $=$ | 4,606 ${ }^{\text { }}$ | 4,156,454 | 1,636,051 | 7,119,034 | 0 | 2,572,845 | 634,788 | 640,713 |
| M | 144,000.00 $=$ | 11,144 ${ }^{\text {P }}$ | 15,084,518 | 5,937,523 | 25,836,250 | 0 | 9,337,317 | 2,303,759 | 2,325,262 |
|  | Productivity loss : |  | 25,135,181 | 10,484,294 | 44,743,699 | 4,511,616 | 15,558,677 | 4,067,906 | 4,026,933 |
|  | Total productivity loss: |  | 62,456,039 | 28,358,118 | 64,565,800 | 34,484,506 | 38,660,288 | 11,002,950 | 5,810,922 |

Note: Formula -
\# Mean LOS (in day) x median daily income
© Mean sick leave/consultation (in day) x median daily income
~ Mean waiting and travelling time/consultation (in hour) x median hourly income
^ Number of episodes (working group aged from 15-64) x labour force rate $x$ employment rate
$+\quad$ Number of consultations $x$ labour force rate $x$ employment rate
$=\quad$ Median monthly income by sex X 12
> Total number of years for those, aged from 15-64, died in year 2000 before 65 years old

Table 4.9: Estimates of willingness to pay (WTP) to avoid death, serious morbidity and minor morbidity for Hong Kong population in year 2000 and the value associated with $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ change in each air pollutant for the fraction related to traffic

(a) Deaths

| Respiratory | 10,000,000 ${ }^{\text {\# }}$ | 5,564 | ( $\mathrm{A} * \mathrm{~B} * 0.81 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.40 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 1.62 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.62 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.50 \%$ ) | (A*B *0.16\%) | ( $\mathrm{A} * \mathrm{~B} * 0.15 \%$ ) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | $\begin{gathered} 450,684,000 \\ (\mathrm{~A} * \mathrm{~B} * 0.94 \%) \end{gathered}$ | $\begin{gathered} 222,560,000 \\ (\mathrm{~A} * \mathrm{~B} * 0.37 \%) \end{gathered}$ | $\begin{aligned} & 901,368,000 \\ & (\mathrm{~A} * \mathrm{~B} * 1.61 \%) \end{aligned}$ | $\begin{aligned} & 344,968,000 \\ & (\mathrm{~A} * \mathrm{~B} * 0 \%) \end{aligned}$ | $\begin{aligned} & 278,973,396 \\ & (\mathrm{~A} * \mathrm{~B} * 0.58 \%) \end{aligned}$ | $\begin{gathered} 86,353,280 \\ (\mathrm{~A} * \mathrm{~B} * 0.14 \%) \end{gathered}$ | $\begin{aligned} & 81,123,120 \\ & (\mathrm{~A} * \mathrm{~B} * 0.14 \%) \end{aligned}$ |
| Cardiovascular | 10,000,000 ${ }^{\text {\# }}$ | 9,480 | 891,120,000 | 350,760,000 | 1,526,280,000 | -- | 551,603,280 | 136,094,880 | 137,365,200 |
|  | Cost for item (a): |  | 1,341,804,000 | 573,320,000 | 2,427,648,000 | 344,968,000 | 830,576,676 | 222,448,160 | 218,488,320 |
| (b) Serious morbidity |  |  |  |  |  |  |  |  |  |
| Respiratory | $00^{\text {@ }} 121,020$ |  | ( $\mathrm{A} * \mathrm{~B} * 0.54 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.50 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.76 \%$ ) | (A*B * $0.55 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.33 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.19 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.07 \%$ ) |
|  |  |  | $\begin{gathered} 3,202,189 \\ (\mathrm{~A} * \mathrm{~B} * 0.73 \%) \end{gathered}$ | $\begin{array}{r} 2,964,990 \\ (\mathrm{~A} * \mathrm{~B} * 0.37 \%) \end{array}$ | $\begin{gathered} 4,506,785 \\ (\mathrm{~A} * \mathrm{~B} * 1.08 \%) \end{gathered}$ | $\begin{aligned} & 3,261,489 \\ & (\mathrm{~A} * \mathrm{~B} * 0.24 \%) \end{aligned}$ | $\begin{gathered} 1,982,155 \\ (\mathrm{~A} * \mathrm{~B} * 0.45 \%) \end{gathered}$ | $\begin{gathered} 1,150,416 \\ (\mathrm{~A} * \mathrm{~B} * 0.15 \%) \end{gathered}$ | $\begin{array}{r} 405,611 \\ (\mathrm{~A} * \mathrm{~B} * 0.10 \%) \end{array}$ |
| Cardiovascular | 4,100 ${ }^{\text {® }}$ | 94,592 | 2,831,139 | 1,434,961 | 4,188,534 | 930,785 | 1,752,475 | 556,765 | 376,968 |
|  | Cost for item (b): |  | 6,033,328 | 4,399,951 | 8,695,319 | 4,192,274 | 3,734,630 | 1,707,181 | 782,579 |
| (c) Minor morbidity |  |  |  |  |  |  |  |  |  |
| Respiratory <br> (Upper respiratory tract) |  |  | ( $\mathrm{A} * \mathrm{~B} * 3.21 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 2.55 \%$ ) | ( A * ${ }^{\text {* } 2.16 \%) ~}$ | ( $\mathrm{A} * \mathrm{~B} * 2.20 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 1.99 \%$ ) | ( $\mathrm{A} * \mathrm{~B} * 0.99 \%$ ) | (A*B *0.19\%) |
| HK\$183.67^ $\times 4$ (day) | 734.68 | 22,688,508 | 535,068,257 | 425,054,223 | 360,045,930 | 366,713,447 | 331,207,251 | 164,921,039 | 32,404,134 |
| Cost for item (c): |  |  | 535,068,257 | 425,054,223 | 360,045,930 | 366,713,447 | 331,207,251 | 164,921,039 | 32,404,134 |

[^1]Table 4.10: Economic valuation (in HK\$ million) for health effects of air pollution, for a change in a pollutant concentration in total air pollution, and for the fraction related to road traffic
(I) for $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ change in a pollutant concentration

Monetary value to avoid mortality/morbidity ${ }^{\#}$

For whole Hong
Kong population
in year 2000
$(6,665,000)$
(a) Due to $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ change in total air pollution ${ }^{@}$ $\mathrm{NO}_{2}$
RSP
$\mathrm{SO}_{2}$
$\mathrm{O}_{3}$

Excluding Including productivity productivity loss loss 227.3289 .7
227.3
$114.3 \quad 142.6$
$142.7 \quad 207.2$
178.9
213.4

$$
1,901.8
$$

$$
285.3
$$

$$
1,015.9
$$

$$
152.4
$$

$$
2,823.8
$$

$$
423.7
$$

$$
727.9
$$

$$
109.2
$$

(b) Due to $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ change in trafficrelated air pollution

| $\mathrm{NO}_{2}$ | 140.7 | 179.3 | $1,177.2$ | 176.6 |
| :--- | ---: | ---: | ---: | ---: |
| RSP | 44.3 | 55.3 | 394.2 | 59.1 |
| $\mathrm{SO}_{2}$ | 12.8 | 18.7 | 254.1 | 38.1 |

Note: ${ }^{@}$ For part (a), excess risk (ER) for a $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ change in $\mathrm{O}_{3}$ for cardiovascular mortality was assumed to be zero.
\# Monetary value is calculated by the sum of WTP to avoid mortality/morbidity and cost of health service utilization due to public hospital admissions.
(II) for mean pollutant concentration in year 2000

Cost of illness
Monetary value to avoid mortality/morbidity ${ }^{\text {\# }}$

|  | Excluding <br> productivity <br> loss | Including <br> productivity <br> loss | For whole <br> Hong Kong <br> population in <br> year 2000 | Per 1 million <br> population |
| :--- | :---: | :---: | :---: | :---: |
| (a)Due to mean pollutant <br> concentration in total air | $1,325.2$ | $1,689.0$ | $(6,665,000)$ <br> pollution |  |
| (b)Due to mean pollutant <br> concentration in traffic- <br> related air pollution | 820.3 | $1,045.3$ | $1,663.6$ |  |

Table 5.1: Sensitivity analysis - Comparison of excess risk (ER) and $95 \%$ confidence interval (CI) of the best single lagged-day effects for a $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ change in pollutant concentration for mortality in 1995-2000: Overall population and roadside population*

|  | Overall population exposed to <br> overall concentrations |  |  | Roadside population exposed to <br> overall concentrations |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: |
| Mortality, age | Lag | ER $(95 \%$ CI $)$ | p-value | Lag | ER $(95 \%$ CI) | p-value |
| Respiratory, <br> all ages |  |  |  |  |  |  |
| $\mathrm{NO}_{2}$ | 0 | $0.81(0.24,1.38)$ | 0.006 | 0 | $0.77(0.22,1.33)$ | 0.006 |
| $\mathrm{SO}_{2}$ | 0 | $1.62(0.77,2.48)$ | 0.000 | 0 | $1.59(0.77,2.42)$ | 0.000 |
| RSP | 1 | $0.40(-0.05,0.85)$ | 0.080 | 1 | $0.38(-0.05,0.82)$ | 0.084 |

Cardiovascular, all ages

| $\mathrm{NO}_{2}$ | 2 | $0.94(0.44,1.44)$ | 0.000 | 2 | $0.90(0.41,1.39)$ | 0.000 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| $\mathrm{SO}_{2}$ | 2 | $1.61(0.78,2.44)$ | 0.000 | 2 | $1.55(0.74,2.37)$ | 0.000 |
| RSP | 2 | $0.37(-0.03,0.77)$ | 0.068 | 2 | $0.36(-0.03,0.76)$ | 0.070 |

*Roadside population is defined according to the Tertiary Planning Unit (TPU) coding of the guidebook from Census \& Statistics Department. Roadside districts include Central (TPU 121124), Causeway Bay (TPU 147), Tsim Sha Tsui (TPU 211-214), Yau Ma Tei (TPU 223-226) and Mongkok (TPU 221-222).

Table 5.2: Sensitivity analysis - Comparison of excess risk (ER) and $\mathbf{9 5 \%}$ confidence interval (CI) of the best single lagged-day effects for a $10 \mu \mathrm{~g} / \mathrm{m}^{3}$ change in pollutant concentration for hospital admissions in 1995-2000: Overall population and roadside population*

|  | Overall population exposed to <br> overall concentrations |  |  |  | Roadside population exposed to <br> overall concentrations |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Hospital admission, <br> Age | Lag | ER $(95 \%$ CI) | p-value | Lag | ER $(95 \% \mathrm{CI})$ | p-value |
| Respiratory, <br> all ages |  |  |  |  |  |  |
| $\mathrm{NO}_{2}$ |  |  |  |  |  |  |

Cardiovascular,
all ages

| $\mathrm{NO}_{2}$ | 0 | $0.73(0.48,0.98)$ | 0.000 | 0 | $0.88(0.17,1.59)$ | 0.016 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| $\mathrm{SO}_{2}$ | 0 | $1.08(0.72,1.44)$ | 0.000 | 0 | $1.18(0.14,2.23)$ | 0.026 |
| RSP | 0 | $0.37(0.18,0.57)$ | 0.000 | 0 | $0.45(-0.11,1.00)$ | 0.113 |

*Roadside population is defined according to district coding sheet provided from Hospital Authority. Roadside districts include Central, Causeway Bay, Wan Chai, Mongkok, Tai Kok Tsui, Tsim Sha Tsui and Yau Ma Tei.

Table 5.3: Sensitivity Analysis - Direct costs of illness due to traffic-related air pollution (TRAP)


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Appendices and Annexes

## Appendix 1:

## Roadside workers' perceptions of air pollution

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March 2002

## Roadside workers' s perceptions of air pollution

## 1. Objective

The main objective of this survey was to obtain the perceptions of roadside workers regarding traffic-related air pollution in order to help inform Government policy regarding roadside pollution levels in Hong Kong.

## 2. Methods

There were seven identified groups of roadside related workers. Each of these groups was surveyed aiming to achieve as many responses as possible from each group within the timespan allocated to the interviews - 24 December 2001 to 19 January 2002. The questionnaire used in this interview-based survey was the same as that used for the population survey, minus the assessment of willingness to pay to avoid symptoms because the numbers of respondents to this survey would be too small to estimate willingness to pay values.

## 3. Results

A total of 60 respondents completed in-person interviews. The distribution of responses within the target groups is shown in Table 1.

Table 1: Target groups and responses

|  | Frequency | $\%$ of total sample |
| :--- | :---: | :---: |
| Bus station workers | 5 | 8.3 |
| Construction workers | 10 | 16.7 |
| Drivers | 13 | 21.7 |
| Gas station workers | 7 | 11.7 |
| Hawkers | 10 | 16.7 |
| Household near busy bridges | 10 | 16.7 |
| Newspaper sellers | 5 | 8.3 |
| Total | 60 | 100.0 |

The following tables present the frequencies of responses for each question.
Table 2: Do you have coronary heart diseases or respiratory diseases?

|  | Frequency | $\%$ |
| :--- | :---: | :---: |
| Yes | 9 | 15.0 |
| No | 51 | 85.0 |
| Total | 60 | 100.0 |

Table 3: Do any of your family members or friends have coronary heart diseases or respiratory diseases such that you know what it is like to have these diseases?

|  | Frequency | $\%$ | Valid \% |
| :--- | :---: | :---: | :---: |
| Yes | 17 | 28.3 | 28.8 |
| No | 42 | 70.0 | 71.2 |
| Reject | 1 | 1.7 |  |
| Total | 60 | 100.0 | 100.0 |

Table 4: How would you rate your overall health at present?

|  | Frequency | $\%$ | Valid $\%$ |
| :--- | :---: | :---: | :---: |
| Excellent | 2 | 3.3 | 3.4 |
| Good | 13 | 21.7 | 22.0 |
| Fair | 43 | 71.7 | 72.9 |
| Poor | 1 | 1.7 | 1.7 |
| Missing | 1 | 1.7 |  |
| Total | 60 | 100.0 | 100.0 |

Table 5: What health problem(s) do you have that you think is related to air pollution (can choose more than 1 answer)?

|  | Frequency | $\%$ | No. (\%) of <br> respondents |
| :--- | :---: | :---: | :---: |
| Breathing problem | 31 | 36.47 |  |
| Allergic rhinitis | 11 | 12.94 |  |
| Dizziness, headache | 2 | 2.35 |  |
| Congested throat, coughing | 21 | 24.71 |  |
| Eye | 7 | 8.24 |  |
| Skin | 7 | 8.24 |  |
| Mental / Emotional status | 5 | 5.88 |  |
| Others | 1 | 1.18 |  |
| Total problems | 85 | 100.00 | $35(58.3)$ |
| No problem |  |  | $25(41.7)$ |

Table 6: How many hours per week on average do you spend outdoors? How many hours per week on average do you spend near a busy road or street with a lot of traffic?

|  | Outdoors |  |  | Busy traffic |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Frequency | \% | Valid \% | Frequency | \% | Valid \% |
| 0-9 | 2 | 3.3 | 3.4 | 10 | 16.7 | 17.9 |
| 10-19 | 5 | 8.3 | 8.5 | 5 | 8.3 | 8.9 |
| 20-29 | 4 | 6.7 | 6.8 | 4 | 6.7 | 7.1 |
| 30-39 |  |  |  | 2 | 3.3 | 3.6 |
| 40-49 | 11 | 18.3 | 18.6 | 8 | 13.3 | 14.3 |
| 50-59 | 9 | 15.0 | 15.3 | 8 | 13.3 | 14.3 |
| 60-69 | 16 | 26.7 | 27.1 | 13 | 21.7 | 23.2 |
| 70-79 | 4 | 6.7 | 6.8 |  |  |  |
| 80-89 | 8 | 13.3 | 13.6 | 6 | 10.0 | 10.7 |
| Reject | 1 | 1.7 |  | 4 | 6.7 |  |
| Total | 60 | 100.0 | 100.0 | 60 | 100.0 | 100.0 |
| Average | 50.8 SD 21.5 hours |  |  | 40.2 SD 25.8 hours |  |  |

Table 7: What do you consider to be the signs of good air quality (can choose more than 1 answer)?

|  | Frequency | $\%$ |
| :--- | :---: | ---: |
| Fresh air | 36 | 21.82 |
| Breathing comfortably | 28 | 16.97 |
| More plants - parks | 17 | 10.30 |
| Rural areas | 12 | 7.27 |
| Less exhaust fumes, less cars, less dust | 41 | 24.85 |
| Wind and rain | 3 | 1.82 |
| Visibility | 4 | 2.42 |
| API | 3 | 1.82 |
| Morning | 12 | 7.27 |
| Peak | 9 | 5.45 |
| Others | 0 | 0.00 |
| Total | 165 | 100.00 |

Table 8: How would you rate the air quality in the district you live over the last 12 months?

|  | Frequency | $\%$ |
| :--- | :---: | :---: |
| Very good | 3 | 5.0 |
| Good | 4 | 6.7 |
| Fair | 46 | 76.7 |
| Poor | 7 | 11.7 |
| Total | 60 | 100.0 |

Table 9: What is your sex?

|  | Frequency | $\%$ |
| :--- | :---: | :---: |
| Male | 42 | 70.0 |
| Female | 18 | 30.0 |
| Total | 60 | 100.0 |

Table 10: What is your age?

|  | Frequency | $\%$ | Valid $\%$ |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: |
| $17-24$ | 4 | 6.7 | 8.5 |  |  |
| $25-34$ | 6 | 10.0 | 12.8 |  |  |
| $35-44$ | 20 | 33.3 | 42.6 |  |  |
| $45-54$ | 14 | 23.3 | 29.8 |  |  |
| $55-64$ |  |  |  |  |  |
| $65+$ | 3 | 5.0 | 6.4 |  |  |
| Reject | 13 | 21.7 |  |  |  |
| Total | 60 | 100.0 | 100.0 |  |  |
| Average |  |  |  |  | $41.4 \pm 11.6$ years |

Table 11: What is the level of your educational attainment?

|  | Frequency | $\%$ |
| :--- | :---: | :---: |
| Primary or below | 20 | 33.3 |
| Secondary | 34 | 56.7 |
| Matriculation/ Diploma | 5 | 8.3 |
| Tertiary (degree) or above | 1 | 1.7 |
| Total | 60 | 100.0 |

Table 12: What is your housing type?

|  | Frequency | $\%$ |
| :--- | :---: | :---: |
| Public housing estate | 29 | 48.3 |
| Home ownership scheme | 14 | 23.3 |
| Private | 17 | 28.3 |
| Total | 60 | 100.0 |

Table 13: What is your marital status?

|  | Frequency | $\%$ |
| :--- | :---: | :---: |
| Single | 16 | 26.7 |
| Married | 40 | 66.7 |
| Separated |  |  |
| Divorced |  |  |
| Widowed | 4 | 6.7 |
| Total | 60 | 100.0 |

Table 14: Ask household near busy streets only: How many household members (including you) live at this address for at least 5 days a week on average?

|  | Frequency | $\%$ | Valid $\%$ |  |
| :--- | :---: | :---: | :---: | :---: |
| 1 | 1 | 10.0 | 14.3 |  |
| 2 | 2 | 20.0 | 28.6 |  |
| 3 |  |  |  |  |
| 4 | 1 | 10.0 | 14.3 |  |
| 5 | 3 | 30.0 | 42.9 |  |
| $6+$ | 3 | 30.0 | 100.0 |  |
| Reject | 10 | 100.0 | 10.0 |  |
| Total | $4.1 \pm 2.4$ members |  |  |  |
| Average |  |  |  |  |

Table 15: Ask household near busy streets only: In your household, how many children are 12 years of age or under?

|  | Frequency | $\%$ | Valid $\%$ |  |
| :--- | :---: | :---: | :---: | :---: |
| 0 | 5 | 50.0 | 71.4 |  |
| 1 | 1 | 10.0 | 14.3 |  |
| 2 | 1 | 10.0 | 14.3 |  |
| Reject | 2 | 20.0 |  |  |
| Missing | 1 | 10.0 |  |  |
| Total | 10 | 100.0 | 100.0 |  |
| Average | $0.4 \pm 0.8$ children |  |  |  |

Table 16: Ask household near busy streets only: What is your relationship with the household head?

|  | Frequency | $\%$ | Valid $\%$ |
| :--- | :---: | :---: | :---: |
| Self | 3 | 30.0 | 33.3 |
| spouse | 1 | 10.0 | 11.1 |
| children | 3 | 30.0 | 33.3 |
| parent |  |  |  |
| grandparent <br> grandchildren | 1 | 10.0 | 11.1 |
| Relative |  | 10.0 | 11.1 |
| Friend |  |  |  |
| Others | 1 | 10.0 |  |
| Reject | 10 | 100.0 | 100.0 |
| Total |  |  |  |

Table 17: How long have you been working in this field?

|  | Frequency | $\%$ | Valid \% |
| :--- | :---: | :---: | :---: |
| $0-5$ | 20 | 33.3 | 37.7 |
| $6-10$ | 14 | 23.3 | 26.4 |
| $11-15$ | 3 | 5.0 | 5.7 |
| $16-20$ | 7 | 11.7 | 13.2 |
| $21-25$ | 3 | 5.0 | 5.7 |
| $26-30$ | 6 | 10.0 | 11.3 |
| Missing | 7 | 11.7 |  |
| Total | 60 | 100.0 | 100.0 |
| Average |  | $11.7 \pm 9.2$ years |  |

Table 18: What is your average monthly household income? What is your average monthly personal income?

|  | Household Income |  |  | Personal Income |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Frequency | $\%$ | Valid $\%$ | Frequency | $\%$ | Valid $\%$ |
| Under $\$ 1,000$ |  |  |  | 2 | 3.3 | 10.5 |
| Under $\$ 2,000$ | 1 | 1.7 | 5.6 |  |  |  |
| $\$ 2,000-\$ 3,999$ | 1 | 1.7 | 5.6 | 1 | 1.7 | 5.3 |
| $\$ 4,000-\$ 5,999$ |  |  |  |  |  |  |
| $\$ 6,000-\$ 7,999$ |  |  |  | 1 | 1.7 | 5.3 |
| $\$ 8,000-\$ 9,999$ | 1 | 1.7 | 5.6 | 3 | 5.0 | 15.8 |
| $\$ 10,000-\$ 14,999$ |  |  |  | 2 | 3.3 | 10.5 |
| $\$ 15,000-\$ 19,999$ | 5 | 8.3 | 27.8 | 3 | 5.0 | 15.8 |
| $\$ 20,000-\$ 24,999$ | 5 | 8.3 | 27.8 | 6 | 10.0 | 31.6 |
| $\$ 25,000-\$ 29,999$ | 2 | 3.3 | 11.1 |  |  |  |
| $\$ 30,000-\$ 39,999$ | 1 | 1.7 | 5.6 | 1 | 1.7 | 5.3 |
| $\$ 40,000-\$ 59,999$ | 2 | 3.3 | 11.1 |  |  |  |
| $\$ 60,000$ and over |  |  |  |  |  |  |
| Reject | 42 | 70.0 |  | 41 | 68.3 |  |
| Total | 60 | 100.0 | 100.0 | 60 | 100.0 | 100.0 |

Table 19: In which district do you live? Ask household near busy streets only: In which district do you work (can choose more than 1 district)?

|  | Living district |  | Working district |  |
| :--- | :---: | :---: | :---: | :---: |
|  | Frequency | Valid $\%$ | Frequency | Valid $\%$ |
| Wanchai |  |  |  |  |
| Eastern District | 9 | 15.3 |  |  |
| Central/West District |  |  |  |  |
| Southern District | 1 | 1.7 |  | 50.0 |
| Kwun Tong | 12 | 20.3 | 4 | 25.0 |
| Kowloon City | 4 | 6.8 | 2 | 12.5 |
| Wong Tai Sin | 6 | 10.2 | 1 |  |
| Mongkok | 1 | 1.7 |  |  |
| Shamshuipo | 3 | 5.1 |  | 12.5 |
| Yaumati/Tsimshatsui |  |  | 1 |  |
| Sai Kung | 2 | 3.4 |  |  |
| Shatin | 5 | 8.5 |  |  |
| Islands |  |  |  |  |
| Tsuen Wan | 3 | 5.1 |  |  |
| Kwai Chung/ Tsing Yi | 2 | 3.4 |  |  |
| Tuen Mun | 1 | 1.7 |  |  |
| Yuen Long | 3 | 5.1 |  |  |
| North District | 2 | 3.4 |  |  |
| Tai Po | 5 | 8.7 |  |  |
| Reject |  |  | 2 |  |
| Missing | 1 | 100.0 | 10 | 100.0 |
| Total | 60 |  |  |  |

Table 20: Place of birth

|  |  | Frequency | $\%$ |
| :--- | :---: | :---: | :---: |
| Valid $\%$ |  |  |  |
| Hong Kong | 43 | 71.7 | 72.9 |
| Mainland China | 16 | 26.7 | 27.1 |
| Reject | 1 | 1.7 |  |
| Total | 60 | 100.0 | 100.0 |

Table 21: Have you ever smoked?

|  | Frequency | $\%$ |
| :--- | :---: | :---: |
| Never | 28 | 46.7 |
| Smoked occasionally in the past (less than one cigarette a day and for more |  |  |
| than 6 months) | 3 | 5.0 |
| Smoked regularly in the past (more than one cigarette a day for over 6 | 5 | 8.3 |
| months continuously) | 24 | 40.0 |
| Smoke occasionally (on average less than one cigarette a day) | 60 | 100.0 |
| Smoke regularly (at least one cigarette a day) |  |  |
| Total |  |  |

Table 22: Excluding yourself, how many smokers reside at your unit/ work with you?

|  | Frequency | Valid \% | $\%$ | Mean (SD) |
| :--- | :---: | :---: | :---: | :---: |
| 0 | 26 | 49.1 | 43.3 |  |
| 1 | 8 | 15.1 | 13.3 |  |
| 2 | 2 | 3.8 | 3.3 |  |
| 3 | 3 | 5.7 | 5.0 |  |
| 4 | 7 | 13.2 | 11.7 |  |
| 5 | 1 | 1.9 | 1.7 |  |
| $6+$ | 6 | 11.3 | 10.0 |  |
| Reject | 5 |  | 8.3 |  |
| Missing | 2 |  | 3.3 |  |
| Total | 60 | 100.0 | 100.0 | $1.8(2.5)$ smokers |

## 4. Comparison of responses of roadside workers and population

Table 23: Age

| Age Group | Sample $\mathrm{N}=60$ |  | 2001 Population census |  | Goodness of fit test $\chi^{2}$ p-value |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | N | \% | N | \% |  |
| Male |  |  |  |  |  |
| 18-24 (15-24)* | 3 | 8.8 | 456639 | 16.8 |  |
| 25-34 | 4 | 11.8 | 499492 | 18.4 |  |
| 35-44 | 15 | 44.1 | 650455 | 24.0 |  |
| 45-54 | 11 | 32.4 | 489891 | 18.1 |  |
| 55-64 | 0 | 0.0 | 269326 | 9.9 |  |
| >=65 | 1 | 2.9 | 345184 | 12.7 | 0.003 |
| Female |  |  |  |  |  |
| 18-24 (15-24)* | 1 | 7.7 | 463806 | 16.1 |  |
| 25-34 | 2 | 15.4 | 609037 | 21.1 |  |
| 35-44 | 5 | 38.5 | 710032 | 24.6 |  |
| 45-54 | 3 | 23.1 | 470526 | 16.3 |  |
| 55-64 | 0 | 0.0 | 232716 | 8.1 |  |
| >=65 | 2 | 15.4 | 401868 | 13.9 | 0.666 |
| Both Sexes |  |  |  |  |  |
| 18-24 (15-24)* | 4 | 8.5 | 920445 | 16.4 |  |
| 25-34 | 6 | 12.8 | 1108529 | 19.8 |  |
| 35-44 | 20 | 42.6 | 1360487 | 24.3 |  |
| 45-54 | 14 | 29.8 | 960417 | 17.2 |  |
| 55-64 | 0 | 0.0 | 502042 | 9.0 |  |
| $>=65$ | 3 | 6.4 | 747052 | 13.3 | 0.001 |

[^2]Table 24: Geographical Distribution by District Council District

| District | Sample $\mathrm{N}=60$ |  | 2001 Population census | Goodness of fit test |  |
| :--- | ---: | ---: | ---: | ---: | ---: |
|  | N | $\%$ | N | $\%$ | $\chi^{2} \mathrm{p}$-value |
| Central and Western | 0 | 0.0 | 261884 | 3.9 |  |
| Wan Chai | 0 | 0.0 | 167146 | 2.5 |  |
| Eastern | 9 | 15.3 | 616199 | 9.2 |  |
| Southern | 1 | 1.7 | 290 | 240 | 4.3 |
| Yau Tsim Mong | 1 | 1.7 | 282020 | 4.2 |  |
| Sham Shui Po | 3 | 5.1 | 353550 | 5.3 |  |
| Kowloon City | 4 | 6.8 | 381352 | 5.7 |  |
| Wong Tai Sin | 6 | 10.2 | 444630 | 6.6 |  |
| Kwun Tong | 12 | 20.3 | 562427 | 8.4 |  |
| Kwai Tsing | 2 | 3.4 | 477092 | 7.1 |  |
| Tsuen Wan | 3 | 5.1 | 275527 | 4.1 |  |
| Tuen Mun | 1 | 1.7 | 488831 | 7.3 |  |
| Yuen Long | 3 | 5.1 | 449070 | 6.7 |  |
| North | 2 | 3.4 | 298657 | 4.5 |  |
| Tai Po | 5 | 8.5 | 310879 | 4.6 |  |
| Sha Tin | 5 | 8.5 | 628634 | 9.4 |  |
| Sai Kung | 2 | 3.4 | 327689 | 4.9 |  |
| Islands | 0 | 0.0 | 86667 | 1.3 |  |

Table 25: Gender

| Gender |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Male | 42 | 70.0 | 2710987 | 48.4 |  |
| Female | 18 | 30.0 | 2887985 | 51.6 | 0.001 |

only those aged $>=15$ for population data
Table 26: Educational attainment

| Educational Attainment | Sample $\mathrm{N}=60$ |  | 2001 Population census |  | Goodness of fit test |  |
| :--- | ---: | ---: | ---: | ---: | :---: | :---: |
|  | N | $\%$ | N | $\%$ | $\chi^{2} \mathrm{p}$-value |  |
| Primary or below | 20 | 33.3 | 1618212 | 28.9 |  |  |
| Secondary | 34 | 56.7 | 2534170 | 45.3 |  |  |
| Matriculation/Diploma | 5 | 8.3 | 737968 | 13.2 |  |  |
| Tertiary | 1 | 1.7 | 708622 | 12.7 |  |  |

## 5. Comparison between the roadside workers and the general population sample

Table 27: Do you have coronary heart diseases or respiratory diseases?

|  | Roadside sample \% | \% in population sample |
| :--- | :---: | :---: |
| Yes | 15.0 | 5.4 |
| No | 85.0 |  |
| Total | 100.0 |  |

Table 28: How would you rate your overall health at present?

|  | Roadside <br> sample $\%$ | \% in population <br> sample |
| :--- | :---: | :---: |
| Excellent | 3.4 | 20.7 |
| Good | 22.0 | 35.4 |
| Fair | 72.9 | 40.0 |
| Poor | 1.7 | 3.9 |
| Total | 100.0 | 100 |

Table 29: What health problem(s) do you have that you think is related to air pollution (can choose more than 1 answer)?

|  | Roadside sample |  | Population sample |  |
| :--- | :---: | :---: | :---: | :---: |
|  | \% distribution <br> of problems | No. (\%) | $\%$ distribution <br> of problems | No. (\%) |
| Breathing problem | 37 |  | 56 |  |
| Allergic rhinitis | 13 |  | 14 |  |
| Dizziness, headache | 2 |  | 4 |  |
| Congested throat, <br> coughing | 25 |  | 15 |  |
| Others | 24 | 11 |  |  |
| Total |  | 100 | $960(69.3)$ |  |
| No perceived problem <br> related to air pollution | 100 | $35(58.3)$ |  | $425(30.7)$ |

Table 30: How many hours per week on average do you spend outdoors? How many hours per week on average do you spend near a busy road or street with a lot of traffic?

|  | Mean (SD) hours per week outdoors | Mean (SD) hours per week near busy roads |
| :---: | :---: | :---: |
| Roadside workers | $50.8(21.5)$ | $40.2(25.8)$ |
| Population | $26.1(20.8)$ | $12.0(14.6)$ |

Table 31: What do you consider to be the signs of good air quality (can choose more than 1 answer)?

|  | Roadside sample <br> $\%$ choosing | Population sample <br> $\%$ choosing |
| :--- | :---: | :---: |
| Fresh air | 22 | 16 |
| Breathing comfortably | 17 | 7 |
| More plants - parks | 10 | 18 |
| Rural areas | 7 | 16 |
| Less exhaust fumes, less | 25 | 31 |
| cars, less dust |  |  |
| Wind and rain | 2 | 2 |
| Others | 17 | 11 |
| Total | 100 | 100 |

Table 32: How would you rate the air quality in the district you live over the last 12 months?

|  | Roadside sample $\%$ | \% in population sample |
| :--- | :---: | :---: |
| Very good | 5.0 | 9.6 |
| Good | 6.7 | 33.1 |
| Fair | 76.7 | 46.1 |
| Poor | 11.7 | 11.2 |
| Total | 100.0 | 100 |

## 6. Discussion

The roadside workers are clearly, as expected, a different group in demographic and socioeconomic characteristics from the general population and the population sample used for the WTP estimates. They have a higher rate of declared heart and respiratory disease ( $15 \%$ versus 5\%) and poorer self-perceived health with $75 \%$ being fair or poor compared with $44 \%$ of the population sample. They are more inclined to complain of throat symptoms than breathing problems but this may reflect a 'survivor effect' i.e. 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 say they have no problem related to air pollution compared with only $31 \%$ of the general population. They spend for 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 ( $88 \%$ versus $57 \%$ ) although the same proportion $11-12 \%$ rate the air quality as poor.

## Appendix 2: <br> Validation of value of life

Health Economics Team: Health Services Research Group
Department of Community Medicine, The University of Hong Kong

## Validation of value of life

## 28 March 2002

## Objective

To test the validity of the estimate taken from the WHO European study for the value of a life lost or saved in Hong Kong.

## Methods

A short questionnaire was designed to determine whether the population would accept a value for avoiding a risk of death that would multiply up to give the same value as used in the WHO European study ( 1.4 million euros or HK $\$ 10$ million).

The question asked was: 'If one life can be saved when there are 100,000 persons in Hong Kong willing to give HK\$100 each, are you willing to pay?'

## Results

Out of 183 households contacted (from 600 numbers attempted), 108 interviews were carried out; response rate is $59 \%$.

Comparison of demographic characteristic of sample with 2001 Census data


\begin{tabular}{|c|c|c|c|c|c|c|}
\hline \multirow[t]{5}{*}{Education
$$
(15+)
$$} \& Primary or below \& 1618212 \& 28.9 \& 30 \& 27.8 \& \multirow[b]{5}{*}{0.968} <br>
\hline \& Secondary \& 2534170 \& 45.3 \& 51 \& 47.2 \& <br>
\hline \& Matriculation/Diploma \& 737968 \& 13.2 \& 13 \& 12.0 \& <br>
\hline \& Tertiary \& 708622 \& 12.7 \& 14 \& 13.0 \& <br>
\hline \& \& 5598972 \& 100.0 \& 108 \& 100.0 \& <br>
\hline \multirow[t]{5}{*}{Marital status
(15+)} \& Never married \& 1787519 \& 31.9 \& 23 \& 21.7 \& \multirow[b]{5}{*}{0.070} <br>
\hline \& Now married \& 3325482 \& 59.4 \& 75 \& 70.8 \& <br>
\hline \& Widowed \& 333622 \& 6.0 \& 4 \& 3.8 \& <br>
\hline \& Divorced/Separated \& 152349 \& 2.7 \& 4 \& 3.8 \& <br>
\hline \& \& 5598972 \& 100.0 \& 106 \& 100.0 \& <br>
\hline \multirow[t]{9}{*}{Occupation} \& Manager \& 349637 \& 10.7 \& 5 \& 7.4 \& \multirow[b]{16}{*}{0.000

0.462} <br>
\hline \& Professionals \& 678496 \& 20.9 \& 10 \& 14.7 \& <br>
\hline \& Clerks \& 529992 \& 16.3 \& 25 \& 36.8 \& <br>
\hline \& Service workers \& 488961 \& 15.0 \& 12 \& 17.6 \& <br>
\hline \& Craft workers \& 321000 \& 9.9 \& 6 \& 8.8 \& <br>
\hline \& Machine operator \& 238666 \& 7.3 \& 1 \& 1.5 \& <br>
\hline \& Elementary \& 635393 \& 19.5 \& 7 \& 10.3 \& <br>
\hline \& Agricultural \& 10561 \& 0.3 \& 2 \& 2.9 \& <br>
\hline \& \& 3252706 \& 100.0 \& 68 \& 100.0 \& <br>
\hline \multirow[t]{7}{*}{Household size} \& 1 \& 321565 \& 15.7 \& 14 \& 13.0 \& <br>
\hline \& 2 \& 447690 \& 21.8 \& 17 \& 15.7 \& <br>
\hline \& 3 \& 438216 \& 21.3 \& 29 \& 26.9 \& <br>
\hline \& 4 \& 481183 \& 23.4 \& 26 \& 24.1 \& <br>
\hline \& 5 \& 245194 \& 11.9 \& 16 \& 14.8 \& <br>
\hline \& 6 and over \& 119564 \& 5.8 \& 6 \& 5.6 \& <br>
\hline \& \& 2053412 \& 100.0 \& 108 \& 100.0 \& <br>
\hline Household \& <2,000 \& 65855 \& 3.2 \& 4 \& 4.4 \& \multirow{12}{*}{0.462} <br>
\hline \multirow[t]{12}{*}{Income} \& 2,000-3,999 \& 97568 \& 4.8 \& 1 \& 1.1 \& <br>
\hline \& 4,000 - 5,999 \& 93018 \& 4.5 \& 5 \& 5.5 \& <br>
\hline \& 6,000-7,999 \& 116340 \& 5.7 \& 5 \& 5.5 \& <br>
\hline \& 8,000 - 9,999 \& 120721 \& 5.9 \& 3 \& 3.3 \& <br>
\hline \& 10,000-14,999 \& 318623 \& 15.5 \& 17 \& 18.7 \& <br>
\hline \& 15,000-19,999 \& 262086 \& 12.8 \& 13 \& 14.3 \& <br>
\hline \& 20,000-24,999 \& 223708 \& 10.9 \& 10 \& 11.0 \& <br>
\hline \& 25,000-29,999 \& 159470 \& 7.8 \& 7 \& 7.7 \& <br>
\hline \& 30,000-39,999 \& 219229 \& 10.7 \& 11 \& 12.1 \& <br>
\hline \& 40,000-59,999 \& 197311 \& 9.6 \& 8 \& 8.8 \& <br>
\hline \& > $=\mathbf{6 0 , 0 0 0}$ \& 179483 \& 8.7 \& 7 \& 7.7 \& <br>
\hline \& \& 2053412 \& 100.0 \& 91 \& 100.0 \& 0.917 <br>
\hline
\end{tabular}

$81.3 \%$ of respondents agreed to be one of 100,000 willing to donate $\$ 100$ i.e. they agree to a total value of $\$ 10$ million for one life. $(\$ 100 * 100,000$ people $=\$ 10,000,000)$.

## Conclusion

These figures imply that a life in HK can actually be valued higher than HK $\$ 10$ million. Therefore, we can say that HK $\$ 10$ million is a conservative estimation for the value of statistical life in Hong Kong.

## Appendix 3: Residuals and auto-correlation plots

(a) Respiratory mortality


(b) Cardiovascular mortality


(c) Respiratory hospital admissions

(d) Cardiovascular hospital admissions



## Appendix 4: Predicted (solid line) according to core model and observed (dotted line)

 plots from 1995-2000

(b) Cardiovascular mortality


(c) Respiratory hospital admissions

(d) Cardiovascular hospital admissions



## Appendix 5: Difference between expected number of hospital admissions and observed

 number of hospital admissions according to 1995-2000 model adjusted by different pollutants from 1 Jan 2001 to 31 Mar 2001(a) Respiratory hospital admissions



RSP


(b) Cardiovascular hospital admissions





Appendix 6: Preliminary analysis of carbon monoxide ( $\mathbf{C O}$ ) and fine suspended particulates (FSP) recorded during 1998-2000 in Tsuen Wan station
(a) Mortality

| Disease, age <br> (ICD9) | Lag | ER (95\% CI) | p-value |
| :--- | :---: | :--- | ---: |
| Non-accidental, all ages <br> (ICD9 001-799) |  |  |  |
| $\quad$ CO | 0 | $-0.10(-0.28,0.08)$ | 0.257 |
| $\quad$ FSP | 3 | $-0.53(-0.94,-0.12)$ | 0.011 |

Respiratory, all ages
(ICD9 460-519)

| CO | 3 | $-0.23(-0.60,0.14)$ | 0.225 |
| :--- | :--- | :--- | :--- |
| FSP | 0 | $-0.54(-1.39,0.32)$ | 0.215 |

COPD, all ages
(ICD9 490-496 excluding 493)
CO
FSP
$1 \quad-0.32(-1.02,0.38)$
0.365
$1 \quad-1.11(-2.76,0.57)$
0.196

Cardiovascular, all ages
(ICD9 390-459)
CO
2
$-0.14(-0.48,0.19)$
0.395
FSP
3
$-0.52(-1.28,0.25)$
0.186

Cardiac, all ages
(ICD9 390-429)

| CO | 3 | $0.15(-0.30,0.60)$ | 0.514 |
| :--- | :--- | ---: | :--- |
| FSP | 3 | $-0.81(-1.84,0.23)$ | 0.125 |

IHD, all ages
(ICD9 410-414)

| CO | 1 | $0.18(-0.35,0.71)$ | 0.516 |
| :--- | :--- | :--- | :--- |
| FSP | 1 | $0.74(-0.48,1.98)$ | 0.237 |

(b) Hospital admission

| Disease, age (ICD9) | Lag | ER (95\% CI) | p-value |
| :---: | :---: | :---: | :---: |
| Respiratory, all ages (ICD9 460-519) |  |  |  |
| CO | 1 | -0.21 (-0.39, -0.04) | 0.013 |
| FSP | 0 | 0.80 (0.43, 1.18) | 0.000 |
| Respiratory, 65+ <br> (ICD9 460-519) |  |  |  |
| CO | 0 | 0.25 (0.06, 0.45) | 0.011 |
| FSP | 0 | 1.36 (0.90, 1.82) | 0.000 |
| Asthma, 15-64 years (ICD9 493) |  |  |  |
| CO | 1 | 0.80 (0.22, 1.39) | 0.007 |
| FSP | 1 | -0.40 (-1.77, 0.99) | 0.572 |
| Cardiovascular, all ages (ICD9 390-459) |  |  |  |
| CO | 3 | 0.12 (-0.03, 0.27) | 0.126 |
| FSP | 0 | 0.41 (0.06, 0.77) | 0.023 |
| Cardiac, all ages <br> (ICD9 390-429) |  |  |  |
| CO | 3 | 0.11 (-0.07, 0.30) | 0.237 |
| FSP | 0 | 0.39 (-0.01, 0.81) | 0.059 |
| IHD, all ages <br> (ICD9 410-414) |  |  |  |
| CO | 0 | 0.81 (-1.73, 3.41) | 0.536 |
| FSP | 0 | 0.54 (-0.11, 1.19) | 0.103 |

# Valuation of health impact of air pollution in Hong Kong: Household survey 

WORKING PAPER NO: AP 02-02-001

## Health Economics Team: Health Services Research Group Department of Community Medicine, The University of Hong Kong March 2002

This report is currently unpublished and therefore should not yet be quoted. Report and questionnaires obtainable from the Department of Community Medicine.

## Valuation of health impacts of air pollution in Hong Kong: Household survey

## Summary

A telephone survey on Hong Kong households was performed during the period August to November, 2001. The objectives were to estimate the willingness to pay (WTP) to avoid respiratory symptoms related to air pollution, 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 topic of air pollution was not mentioned until after the respondent had reported on their health status and symptoms.

The sample under-represented the higher income groups and smaller households in the population and any implications drawn from the data should take this into account. 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 average number of hours per week spent near busy roads was $12,46 \%$ of the time outdoors. Regarding where they lived, $11 \%$ thought the air quality was poor, almost half thought it was only fair. In Kowloon, those who lived closer to ground level considered their air quality poorer.

## 1. Background

There is a growing interest in quantifying the effects of risk factors in the environment in order to inform public policy. One of the most serious current concerns is air pollution. Reducing air pollutants is not cheap and decision-makers may want to have some idea of the value of the benefits that will be brought about by any reduction before determining what level of resources to commit to reducing air pollution. We lack information on the monetary value of many of the potential benefits in Hong Kong. It is doubtful whether information on values from overseas populations, even if available, could be directly extrapolated to Hong Kong. There is clearly a need for new empirical studies valuing the avoidance symptoms associated with air pollution.

To value the avoidance of health impacts of air pollution, contingent valuation is being increasingly used. This involves obtaining a representative sample of the population and determining their WTP to avoid specific symptoms. The currently favoured method of obtaining the values is by closed-ended questions (bids) to which the respondent answers yes or no and this method was used in the current study.

## 2. Objectives

1. To obtain the WTP to avoid symptoms related to air pollution
2. To obtain data on factors which may confound the relationship between WTP and exposure to air pollution
3. To obtain other relevant data on exposure to and perceptions of air pollution and health status.

## 3. Methods

The detailed methods and results of the WTP valuations are described in another working paper no. AP 02-02-002. This working paper reports on the methods of the survey and the other results obtained
3.1 Sample: A population sample was obtained by a telephone survey on Hong Kong households during the period August 8, 2001 to November 17, 2001. To minimise sampling bias, the random digit dialing method for generating the sample list of telephone numbers and the "Kish Grid" approach to randomly select target respondents were adopted. The interviewers first asked the household how many adult family members of 18 years old or above were living in the unit. Next, they requested to interview the target respondent, which was determined by asking the household to rank the age of all family members from the eldest to the youngest and then choosing the person who was ranked as the random number pre-determined by us. Up to 15 attempts were made to contact the targetted respondent. When contacted, he or she was interviewed using a structured questionnaire in a telephone interview.
3.2 Questionnaire: The questionnaire was developed by using as many previously validated questions as possible and was extensively pilotted on the local population and amended. All interviews were in Cantonese.

The questionnaire had 3 main sections:

1. Health status and WTP including prevalence of symptoms, value of avoiding symptoms ranking of symptoms, existing health problems and self-perceived health
2. Perceptions of air pollution
3. Demographic characteristics

In the initial section of the questionnaire, we asked the respondent whether he/ she had experienced the relevant symptoms in the past 12 months. The symptoms were coughing, shortness of breath, sinus congestion, congested throat, itching and smarting eyes, and fever. We asked every respondent about three symptoms: coughing, breathing trouble, and a randomly allocated symptom from the other four symptoms (sinus congestion, congested throat, itching and smarting of eyes, or fever). Therefore, each respondent was asked about a sub-set of the symptoms but the remainder of the questionnaire was identical for everyone.

We followed previous studies and use a closed-ended question format to elicit people's WTP for avoiding one day of each symptom. To maintain comparability, our symptom descriptions mainly follow those of Navrud (1997) but were translated into the local Chinese dialect. Air pollution was not mentioned in the survey. Thus, we estimate non-contextual values which should be more transferable from one project to another. A separate working paper no. AP 02-02-002 describes the details of the methods used for the WTP questions.

## 4. Results

During the period August 8, 2001 to November 17, 2001, we made 5,416 calls to randomly selected individuals. Of these, about 1,671 phone numbers were invalid (no such number, need password, fax line, moved, etc.), and 727 numbers were commercial lines. Another 904 numbers were unanswered after at least 5 tries and 147 people could not speak Chinese or
were too old to participate. Only 580 subjects refused to participate in the survey. The final response rate is $71 \%$.

There were 1,387 sets of observations. Usual error checking procedures were applied. One subject did not answer the WTP questions and one observation was deemed invalid because the amount was over the budget constraint, leaving 1,385 complete sets of data for analysis.

The following tables provide the frequencies of responses for questions in the questionnaire but not including the WTP questions which are reported in the working paper no. AP 02-02002.

## Health status : symptoms

Table 1: Have you experienced coughing in the past 12 months?

|  | Frequency | $\%$ |
| :--- | :---: | :---: |
| Yes | 466 | 33.7 |
| No | 919 | 66.4 |
| Total | 1385 | 100.0 |

Table 2: Have you experienced breathing trouble in the past 12 months?

|  | Frequency | $\%$ |
| :--- | :---: | :---: |
| Yes | 425 | 30.7 |
| No | 960 | 69.3 |
| Total | 1385 | 100.0 |

Table 3: Have you experienced sinus congestion in the past 12 months?

|  | Frequency | $\%$ | Valid $\%$ |
| :---: | :---: | :---: | :---: |
| Yes | 159 | 11.5 | 43.3 |
| No | 208 | 15.0 | 56.7 |
| Total | 367 | 26.5 | 100.0 |
| Question not asked | 1018 | 73.5 |  |
| Total | 1385 | 100.0 |  |

Table 4: Have you experienced congested throat in the past 12 months?

|  | Frequency | $\%$ | Valid \% |
| :---: | :---: | :---: | :---: |
| Yes | 174 | 12.6 | 51.1 |
| No | 167 | 12.0 | 49.0 |
| Total | 341 | 24.6 | 100.0 |
| Question not asked | 1044 | 75.4 |  |
| Total | 1385 | 100.0 |  |

Table 5: Have you experienced itching and smarting of eyes in the past 12 months?

|  | Frequency | $\%$ | Valid \% |
| :---: | :---: | :---: | :---: |
| Yes | 113 | 8.2 | 31.8 |
| No | 243 | 17.5 | 68.3 |
| Total | 356 | 25.7 | 100.0 |
| Question not asked | 1029 | 74.3 |  |
| Total | 1385 | 100.0 |  |

Table 6: Have you experienced fever in the past 12 months?

|  | Frequency | $\%$ | Valid \% |
| :---: | :---: | :---: | :---: |
| Yes | 136 | 9.9 | 42.4 |
| No | 185 | 13.4 | 57.6 |
| Total | 321 | 23.2 | 100.0 |
| Question not asked | 1064 | 76.8 |  |
| Total | 1385 | 100.0 |  |

Table 7: If you have one day of symptoms tomorrow, which symptom is most troublesome?

|  | Frequenc <br>  <br>  <br>  <br>  <br> Coughing | $\%$ | Valid <br> $\%$ |  |
| :--- | :--- | :---: | :---: | :---: |
| Breathing trouble | 419 | 30.3 | 30.3 |  |
|  | 653 | 47.1 | 47.3 |  |
|  | Sinus congestion | 98 | 7.1 | 7.1 |
|  | Congested throat | 55 | 4.0 | 4.0 |
|  | Itching and smarting of | 83 | 6.0 | 6.0 |
|  | eyes |  |  |  |
|  | Fever | 74 | 5.3 | 5.4 |
|  | Total | 1382 | 99.8 | 100.0 |
|  | Missing | 3 | .2 |  |
| Total |  | 1385 | 100.0 |  |

Table 8: If you have one day of symptoms tomorrow, which symptom is least troublesome?

|  | Frequenc <br>  <br>  <br>  <br> Coughing | $\%$ | Valid <br> $\%$ |
| :--- | :---: | :---: | :---: |
| Breathing trouble | 501 | 36.2 | 36.3 |
|  | 174 | 12.6 | 12.6 |
|  | Sinus congestion | 197 | 14.2 |
| Congested throat | 187 | 13.3 |  |
|  | Itching and smarting of | 162 | 11.7 |
| eyes |  | 13.6 |  |
|  |  |  |  |
|  | Fever | 158 | 11.4 |
|  | Total | 6 | 11.5 |
|  | Missing | 1385 | .4 |
| Total |  |  | 100.0 |

## Existing health problems

Table 9: Has your doctor ever told you you had acute bronchitis?

|  | Frequency | $\%$ | Valid $\%$ |
| :--- | :---: | :---: | :---: |
| Yes | 96 | 6.9 | 6.9 |
| No | 1289 | 93.1 | 93.1 |
| Total | 1385 | 100.0 | 100.0 |

Table 10: Has your doctor ever told you you had asthma?

|  | Frequency | $\%$ | Valid $\%$ |
| :--- | :---: | :---: | :---: |
| Yes | 57 | 4.1 | 4.1 |
| No | 1328 | 95.9 | 95.9 |
| Total | 1385 | 100.0 | 100.0 |

Table 11: Has your doctor ever told you you had coronary heart disease?

|  | Frequency | $\%$ | Valid $\%$ |
| :--- | :---: | :---: | :---: |
| Yes | 30 | 2.2 | 2.2 |
| No | 1355 | 97.8 | 97.8 |
| Total | 1385 | 100.0 | 100.0 |

Table 12: Has your doctor ever told you you had either one of these: chronic bronchitis, emphysema, or chronic obstructive airways disease?

|  | Frequency | $\%$ | Valid $\%$ |
| :--- | :---: | :---: | :---: |
| Yes | 75 | 5.4 | 5.4 |
| No | 1310 | 94.6 | 94.6 |
| Total | 1385 | 100.0 | 100.0 |

## Self-perceived health

Table 13:How would you rate your overall health at present?

|  | Frequency | $\%$ | Valid \% |  |
| :--- | :--- | :---: | :---: | :---: |
|  | Excellent | 287 | 20.7 | 20.7 |
|  | Good | 490 | 35.4 | 35.4 |
|  | Fair | 553 | 39.9 | 40.0 |
|  | Poor | 54 | 3.9 | 3.9 |
|  | Total | 1384 | 99.9 | 100.0 |
|  | Missing | 1 | .1 |  |
| Total |  | 1385 | 100.0 |  |

## Perceptions of air pollution

Table 14: Do you think air pollution affects your health?

|  | Frequency | $\%$ | Valid $\%$ |
| :--- | :---: | :---: | :---: |
| Yes | 960 | 69.3 | 69.3 |
| No | 425 | 30.7 | 30.7 |
| Total | 1385 | 100.0 | 100.0 |

Table 15: If yes, what health problem do you have that you think is related to air pollution (can choose more than 1 answer)?

|  | Frequency | $\%$ |
| :--- | :---: | :---: |
| Breathing problem | 632 | 56.3 |
| Allergic rhinitis | 156 | 13.9 |
| Dizziness, headache | 41 | 3.7 |
| Congested throat, coughing | 169 | 15.0 |
| Others | 125 | 11.1 |
| Total | 1123 | 100.0 |

Table 16: How many hours per week on average do you spend outdoors?
How many hours per week do you spend near a busy road/one with lots of traffic?

|  | N | Minimu <br> m | Maximu <br> m | Mean | Std. <br> Deviation |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Average hours per week <br> spend outdoors | 1385 | 0 | 105 | 26.1 | 20.8 |
| Average hours per week <br> spend busy road | 1385 | 0 | 105 | 12.0 | 14.6 |

Table 17: What do you consider to be the signs of good air quality?

|  | Frequency | $\%$ |
| :--- | :---: | :---: |
| Fresh air | 330 | 16.4 |
| Breathing comfortably | 136 | 6.8 |
| More plants | 371 | 18.4 |
| Rural areas | 314 | 15.6 |
| Less exhaust fumes, cars, | 617 | 30.6 |
| dust |  |  |
| Wind and rain | 32 | 1.6 |
| Others | 214 | 10.6 |
| Total | 2014 | 100.0 |

Table 18: How would you rate the air quality in the district you live over the last 12 months?

|  | Frequency | $\%$ | Valid $\%$ |
| :--- | :---: | :---: | :---: |
| Very good | 133 | 9.6 | 9.6 |
| Good | 459 | 33.1 | 33.1 |
| Fair | 638 | 46.1 | 46.1 |
| Poor | 155 | 11.2 | 11.2 |
| Total | 1385 | 100.0 | 100.0 |

## Housing

Table 19: What is your housing type?

|  | Frequenc | $\%$ | Valid \% |  |
| :--- | :--- | :---: | :---: | :---: |
|  | y |  |  |  |
|  | Public housing estate | 506 | 36.5 | 36.6 |
|  | Homeownership | 199 | 14.4 | 14.4 |
|  |  |  |  |  |
|  | scheme | 678 | 49.0 | 49.0 |
|  | Private | 1383 | 99.9 | 100.0 |
|  | Total | 2 | .1 |  |
| Total | Missing | 1385 | 100.0 |  |

Table 20: On what floor do you live in your building?

| Floor | Frequency | $\%$ |
| :--- | :---: | :---: |
|  |  |  |
| $1-10$ | 696 | 50 |
| $11-20$ | 412 | 30 |
| $21-30$ | 204 | 15 |
| $31-40$ | 70 | 5 |
| $41+$ | 1 | - |
| Total | 1383 | 100 |

The mean floor level is 13 , range is 1 to 45 .
Table 21: Is there a busy road or street with a lot of traffic that is 100 metres away ( 5 minutes
walking distance) from your building?

|  | Frequenc | $\%$ | Valid \% |  |
| :--- | :--- | :---: | :---: | :---: |
|  | y |  |  |  |
|  | Yes | 635 | 45.8 | 46.1 |
|  | No | 742 | 53.6 | 53.9 |
|  | Total | 1377 | 99.4 | 100.0 |
|  | Missing | 8 | .6 |  |
| Total |  | 1385 | 100.0 |  |

5. Comparison of the sample demographics with the general population demographics according to the Census 2001

Table 22: Age and gender

| Age Group | Sample$N=1385$ <br> $N$ |  | 2001 Population census <br>  | Goodness of fit <br> p-value |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | $\%$ |  |
| $18-24(15-24)^{*}$ | 73 | 12.0 | 456639 | 16.8 |  |
| $25-34$ | 119 | 19.6 | 499492 | 18.4 |  |
| $35-44$ | 171 | 28.2 | 650455 | 24.0 |  |
| $45-54$ | 95 | 15.7 | 489891 | 18.1 |  |
| $55-64$ | 48 | 7.9 | 269326 | 9.9 |  |


| $>=65$ | 100 | 16.5 | 345184 | 12.7 | $<0.001$ |
| :--- | :--- | :--- | :--- | :--- | :--- |

Female

| $18-24(15-24)^{*}$ | 56 | 7.2 | 463806 | 16.1 |  |
| :---: | :---: | :---: | :---: | :---: | :--- |
| $25-34$ | 151 | 19.5 | 609037 | 21.1 |  |
| $35-44$ | 234 | 30.2 | 710032 | 24.6 |  |
| $45-54$ | 153 | 19.7 | 470526 | 16.3 |  |
| $55-64$ | 69 | 8.9 | 232716 | 8.1 |  |
| $>=65$ | 113 | 14.6 | 401868 | 13.9 | $<0.001$ |

Both Sexes

| $18-24(15-24)^{*}$ | 129 | 9.3 | 920445 | 16.4 |  |
| :---: | :---: | :---: | :---: | :---: | :--- |
| $25-34$ | 270 | 19.5 | 1108529 | 19.8 |  |
| $35-44$ | 405 | 29.3 | 1360487 | 24.3 |  |
| $45-54$ | 248 | 17.9 | 960417 | 17.2 |  |
| $55-64$ | 117 | 8.5 | 502042 | 9.0 |  |
| $>=65$ | 213 | 15.4 | 747052 | 13.3 | $<0.001$ |

Gender**

| Male | 609 | 44.0 | 2710987 | 48.4 |  |
| :---: | :--- | :--- | :--- | :--- | :--- |
| Female | 776 | 56.0 | 2887985 | 51.6 | 0.001 |

*2001 population census grouping of age (15-24)
** only those age $>=15$ for population data
Table 23: Educational attainment

| Educational Attainment | Sample$\mathrm{N}=1385$ <br> $\%$ |  | N | 2001 Population census <br> N |  |
| :--- | :---: | :---: | :---: | :---: | :---: |
|  | 421 | 30.4 | 1618212 | Goodness of <br> fit <br> p-value |  |
| Secondary | 683 | 49.4 | 2534170 | 45.3 |  |
| Matriculation/Diploma | 110 | 8.0 | 737968 | 13.2 |  |
| Tertiary | 169 | 12.2 | 708622 | 12.7 | $<0.001$ |

Table 24: Marital status

| Marital status | Sample $\mathrm{N}=1385$ |  | 2001 Population census* |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: |
|  | N | $\%$ | N | $\%$ | Goodness of fit |
|  | 351 | 25.4 | 1787519 | 31.9 |  |
| Single | 928 | 67.1 | 3325482 | 59.4 |  |
| Married | 30 | 2.2 | 152349 | 2.7 |  |
| Divorced / Separated | 73 | 5.3 | 333622 | 6.0 | $<0.001$ |
| Widowed |  |  |  |  |  |

[^3]Table 25: Geographical distribution by district

| District | Sample N (1385) <br> $\%$ | 2001 Population census | p-value |  |
| :--- | :---: | :---: | :---: | :---: |
| Central and Western | 51 | 3.7 | 3.9 |  |
| Wan Chai | 18 | 1.3 | 2.5 |  |
| Eastern | 136 | 9.9 | 9.2 |  |
| Southern | 59 | 4.3 | 4.3 |  |
| Yau Tsim Mong | 62 | 4.5 | 4.2 |  |
| Sham Shui Po | 70 | 5.1 | 5.3 |  |
| Kowloon City | 103 | 7.5 | 5.7 |  |
| Wong Tai Sin | 91 | 6.6 | 6.6 |  |
| Kwun Tong | 109 | 7.9 | 8.4 |  |
| Kwai Tsing | 79 | 5.8 | 7.1 |  |
| Tsuen Wan | 71 | 5.2 | 4.1 |  |
| Tuen Mun | 99 | 7.2 | 7.3 |  |
| Yuen Long | 84 | 6.1 | 6.7 |  |
| North | 85 | 6.2 | 4.5 |  |
| Tai Po | 71 | 5.2 | 4.6 |  |
| Sha Tin | 124 | 9.0 | 9.4 |  |
| Sai Kung | 47 | 3.4 | 4.9 |  |
| Islands | 14 | 1.0 | 1.3 |  |

Table 26: Household size

| Household size | Sample N (1385) |  |  |  |
| :--- | :---: | :---: | :---: | :--- |
| $\%$ | 2001 Population census \% | p-value |  |  |
| 1 | 126 | 9.1 | 15.7 |  |
| 2 | 249 | 18.0 | 21.8 |  |
| 3 | 319 | 23.1 | 21.3 |  |
| 4 | 400 | 28.9 | 23.4 |  |
| 5 | 187 | 13.5 | 11.9 |  |
| $6+$ | 102 | 7.4 | 5.8 | $<0.001$ |

Table 27: Working population* by occupation
$\left.\begin{array}{lcccc}\hline \text { Occupation } & \text { Sample N (1385) } \\ \%\end{array}\right)$ 2001 Population census \% $\quad$ p-value

[^4]Table 28: Average monthly personal income
\(\left.\begin{array}{lcccl}\hline Monthly Income \& Sample N (1385) <br>

\%\end{array} $$
\begin{array}{l}\text { 2001 Population census* }\end{array}
$$\right)\) p-value |  |
| :--- |
| $<1 \mathrm{~K}$ |

[^5]
## 6. Association between floor lived on and perceptions of air quality

We have examined the data in an attempt to confirm or refute the prior hypothesis that those who live nearer street level will perceive their air quality to be poorer than those who live at higher levels. We have initially examined the possible confounders of age, gender, education and income but find no association between these variables and the floor lived on. We then stratified the sample according to district and examined the association between perceptions of air quality at home and floor of housing block for Hong Kong Island (HKI), Kowloon (K) and other New Territories plus Islands (NTI).

Table 29 shows the results. There is no association between floor and air quality for Hong Kong Island but a significant association for Kowloon where those who live on lower floors ( 1 to 10 ) are more likely to say that the air quality where they live is poor and a borderline association for New Territories where those on lower floors are less likely to say that air quality is very good.

Table 29: Association between floor of building on which respondent lives and perception of air quality in that district

| Floor | Perceived air quality |  |  |  |  |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Very good <br> $\mathrm{N}(\%)$ | Good <br> $\mathrm{N}(\%)$ | Fair <br> $\mathrm{N}(\%)$ | Poor <br> $\mathrm{N}(\%)$ | $\mathrm{N}(\%)$ |  |  |
| Hong Kong Island |  |  |  |  |  |  |  |
| $1-10$ | $9(6)$ | $43(29)$ | $79(53)$ | $17(11)$ | $148(100)$ |  |  |
| $11-20$ | $7(10)$ | $23(32)$ | $34(47)$ | $9(12)$ | $73(100)$ |  |  |
| $21+$ | $3(7)$ | $15(36)$ | $22(52)$ | $2(5)$ | $42(100)$ |  |  |
| Total | $19(7)$ | $81(31)$ | $135(51)$ | $28(11)$ | $263(100)$ |  |  |
| $\chi^{2}=3.4, \mathrm{p}=0.75$ |  |  |  |  |  |  |  |
| Kowloon | $12(5)$ | $54(22)$ | $127(51)$ | $54(22)$ | $247(100)$ |  |  |
| $1-10$ | $3(3)$ | $47(40)$ | $47(40)$ | $20(17)$ | $117(100)$ |  |  |
| $11-20$ | $4(6)$ | $24(34)$ | $37(53)$ | $5(7)$ | $70(100)$ |  |  |
| $21+$ | $19(4)$ | $125(29)$ | $211(49)$ | $79(18)$ | $434(100)$ |  |  |
| Total | $\chi^{2}=20.4, \mathrm{p}=0.002$ |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
| New Territories | $55(19)$ | $103(35)$ | $119(40)$ | $19(6)$ | $296(100)$ |  |  |
| $1-10$ | $24(11)$ | $82(38)$ | $92(42)$ | $20(9)$ | $218(100)$ |  |  |
| $11-20$ | $15(9)$ | $64(40)$ | $73(46)$ | $8(5)$ | $160(100)$ |  |  |
| $21+$ | $94(14)$ | $249(37)$ | $284(42)$ | $47(7)$ | $674(100)$ |  |  |
| Total | $\chi^{2}=12.4, \mathrm{p}=0.05$ |  |  |  |  |  |  |

## 7. Discussion/comments

This working paper presents the frequencies for questions related to air pollution and a comparison of the sample with the general population, as reported in the 2001 census. Our sample slightly under-represents the higher income, more highly educated and professional groups and has fewer single person households than the general population. However the
geographical distribution is quite similar to the whole population. The disparity in income and educational levels should be taken into account when the data is used e.g. by weighting or by stratification.

The prevalence of self-reported respiratory symptoms is quite high - 31/32\% for eye and breathing problems and $51 \%$ for throat problems. Breathing trouble and coughing were considered to be the most troublesome symptoms. Chronic and respiratory illness were not very common in the population with only $7 \%$ reporting that they had had acute bronchitis, $4 \%$ reporting asthma and $5 \%$ other chronic respiratory problems while $2 \%$ reported heart disease. Self-perceived health was quite good with $56 \%$ reporting good or excellent health and only $4 \%$ reporting poor health. However $69 \%$ of the sample thought air pollution affected their health with $56 \%$ thinking it caused breathing problems and $15 \%$ throat problems. The most common suggestions as to the signs of good air quality were less vehicle exhaust fumes and dust and more green plants.

The sample estimated that they spent an average of 26 hours outdoors per week of which 12 hours, or $46 \%$, was near a busy road. Almost half considered the air quality where they live to be fair and one third thought is good but $11 \%$ thought it was poor. As shown in section 6, the prior hypothesis that those who live nearer ground level in busy, traffic congested areas would be more likely to report poor air quality in their living district was supported by the study findings

# Valuation of the avoidance of respiratory symptoms in Hong Kong 

WORKING PAPER NO: AP 02-02-002

Health Economics Team: Health Services Research Group Department of Community Medicine, The University of Hong Kong March 2002

## Valuation of the avoidance of respiratory symptoms in Hong Kong

## 1. Background

This paper reports the detailed methods and results of the valuation of avoiding one day of respiratory symptoms which may result from air pollution. Other aspects of the survey and its results are reported in working paper no. AP-02-02-001.

## 2. Objectives

The main objective for this part of the survey is to estimate the WTP to avoid six respiratory symptoms in Hong Kong: coughing, shortness of breath, sinus congestion, congested throat, itching and smarting eyes and fever. A secondary objective is to compare the values that people in Hong Kong place on avoiding minor illness with those obtained in the United States and Norway.

## 3. Methods

A telephone survey was conducted on a population sample. Details of the sampling methods are in paper AP 02-02-001.

Dichotomous choice (or closed-ended) question formats are now widely used for contingent valuation (CV) of nonmarket goods and services. One advantage of this "take-it-or-leave-it" format is that it mimics the decision making task that individuals face in everyday market transactions. In addition, follow-up questions (or double-bounded dichotomous choice) (DB) have been proposed as one way to improve the efficiency of single-bounded questionnaires (SB). Here we follow previous studies and use DB question format to elicit people's WTP for avoiding one day of each symptom.

To maintain comparability with others' findings, our symptom descriptions mainly follow those of Navrud (1997). Furthermore, air pollution was not mentioned in the survey until after the valuation had been done. Thus, we estimate non-contextual values. The non-contextual values should be transferable from one project to another.

A number of pretests of the survey instrument were conducted prior to the main study. These pretests confirmed that original questionnaire worked well, and only minor changes were required. 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 eight first bids were $\$ 30, \$ 50, \$ 100, \$ 200, \$ 300, \$ 500, \$ 1000$, and $\$ 5000$. The second bid was conditional on the respondent's response to the first bid: half the first bid if the first response is 'no' and double the first bid if it is 'yes' (Table 1). Eight initial bid amounts were assigned randomly to respondents.

To avoid the questionnaire being too long, we only ask three symptoms at a time. Everyone was asked about cough and shortness of breath and one randomly allocated from sinus congestion, congested throat, itching \& smarting eyes and fever.

Table 1: Structure of the bids

| Initial bid <br> (first bid) | First bid <br> respond | Follow-up bid <br> (second bid) | Second bid <br> respond |
| :---: | :---: | :---: | :---: |
| $\$ 30$ | Y | $\$ 60$ | $\mathrm{Y} / \mathrm{N}$ |
|  | N | $\$ 15$ | $\mathrm{Y} / \mathrm{N}$ |
| $\$ 50$ | Y | $\$ 100$ | $\mathrm{Y} / \mathrm{N}$ |
|  | N | $\$ 25$ | $\mathrm{Y} / \mathrm{N}$ |
| $\$ 100$ | Y | $\$ 200$ | $\mathrm{Y} / \mathrm{N}$ |
|  | N | $\$ 50$ | $\mathrm{Y} / \mathrm{N}$ |
| $\$ 200$ | Y | $\$ 400$ | $\mathrm{Y} / \mathrm{N}$ |
|  | N | $\$ 100$ | $\mathrm{Y} / \mathrm{N}$ |
| $\$ 300$ | Y | $\$ 600$ | $\mathrm{Y} / \mathrm{N}$ |
|  | N | $\$ 150$ | $\mathrm{Y} / \mathrm{N}$ |
| $\$ 500$ | Y | $\$ 1,000$ | $\mathrm{Y} / \mathrm{N}$ |
|  | N | $\$ 250$ | $\mathrm{Y} / \mathrm{N}$ |
| $\$ 1,000$ | Y | $\$ 2,000$ | $\mathrm{Y} / \mathrm{N}$ |
|  | N | $\$ 500$ | $\mathrm{Y} / \mathrm{N}$ |
| $\$ 5,000$ | Y | $\$ 10,000$ | $\mathrm{Y} / \mathrm{N}$ |
|  | N | $\$ 2,500$ | $\mathrm{Y} / \mathrm{N}$ |

## Statistical Analysis

As opposed to the open-ended approach, our data collected from the closed-ended is the proportion of respondents replying 'yes' or 'no'. Therefore, we need to recover the value of WTP from their discrete choices. This involves discrete choice econometric modelling. We can estimate the WTP by either a simple linear model or a log-linear model. The latter would rule out negative WTP. On the other hand, we can also estimate the WTP by using SB or DB data. DB data can provide more information about the location of the respondent's WTP than using only the SB data. This improves the efficiency of dichotomous choice questionnaires. Thus, we use DB log-linear interval regression model.

An individual's WTP is the monetary amount that equates the utility level derived from the current health state to that enjoyed in the improved health state. Denoting $W T P_{i}$ as WTP for respondent $i$, assume that sample WTP follows a lognormal distribution,

$$
\log \left(W T P_{i}\right)=W_{i}=\beta_{0}+\varepsilon_{i}
$$

where

$$
\varepsilon_{i} \sim N\left(0, \sigma^{2}\right)
$$

From our bidding data, $W_{i}$ is manifested through the discrete variable $I_{1 i}, I_{2 i}$ of the two responses. Suppose $t_{i}$ is the bid level facing the respondents. The first and second bid together then define three types of regions $R_{1}, R_{2}, R_{3}$ with different lower and upper bounds $B_{L}, B_{U}$ where $W_{i}$ locates:

$$
\begin{aligned}
& R_{1}:-\infty \leq W_{i} \leq \min \left(t_{1 i}, t_{2 i}\right)=B_{U} \quad \text { if } \quad I_{1 i}=0 \quad \text { and } \quad I_{2 i}=0 ; \\
& R_{2}: B_{L}=t_{1 i} \leq W_{i} \leq t_{2 i}=B_{U} \quad \text { if } \quad I_{1 i}=1 \quad \text { and } I_{2 i}=0 ; \\
& R_{2}: B_{L}=t_{2 i} \leq W_{i} \leq t_{1 i}=B_{U} \quad \text { if } \quad I_{1 i}=0 \quad \text { and } I_{2 i}=1 ; \\
& R_{3}: \infty \geq W_{i} \geq \max \left(t_{1 i}, t_{2 i}\right)=B_{L} \quad \text { if } \quad I_{1 i}=1 \quad \text { and } I_{2 i}=1 .
\end{aligned}
$$

Using the estimate of $\beta_{0}$, we can calculate the mean or median WTP. Because of the lognormal distribution, the median WTP is $\exp \left(\beta_{0}\right)$ and the mean is $\exp \left(\beta_{0}\right) \exp \left(\sigma^{2} / 2\right)$. Since we are interested in the median WTP, the $95 \%$ confidence interval for the median WTP was estimated by non-parametric bootstrap percentile interval with 5000 bootstrap replications. We decided to use a bootstrap percentile interval because the bootstrap median WTP is not normally distributed.

## 4. Results

During the period August 8, 2001 to November 17, 2001, we made 5,416 calls to randomly selected individuals. Of these, about 1,671 phone numbers were invalid (no such number, need password, fax line, moved, etc.), and 727 numbers were commercial lines. Another 904 numbers were unanswered after at least 5 tries and 147 people could not speak Chinese or were too old to participate. Only 580 subjects refused to participate in the survey. The final response rate is $71 \%$.

There were 1,387 sets of observations. Usual error checking procedures were applied. One subject did not answer the WTP questions and one observation was deemed invalid because the amount was over the budget constraint, leaving 1,385 complete sets of data for analysis.

Table 2 compares the age and sex structure of the final sample and that of 2001 Hong Kong population. Chi-squared tests ( p -values $<=0.001$ ) show that the sample age and sex structure are significantly different from the 2001 Population Census.

Table 2: Comparison of sample and population age and sex structure

| Age Group | Sample$\mathrm{N}=1385$ <br> N |  | 2001 Population census <br> N |  | Goodness of fit test <br> $\chi^{2} \mathrm{p}$-value |
| :--- | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  |
| $18-24(15-24)^{*}$ | 73 | 12.0 | 456639 | 16.8 |  |
| $25-34$ | 119 | 19.6 | 499492 | 18.4 |  |
| $35-44$ | 171 | 28.2 | 650455 | 24.0 |  |
| $45-54$ | 95 | 15.7 | 489891 | 18.1 |  |
| $55-64$ | 48 | 7.9 | 269326 | 9.9 |  |
| $>=65$ | 100 | 16.5 | 345184 | 12.7 | $<0.001$ |
| Female |  |  |  |  |  |
| $18-24(15-24)^{*}$ | 56 | 7.2 | 463806 | 16.1 |  |
| $25-34$ | 151 | 19.5 | 609037 | 21.1 |  |
| $35-44$ | 234 | 30.2 | 710032 | 24.6 |  |
| $45-54$ | 153 | 19.7 | 470526 | 16.3 |  |
| $55-64$ | 69 | 8.9 | 232716 | 8.1 |  |
| $>=65$ | 113 | 14.6 | 401868 | 13.9 | $<0.001$ |


| Both Sexes |  |  |  |  |  |
| :--- | :---: | :---: | :---: | :---: | :--- |
| $18-24(15-24)^{*}$ | 129 | 9.3 | 920445 | 16.4 |  |
| $25-34$ | 270 | 19.5 | 1108529 | 19.8 |  |
| $35-44$ | 405 | 29.3 | 1360487 | 24.3 |  |
| $45-54$ | 248 | 17.9 | 960417 | 17.2 |  |
| $55-64$ | 117 | 8.5 | 502042 | 9.0 |  |
| $>=65$ | 213 | 15.4 | 747052 | 13.3 | $<0.001$ |
|  |  |  |  |  |  |
| Gender** | 609 | 44.0 | 2710987 | 48.4 |  |
| Male | 776 | 56.0 | 2887985 | 51.6 | 0.001 |
| Female |  |  |  |  |  |

*2001 population census grouping of age (15-24)
** only those age $>=15$ for population data
Table 3 shows the estimated median WTP of the Hong Kong people to avoid 1 day of each symptom. Comparing the unweighted WTP with the weighted WTP, we find that the results are similar. To avoid any bias created from the weighting process, we recommend using the unweighted WTP. As indicated in the table, respondents are willing to pay more to avoid one day of shortness of breath, followed by itching eyes, fever, coughing, congested throat and sinus congestion. The ranking of WTP confirmed the consistency with the ranking of disutility of those symptoms (Table 4).

Table 3: Estimated median WTP to avoid 1 day of each symptom using DB log-linear model

| Symptom | Unweighted <br> Median WTP | $95 \%$ CI* | Weighted** <br> Median WTP |
| :--- | :---: | :---: | :---: |
| Coughing | 179.16 | $164.97-195.47$ | 183.67 |
| Shortness of breath | 265.28 | $239.63-295.87$ | 276.86 |
| Sinus congestion | 138.58 | $117.28-165.17$ | 139.22 |
| Congested throat | 145.54 | $122.76-171.65$ | 149.74 |
| Itching \& smarting of eyes | 211.55 | $174.16-259.93$ | 211.73 |
| Fever | 203.67 | $171.21-242.65$ | 212.20 |

*nonparametric bootstrap $95 \%$ percentile interval for median WTP based on 5000 replication.
**we create a sample weighting based on age and sex structure of the 2001 Census
Table 4: Ranking of symptoms

|  | $\begin{aligned} & \stackrel{\rightharpoonup}{0} \\ & \underset{\sim}{0} \end{aligned}$ | Sinus congestion |  | Congested throat |  | Itching \& smarting of eyes |  | Fever |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | N | \% | N | \% | N | \% | N | \% |
| C B | R | 82 | 22.3 | 88 | 25.9 | 75 | 21.1 | 84 | 26.3 |
| C R | B | 17 | 4.6 | 37 | 10.9 | 23 | 6.5 | 13 | 4.1 |
| B C | R | 115 | 31.3 | 99 | 29.1 | 88 | 24.8 | 75 | 23.5 |
| B R | C | 55 | 15.0 | 61 | 17.9 | 86 | 24.2 | 74 | 23.2 |
| R C | B | 27 | 7.4 | 20 | 5.9 | 19 | 5.4 | 18 | 5.6 |
| R B | C | 71 | 19.3 | 35 | 10.3 | 64 | 18.0 | 55 | 17.2 |
| Total |  | 367 | 100.0 | 340 | 100.0 | 355 | 100.0 | 319 | 100.0 |

[^6]Table 5 compares the results in this report with those reported in similar studies for Norway (Navrud 1997) and United States (Tolley 1994). Median values for the US and Norway are both lower than those for Hong Kong. Differences across the three studies could be due to differences in the elicitation approach or survey methodology or could be real economic or cultural effects.

Table 5: WTP for avoiding one day of symptom in 3 studies (US\$)

| Symptom | Hong Kong* | US** | Norway*** |
| :--- | :---: | :---: | :---: |
| Cough | 26.0 | 18.1 | 2.1 |
| shortness of breath | 38.4 | - | 10.7 |
| sinus congestion | 20.1 | 23.0 | 8.0 |
| congested throat | 21.1 | 21.4 | 2.1 |
| itching \& smarting of eyes | 30.7 | 20.6 | 5.3 |
| Fever | 29.5 | - | - |

Note: US survey was conducted in 1985 and Norway survey was conducted in 1996.
*Adjusted by 6.9 PPP exchange rate (from EIU)
** Adjusted by 164.59 CPI (from U.S. Department of Labor)
*** Adjusted by 114.06 CPI (from Statistics Norway) then 10.7 PPP exchange rate (from OECD)

## 5. Valuing more than one day of symptoms

We conducted a further, smaller, survey to estimate WTP to avoid 3 or 7 days of the same symptom. We find that, to avoid three days of symptoms, respondents are willing to pay three times the value to of avoiding one day of symptom. However, there is a declining marginal value of a symptom day as the number of symptom days increases because the value for avoiding seven days is less than seven times one day and is nearer five times one day more than 3 days (details reported separately).

## 6. Reliability of the questionnaire

To test the reliability of the questionnaire, we randomly selected 311 out of 1385 respondents to call back and asked again; 268 were successfully asked eight questions. Using test-retest reliability method, we are confident that the willingness to pay question is quite reliable (see Table 6).

Table 6: Reliability for eight questions

|  | \% of same answer | Correlation coefficients |
| :--- | :---: | :---: |
| Q9 WTP for 1 day of coughing* | 66 | NA |
| Q21 Air quality in the district | 61 | .5681 |
| Q27 Live near busy traffic | 76 | .5163 |
| Q28 Marital status | 96 | .9150 |
| Q24 Education | 93 | .9504 |
| Q32 Occupation | 89 | .9149 |
| Q33 District | 96 | .9760 |
| Q36 Personal income | 70 | .9128 |

* $19 \%$ changed to lower WTP and $14 \%$ changed to higher WTP


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# Value of avoiding cardiovascular or respiratory illness in Hong Kong 

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## Value of avoiding cardiovascular or respiratory illness in Hong Kong

## 1. Background

Medical research has provided evidence that air pollution in Hong Kong is responsible for many acute health problems and chronic illnesses. In recent year, the community has been increasingly concerned with the policy issues involved in air pollution control. In evaluation of possible policy impact, it is important to conduct some cost-benefit analyses. However, because health and quality of life are not market goods, we have to estimate the benefits in some way other than by reference to market prices. Stated-preference methods have been found useful to elicit the value of such benefits.

In this paper, we describe the application of stated-preference methods using a conjoint analysis approach to estimate the value of health benefits from air quality improvement. The health benefits in this study are serious cardiovascular and respiratory illness.

## 2. Objectives of the study

1. To estimate the willingness to pay (WTP) of the Hong Kong population to avoid serious cardiovascular and respiratory disease through air quality improvements.
2. To estimate the relative value of other factors also related to air quality improvement which might be traded against health effects.

## 3. Methods

Conjoint analysis (CA) is a commonly used technique for estimating WTP when the subjects are faced with a trade-off situation. According to Ryan and Farrar (2000):
"CA was developed in mathematical psychology and has a strong theoretical basis. It has been successfully used in market research, transport economics, and environmental economics and was recommended to the UK Treasury for valuing quality in the provision of public services. Within these areas it has been well received by policymakers."

CA involves surveying respondents' preference among alternatives or scenarios. We followed the practice of Ryan (1999), Bryan et al (2000), Hakim and Pathak (1999) and Farrar and Ryan (1999) to use discrete choice format questions, asking respondents to make a choice between two scenarios: the current state and a new hypothetical state. We also allowed respondents to rate the intensity of preference between the two alternatives on a 5-point scale. Respondents' WTP was estimated based on the choices made and the variation of economic costs between the two scenarios.

We followed the procedure of undertaking a CA study suggested by Ryan and Farrar (2000).

Stage 1 Identifying the characteristics: The dichotomous choice question includes a set of characteristics (or attributes). The characteristics were selected according to the nature of the policy concerned, literature reviews, focus group studies and expert advice. Four characteristics were included in our scenarios: (1) the perceived morbidity risks; (2) the convenience of commuting in the respondents' daily life; (3) amount of time spent on commuting and (4) expenditure on transportation in the coming 12 months.

Table 1: Characteristics and levels of the choice set

| Characteristic | Levels |
| :--- | :--- |
| The probability of getting the disease in the coming | 1) Base case $0 \%$ reduction, |
| 12 months according to the respondent's age | 2) $2 \%$ reduction, |
|  | 3) $10 \%$ reduction |
| The convenience of daily commuting | 1) Current level, <br>  <br>  <br>  <br>  <br>  <br> 2) Need to make one transit <br> and have a chance of unable <br> to find a seat |
| Amount of time spent on commuting | 1) Current situation, |
|  | 2) $10 \%$ increase in time |
| Cost of transportation in the coming 12 months | 1) No change, |
|  | 2) HK $\$ 50$ more, |
|  | 3) HK $\$ 100$ more, |
|  | 4) HK $\$ 500$ more |
|  | 5) HK $\$ 1000$ more |

Stage 2 Assigning levels to the characteristics: The levels assigned to the characteristics define a set of variations to identify the respondents' preferences. They can be cardinal, ordinal and categorical. Table 1 shows the attributes and the levels included in this study. There were two sets of questionnaires focusing on respiratory diseases and cardiovascular diseases. The only difference between the two sets of questions was their levels of morbidity risks which do differ between the two diseases with the risk of cardiovascular disease being much higher than that of respiratory disease.

The probability of getting respiratory diseases and cardiovascular diseases were calculated from the number of people who were admitted to hospital with these conditions, grouped into three age groups. When considering the base case and then changes in the probabilities of getting disease in the alternative scenarios, respondents were supplied with information on the actual probabilities of disease per 100,000 members of the local population. Table 2 shows these probabilities.

Stage 3 Choice of scenarios: Given the number of attributes and the number of levels, there were $60(3 \times 2 \times 2 \times 5)$ possible combinations; 59 scenarios were to be compared with the status quo. By elimination of dominant choices, the size of the experiment was reduced to 38 meaningful sets of alternative scenarios. The 38 dichotomous choices were distributed randomly to 4 sets of respondents.

Table 2: The morbidity risk in numbers by age group

|  | Respiratory disease | Cardiovascular disease |
| :--- | :--- | :--- |
| Age 15-34 | Base case $327 / 100,000$ | Base case $147 / 100,000$ |
|  | $2 \%$ reduction $=7$ | $2 \%$ reduction $=2$ |
|  | $10 \%$ reduction $=33$ | $10 \%$ reduction $=15$ |
| Age 35-64 | Base case $659 / 100,000$ | Base case $1,021 / 100,000$ |
|  | $2 \%$ reduction $=13$ | $2 \%$ reduction $=20$ |
|  | $10 \%$ reduction $=66$ | $10 \%$ reduction $=102$ |
| Age 65 or above | Base case $9,293 / 100,000$ | Base case $8,303 / 100,000$ |
|  | $2 \%$ reduction $=186$ | $2 \%$ reduction $=166$ |
|  | $10 \%$ reduction $=929$ | $10 \%$ reduction $=830$ |

Stage 4 Establishing preferences: Respondents were asked to choose between two sets of attributes and, depending on their choice, they were then given a further two sets. This is a preferred method because the questions closely resemble a real life decision. This continued until each respondent had valued 9 or 10 choice sets.

Stage 5 Data analysis: Given the nature of our data, a benefit function was estimated based on regression techniques of which only the dichotomous choice (and rating scale) was observed. The benefit function was specified as:

$$
\Delta B=\beta_{1} X_{1}+\beta_{2} X_{2}+\beta_{3} X_{3}+\beta_{4} X_{4}
$$

where $\Delta \mathrm{B}$ is the change in benefit in moving from the status quo to the alternative scenario and $X_{j}(j=1,2,3,4)$ are the changes in level of characteristics; $\beta_{j}(j=1,2,3,4)$ are the coefficients of the model to be estimated. The coefficients indicate the relative importance of the different characteristics and show the change of utilities for a unit of change in these characteristics. The ratios of $\beta_{1}, \beta_{2}, \beta_{3}$ to $\beta_{4}$ represent the marginal WTP (the dollarcharacteristic tradeoffs) for an increment of a level of an attribute.

## 4. Data collection

The questionnaires containing 9 or 10 choices were mailed to the interviewees before the telephone interviews. A total of 409 subjects were drawn randomly from the respondents in the main survey. They were divided into two groups and each group was allocated to one of the disease categories - 204 subjects for respiratory disease and 205 for cardiovascular disease. Of the two groups, 110 and 135 respectively completed the interviews, giving response rates of $54 \%$ and $66 \%$.

## 5. Subjects

Table 3 shows the age structure of the collected sample. Because of missing data, we report the data of 231 of the 245 respondents. The age structure of the males is not different from that of the Hong Kong adult population (18 years or over). The female sample has a statistically different age structure from that of the population, mainly due to the over representation of 45-54 year age group in the cardiovascular disease category and the 35-44 year age group in the respiratory disease category.

Table 3: Age distribution of the sample

| Age Group | 2001 Census |  | Total sample$\mathrm{N}=231$ |  | Cardiovascular$\mathrm{N}=130$ |  | Respiratory$\mathrm{N}=101$ |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | N | \% | N | \% | N | \% | N | \% |
| Male |  |  |  |  |  |  |  |  |
| 17-24 * | 456639 | 16.8 | 14 | 12.6 | 7 | 11.1 | 7 | 14.6 |
| 25-34 | 499492 | 18.4 | 18 | 16.2 | 10 | 15.9 | 8 | 16.7 |
| 35-44 | 650455 | 24.0 | 29 | 26.1 | 18 | 28.6 | 11 | 22.9 |
| 45-54 | 489891 | 18.1 | 28 | 25.2 | 17 | 27.0 | 11 | 22.9 |
| 55-64 | 269326 | 9.9 | 8 | 7.2 | 5 | 7.9 | 3 | 6.3 |
| >=65 | 345184 | 12.7 | 14 | 12.6 | 6 | 9.5 | 8 | 16.7 |
|  |  |  | $P=0.341$ |  | $\boldsymbol{P}=0.354$ |  | $\boldsymbol{P}=0.833$ |  |
| Female |  |  |  |  |  |  |  |  |
| 17-24* | 463806 | 16.1 | 10 | 8.3 | 6 | 9.0 | 4 | 7.5 |
| 25-34 | 609037 | 21.1 | 20 | 16.7 | 6 | 9.0 | 14 | 26.4 |
| 35-44 | 710032 | 24.6 | 41 | 34.2 | 19 | 28.4 | 22 | 41.5 |
| 45-54 | 470526 | 16.3 | 28 | 23.3 | 21 | 31.3 | 7 | 13.2 |
| 55-64 | 232716 | 8.1 | 10 | 8.3 | 8 | 11.9 | 2 | 3.8 |
| > $=65$ | 401868 | 13.9 | 11 | 9.2 | 7 | 10.4 | 4 | 7.5 |
|  |  |  | $\boldsymbol{P}=0.008$ |  | $\boldsymbol{P}=0.003$ |  | $P=0.030$ |  |
| Both Sexes |  |  |  |  |  |  |  |  |
| 17-24* | 920445 | 16.4 | 24 | 10.4 | 13 | 10.0 | 11 | 10.9 |
| 25-34 | 1108529 | 19.8 | 38 | 16.5 | 16 | 12.3 | 22 | 21.8 |
| 35-44 | 1360487 | 24.3 | 70 | 30.3 | 37 | 28.5 | 33 | 32.7 |
| 45-54 | 960417 | 17.2 | 56 | 24.2 | 38 | 29.2 | 18 | 17.8 |
| 55-64 | 502042 | 9.0 | 18 | 7.8 | 13 | 10.0 | 5 | 5.0 |
| >=65 | 747052 | 13.3 | 25 | 10.8 | 13 | 10.0 | 12 | 11.9 |
|  |  |  | $\boldsymbol{P}=0.003$ |  | $\boldsymbol{P}=0.001$ |  | $P=0.220$ |  |

Table 4: Gender distribution of the sample

| Gender** | 2001 Census |  | Total sample |  | Cardiovascular |  | Respiratory |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | N | \% | N | \% | N | \% | N | \% |
| Male | 2710987 | 48.4 | 111 | 48.1 | 63 | 48.5 | 48 | 47.5 |
| Female | 2887985 | 51.6 | 120 | 51.9 | 67 | 51.5 | 53 | 52.5 |
|  |  |  | $P=0.911$ |  | $P=0.992$ |  | $P=0.857$ |  |

** only those age $>=15$ for 2001 Census
$\dagger \mathrm{P}=\mathrm{p}$-value of the goodness of fit $\chi^{2}$ test
Table 4 shows the distribution of gender in our sample. The p-values based on chi-square statistics suggested that our sample is not statistical significantly different from the Hong Kong population.

Table 5 displays the income distribution of our sample.

Table 5: Income distribution of the collected sample

| Income group | Household monthly income |  |  |  |
| ---: | :---: | :---: | :---: | :---: |
|  | N | $\%$ | Personal monthly income |  |
| $<1 \mathrm{k}$ | 8 | 4.0 | 46 | 24.5 |
| $1-2 \mathrm{k}$ |  |  | 2 | 1.1 |
| $2-4 \mathrm{k}$ | 2 | 1.0 | 6 | 3.2 |
| $4-6 \mathrm{k}$ | 6 | 3.0 | 9 | 4.8 |
| $6-8 \mathrm{k}$ | 9 | 4.6 | 13 | 6.9 |
| $8-10 \mathrm{k}$ | 15 | 7.6 | 18 | 9.6 |
| $10-15 \mathrm{k}$ | 47 | 23.7 | 41 | 21.8 |
| $15-20 \mathrm{k}$ | 21 | 10.6 | 17 | 9.0 |
| $20-25 \mathrm{k}$ | 24 | 12.1 | 16 | 8.5 |
| $25-30 \mathrm{k}$ | 15 | 7.6 | 3 | 1.6 |
| $30-40 \mathrm{k}$ | 24 | 12.1 | 8 | 4.3 |
| $40-60 \mathrm{k}$ | 23 | 11.6 | 6 | 3.2 |
| $>=60 \mathrm{k}$ | 4 | 2.0 | 3 | 1.6 |
| Total | 198 | 100.0 | 188 | 100.0 |
| Refuse to answer | 46 |  | 56 |  |
| Missing | 1 |  | 1 |  |
| Total | 245 |  | 245 |  |

## 6. Results

The ratio of $\beta_{1}$ to $\beta_{4}$ represents the marginal WTP (the dollar-characteristic tradeoffs) for an increment of health risk. Table 6 presents 3 types of estimation strategy of 2 sets of data. Full sample estimation used observed choices from all subjects. We also estimated WTP based only on a subset of subjects who could answer two questions in the survey testing their numerical abilities. These sub-samples should be more knowledgeable in assessing risk reduction.

Three estimation models were attempted. Random effect probit models heterogeneity across subjects by decomposing the proportion of stochastic errors to overall and personal level variance. The population average model considers an equal correlation structure across observations (choices) within the same subject and all subjects are assumed to have the same within-subject correlation. Ordered probit is supposed to be more efficient in the sense that it takes into account the 5-point scale which describes the intensity of the respondents' preference.

However, there is no preprogrammed routine available in STATA for ordered probit to estimate the panel data structure. Therefore, ordered probit estimates ignore the heterogeneity of subjects. For random effect and population average models, which take the panel data features into account, special treatment is required for observations where the respondent states that they are indifferent among the two alternatives (rating = 3). To apply the panel data methods, we therefore force these observations into one of the two choices based on a 50-50 chance random number generator. Statistically, this method is similar to removing these observations.

| Reduction in risk | Cardiovascular |  |  | Respiratory |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 1\% | 8\% | 100\% | $1 \%$ | 8\% | 100\% |
| Dichotomous choice model |  |  |  |  |  |  |
| Random Effect Probit |  |  | HK\$ |  |  | HK\$ |
| Full sample | 41 | 328 | 4100 | 49 | 392 | 4900 |
| Sub-sample | 51 | 408 | 5100 | 48 | 384 | 4800 |
| Population Average |  |  |  |  |  |  |
| Full sample | 43 | 344 | 4300 | 51 | 408 | 5100 |
| Sub-sample | 52 | 416 | 5200 | 50 | 400 | 5000 |
| Rating model |  |  |  |  |  |  |
| Ordered probit estimation |  |  |  |  |  |  |
| Full sample | 17 | 136 | 1700 | 15 | 120 | 1500 |
| Sub-sample | 33 | 264 | 3300 | 14 | 112 | 1400 |
| Full sample - no. of subjects |  | 135 |  |  | 110 |  |
| No. of observations |  | 1396 |  |  | 1182 |  |
| Subsample - no. of subjects |  | 94 |  |  | 77 |  |
| No. of observations |  | 973 |  |  | 827 |  |
| Note: WTP is calculated as the ratio of estimated $\beta_{1}$ to $\beta_{4}$ |  |  |  |  |  |  |

## 7. Discussion

The questionnaire is structured in a way that leads the respondents to think about the degradation of quality of life. The valuation of morbidity may therefore excludes loss of productivity and cost of medication.

The aggregated WTP to avoid $100 \%$ (certain) chance of suffering a disease is the valuation of morbidity. This $100 \%$ is calculated by multiplying the value for a change in risk up to the value that would be required for a $100 \%$ change (i.e. multiply value by 100/change in risk valued)

The estimated values of avoiding morbidity vary greatly between estimation methods, greatly between sample, and a little between the two diseases. Based on the full sample, the value of avoiding cardiovascular disease calculated using the 3 estimation methods are HK\$4300 (population average model), $\$ 1700$ (ordered probit), and $\$ 4100$ (random effect probit). If we only use the sub-sample, the values are HK $\$ 5200, \$ 3300$, and $\$ 5100$. For respiratory diseases, the full sample estimates are $\mathrm{HK} \$ 5100$ (population average), $\$ 1500$ (ordered probit) and $\$ 4900$ (random effect probit) whereas the sub-sample estimates are $\mathrm{HK} \$ 5000, \$ 1400$ and $\$ 4800$.

Between the two diseases the WTPs are similar in magnitude. For the respiratory disease group, the full-sample estimates and the sub-sample estimates are similar in magnitude. But the sub-sample of the cardiovascular disease group has higher WTP than that of the full sample. The reason behind this variation requires further investigation.

For both diseases, the random effect model produced slightly lower estimates of WTP than the population average model. The ordered probit model provides a substantially lower WTP estimate, probably due to the presence of the constant term in the estimation equation (The ordered probit model cannot be without the constant). There is no standard method to determine the selection of the best model. From an econometric point of view, model selection is based on the theory behind the data generation process. To follow previous practice (Ryan and Farrar, 2000), the random effect estimates are recommended for subsequent use. Therefore, the value used to estimate monetary value of avoiding one admission to hospital is $\$ 4,100$ for cardiovascular disease and $\$ 4,900$ for respiratory disease.

## 8. Validation of the estimate of value of avoiding serious morbidity

### 8.1 Objective

To test the validity of the WTP amount to avoid serious morbidity derived from the conjoint analysis.

### 8.2 Methods

The derived values of $\$ 4100$ to avoid having coronary heart disease and $\$ 4900$ to avoid having respiratory disease were tested in a random population sample using a close-ended question. The survey was carried out during March 2002.

### 8.3 Results

A total of 75 successful responses and 100 refusals were obtained from 175 approaches. This gives a response rate of $43 \% ; 37(49 \%)$ interviewees were first asked the WTP to avoid coronary heart disease, followed by the WTP to avoid respiratory disease. Another 38 (51\%) observations were first asked the WTP to avoid respiratory disease, then the WTP to avoid coronary heart disease.
$84 \%$ interviewees don't have any chronic disease. For those who have, mostly are high blood pressure and bronchitis; $25 \%$ of respondents do have family members or friends with chronic disease. Mostly are asthmatic, diabetic, have heart disease or high blood pressure; $63 \%$ of respondents rated their current health good or very good.

Table 7:Demographic characteristics of the sample and the whole population

|  |  | 2001 census |  | Sample |  | p |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | N | \% | N | \% |  |
| Gender$(15+)$ | Male | 2710987 | 48.4 | 31 | 41.3 | 0.219 |
|  | Female | 2887985 | 51.6 | 44 | 58.7 |  |
|  |  | 5598972 | 100.0 | 75 | 100.0 |  |
| Age - Male | 15/18-24 | 456639 | 16.8 | 3 | 10.7 |  |
|  | 25-34 | 499492 | 18.4 | 6 | 21.4 |  |
|  | 35-44 | 650455 | 24.0 | 8 | 28.6 |  |
|  | 45-54 | 489891 | 18.1 | 4 | 14.3 |  |
|  | 55-64 | 269326 | 9.9 | 0 | 0.0 | 0.198 |
|  | >=65 | 345184 | 12.7 | 7 | 25.0 |  |
|  |  | 2710987 | 100.0 | 28 | 100.0 |  |


| Age - Female | 15/18-24 |
| :---: | :--- |
|  | $25-34$ |
|  | $35-44$ |
|  | $\mathbf{4 5 - 5 4}$ |
|  | $55-64$ |
|  | $>=65$ |
|  |  |
| Age - Both | $15 / 18-24$ |
|  | $25-34$ |
|  | $35-44$ |
|  | $\mathbf{4 5 - 5 4}$ |
|  | $\mathbf{5 5 - 6 4}$ |
|  | $>=65$ |


| $\begin{aligned} & \text { Education } \\ & (15+) \end{aligned}$ | Primary or below | 1618212 | 28.9 | 12 | 16.0 | 0.092 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Secondary | 2534170 | 45.3 | 41 | 54.7 |  |
|  | Matriculation/Diploma | 737968 | 13.2 | 10 | 13.3 |  |
|  | Tertiary | 708622 | 12.7 | 12 | 16.0 |  |
|  |  | 5598972 | 100.0 | 75 | 100.0 |  |
| Household | <2,000 | 65855 | 3.2 | 3 | 4.9 |  |
| Income | 2,000-3,999 | 97568 | 4.8 | 1 | 1.6 |  |
|  | 4,000-5,999 | 93018 | 4.5 | 0 | 0.0 |  |
|  | 6,000-7,999 | 116340 | 5.7 | 1 | 1.6 |  |
|  | 8,000-9,999 | 120721 | 5.9 | 4 | 6.6 |  |
|  | 10,000-14,999 | 318623 | 15.5 | 22 | 36.1 |  |
|  | 15,000-19,999 | 262086 | 12.8 | 8 | 13.1 |  |
|  | 20,000-24,999 | 223708 | 10.9 | 7 | 11.5 |  |
|  | 25,000-29,999 | 159470 | 7.8 | 4 | 6.6 |  |
|  | 30,000-39,999 | 219229 | 10.7 | 3 | 4.9 |  |
|  | 40,000-59,999 | 197311 | 9.6 | 6 | 9.8 |  |
|  | > $=\mathbf{6 0 , 0 0 0}$ | 179483 | 8.7 | 2 | 3.3 | 0.004 |
|  |  | 2053412 | 100.0 | 61 | 100.0 |  |

Only $41 \%$ of respondents accepted the first bid amount (\$4100) to avoid having coronary heart disease; $57 \%$ accepted the first bid amount (\$5100) to avoid having respiratory disease. Using a simple interval regression model, we estimated the WTP are $\$ 5083$ and $\$ 4227$ to avoid having coronary heart disease and respiratory disease respectively. The estimated WTP are $\$ 4792$ and $\$ 3227$ respectively using log interval regression.

## 9. References

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2. Farrar S, Ryan M. (1999) Response-ordering effects: a methodological issue in conjoint analysis. Health Economics 8:75-9.
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5. Ryan M, Farrar S. (2000) Using conjoint analysis to elicit preferences for health care. BMJ 320:1530-3.

[^0]:    \# Data is extracted from HA database

[^1]:    Note: ${ }^{\#}$ Obtained from Sommer (1999) ${ }^{1}$ and validated in Hong Kong (2002) Appendix 2
    ${ }^{@}$ Obtained by conjoint analysis ${ }^{21}$
    ${ }^{\wedge}$ Obtained by contingent valuation ${ }^{20}$

    Explanation of calculations refers to page 13.

[^2]:    *2001 population census grouping of age (15-24)

[^3]:    * only those age $>=15$ for population data

[^4]:    * include those age $>=15$ working population for population data

[^5]:    * include those age $>=15$ working population and exclude unpaid family workers for population data

[^6]:    Note: Denote C as coughing, B as shortness of breath, R as one of the four symptoms randomly (sinus congestion, congested throat, itching \& smarting eyes and fever)

