ANALYSIS OF AIR POLLUTION EXPOSURE OF INDIVIDUALS IN THE ROAD ENVIRONMENT

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Abstract: This paper examines the current levels of exposure inside public transportation vehicles, particularly jeepneys, along major trunk roads in Metro Manila. Recent studies show that levels of suspended particulate matter (SPM) in Metro Manila often exceed the limits prescribed by the local Clean Air Act of 1999. Jeepney passengers are prone to high levels of SPM while in transit and along the roadside. The increasing number of diesel-fed public transportation vehicles in the urban area exacerbates SPM levels, especially along the carriageways. The study employed in-transit surveys on the levels of SPM and the passengers' perception on air pollution and policy while traveling along a selected route. The average levels of exposure of passengers are estimated by correlating travel time and delay to the observed concentration of SPM. Contingent valuation is employed in estimating the passengers' willingness-to-pay for improved air quality conditions by the strict maintenance of jeepneys in exchange for health benefits. The value derived from the surveys showed that the respondents were willing to pay for an increase in fare by as much as PhP1.24.

Keywords: suspended particulate matter (SPM), in-transit exposure, contingent valuation method, willingness-to-pay

1. INTRODUCTION

Air pollution has worsened immensely in urban areas over the last decade because of emissions from industrial establishments and motor vehicles. Air pollution along with the solid waste problem and potable water scarcity has led to the constant deterioration of the quality of life in urban areas. With approximately 10 million people, the over concentration of population in Metro Manila, accompanied by increased motorization, as well as the intensity of economic activities, led to road traffic congestion and consequently high levels of air pollution especially along trunk roads and commercial districts. The 1992 study by the Asian Development Bank on vehicular emissions showed that jeepney, buses, and taxis contribute to two-thirds of particulate matter pollution in Metro Manila.

Recent air quality data by the Philippine Department of Environment and Natural Resources (DENR) - Metro Manila Air Quality Monitoring Section showed high concentrations of Total Suspended Particulates (TSP) in several areas in the metropolis. The summary report for the year 2000 showed that at the Congressional Plaza station, the highest record for 24-hour sampling reached a maximum of 921μg/Ncm. It averaged 358.74μg/Ncm. In 1999, the highest record was at 699μg/Ncm and averaged 226μg/Ncm in its Quezon Avenue station.

Human exposure to motor vehicle emissions is greater in urban areas as compared to rural areas, primarily because cities have more roadways, parking garages, and street canyons where people may be exposed to high pollutant concentrations due to motor vehicle emissions (Schwela and Zali, 1999). Variations in pollutant concentration are observed in different microenvironments (inside buildings, inside homes, inside vehicles, along roadways, etc.) in the urban area. Individuals in the roadside environment and in-transit are both exposed to pollutants; they vary with the amount of concentration and the length of exposure. Several studies have already confirmed the health effects of air pollutants on the exposed public. Observed effects may be an aggravation of existing respiratory diseases, disruption of physiological processes or physical inconveniences to the affected population.

The number of people exposed to air pollutants from motor vehicles depends upon the extent to which a country is motorized (Schwela and Zali 1999). The number of registered motor vehicles in Metro Manila as shown by the Land Transportation Office statistics is at an increasing trend with a very high rate, the number of registered vehicles by fuel type shows that diesel-run vehicles have increased by 613% and gas-run vehicles by 115% from 1980 to 1999.

There have been few studies investigating in-transit levels of SPM and other pollutants. The California Air Resources Board has posted a summary of the study "Measuring Concentrations of Selected Air Pollutants inside California Vehicles". This study was conducted to characterize the concentration levels of selected pollutants inside commuting in the Sacramento and Los Angeles areas in California. The results showed relatively higher levels of all pollutants measured as compared to ambient concentrations as taken from the mean of commutes in Sacramento and Los Angeles.

The health of passengers and pedestrians can be adversely affected as a result of their constant exposure to high levels of air pollutants. Majority of the population in Metro Manila rely heavily on public transportation and spends a considerable amount of time traveling along congested roadways. The purpose of this study is to evaluate the levels of exposure to SPM of commuters in major trunk roads in Metro Manila. The study also aims to investigate the factors influencing in-transit levels of SPM. Specifically, the research aims to:

- measure the amount of typical SPM concentration inside public vehicles during peak hours along key trunk roads in Metro Manila
- estimate the length of time a commuter is exposed to varying concentration of SPM
- compare in-transit concentration to ambient concentration of SPM
- investigate the feasibility of a policy aiming to reduce vehicle-generated emissions

Figure 1 shows the relationship of factors affecting air pollution in the transportation environment. This study is focused on air pollution, particularly SPM, from motor vehicles. The jeepney is selected as the representative public transportation mode, since according to the Metro Manila Urban Transportation Integration Study (MMUTIS, 1996), 62% of the respondents use the jeepney to reach their destination, making the jeepney a major mode of public transportation in the urban area. The jeepney is a paratransit vehicle sitting 18-20 passengers, with a second-hand truck diesel engine.

Air pollutants from motor vehicles are greatly dependent on meteorological conditions such as wind velocity, temperature, and humidity and also the way these pollutants interact with the elements. This study focuses on in-transit levels of SPM concentration. The behavior of these pollutants inside vehicles is dependent on the vehicles' ventilation characteristics as affected by the ambient concentration but does not follow the dispersion of ambient air pollutants. The health effects of air pollution on passengers may be deduced from the investigation of their travel behavior, socio-economic status and the observed levels of exposure.

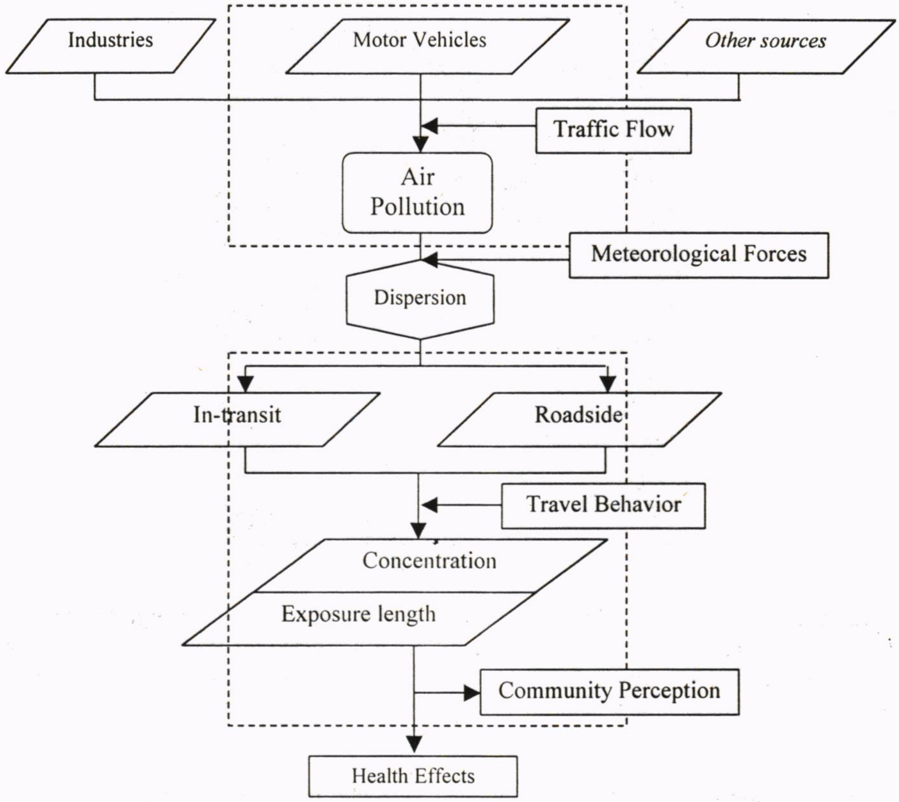

Figure 1. Conceptual Framework of the Study

The succeeding parts of this paper include the analysis of jeepney passengers' daily exposure to suspended particulate matter, followed by the multivariate analysis of the passengers' willingness-to-pay for air quality improvement. Furthermore, the proposed strategy to improve air quality in the road environment would be discussed as per the results of the willingness-to-pay analysis.

2. ANALYSIS OF INDIVIDUAL EXPOSURE TO SPM

2.1 Route Selection

Based from MMUTIS (MMUTIS, 1996) data, one of the route that have a high volume of passengers per day was identified as coming from the northern part of Quezon City, along Commonwealth Avenue, Quezon Avenue, España Avenue towards the southwest to Taft Avenue in the heart of Manila. The jeepney route selected started from Philcoa bus and jeepney stop, passing the stretch of Quezon Avenue and España Avenue, over Quezon

Bridge and finally to Taft Avenue ending in T.M. Kalaw Avenue. The route from Philcoa to T.M. Kalaw Avenue was measured to be 11.61 km, while the return trip measured 11.85 km.

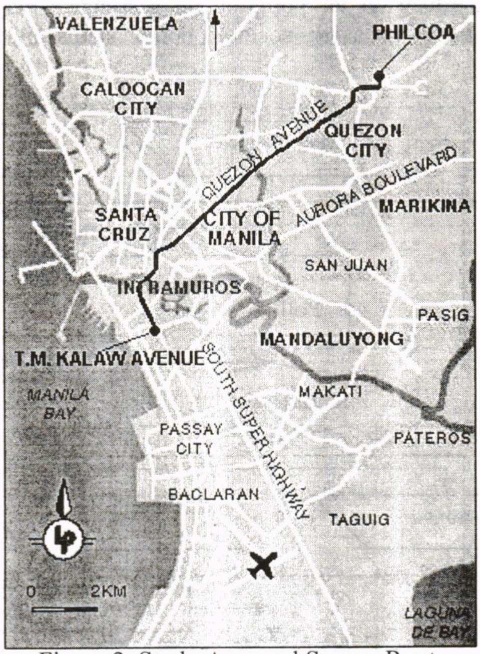

Figure 2. Study Area and Survey Route

The high volume of jeepneys along this route was also indicative of the high levels of SPM emitted by diesel engines. The "Air Pollution Survey Using Filter Badge in Metro Manila" (1998) obtained data on traffic volume along Quezon Avenue and España Avenue. The jeepney traffic volume along Quezon Avenue had an average of 153 jeepneys/hr, while España Avenue had 400 jeepneys/hr for both directions.

Ambient monitoring stations for SPM may not be found in all parts of the route, however, the DENR-NCR Air Quality Monitoring Section has one station along Quezon Avenue as released from their summary report for 1999. The summary shows that it had an annual average of 226μg/Ncm for 24-hour sampling of Total Suspended Particles, nearing the limit of 230μg/Ncm for 24-hour sampling.

2.2 SPM Count, Travel Time and Delay Survey

A surveyor was tasked to record the readings of SPM count cumulatively per minute starting from the time the jeepney was boarded on Philcoa bus/jeepney stop. The Sibata® Digital Dust Indicator LD-3 was used as the measuring device. Simultaneously, another surveyor records travel time and delay starting when the jeepney was boarded. Both measurements stop when T.M. Kalaw Avenue was reached, this was considered as one run with starting time of approximately 7:00 am. The second run started from T.M. Kalaw Avenue and ended in Philcoa, which is the return trip of the jeepney. Another set of runs started in the afternoon, approximately starting at 4:00 pm from Philcoa. The dates for the survey runs were all weekdays, February 8, 9 and 12, 2001 respectively, so as to capture the bulk of passenger trips. The actual time of observations during the morning and afternoon runs are presented in Table 1.

Table 1. Start and End Time of the Runs to and from Philcoa to Kalaw

	Philcoa - Kalaw		Kalaw - Philcoa	
	AM	PM	AM	PM
2/8/2001	7:12 - 8:17	4:13 - 5:12	8:29 - 9:14	5:33 - 6:50
2/9/2001	6:51 - 7:53	4:18 - 5:21	7:59 - 8:55	5:27 - 6:34
2/12/2001	7:05 - 8:09	4:03 - 5:20	8:17 - 9:07	5:21 - 6:42

2.3 SPM Exposure and Travel Time Analysis

The level of exposure of individuals in the road environment is greatly dependent on the amount of time they spend on the road environment, along the roadside and in-transit. The total daily exposure of an individual to air pollution is the sum of the separate contacts to air pollution experienced by the individual as he pass through a series of environments (also called microenvironments) during the course of the day (e.g. at home, while commuting, in the streets, etc.). Exposure in each of these environments can be estimated as the product of the pollutant concentration and the time spent in specific microenvironments (WHO, 2000). This paper uses this concept in estimating the total exposure of the affected population using public transportation. The general form of the equation used to calculate time-weighted integrated exposure is:

$$E_i = \sum_{j}^{J} C_j\, t_{ij} \tag{1}$$

where E_i is the time-weighted integrated exposure for person i over the specified time period; C_j is the pollutant concentration in micro-environment j; and J is the total number of microenvironments that person i moves through the specified time period (Sexton and Ryan, 1988). A microenvironment is defined as a three-dimensional space where the pollutant level at some specified time is uniform or has constant statistical properties. Outdoors in a specific community, inside a motor vehicle, and inside a particular residence are examples of locations that can be defined, under appropriate conditions, microenvironments (Sexton and Ryan, 1988).

The results of the observed values of SPM concentrations are presented in the following figures. The graphical representations of the runs show similarities with the trends of SPM concentrations by time. Figures 3 and 4 show the observed SPM concentrations inside the jeepney from Philcoa to T.M. Kalaw. Figures 5 and 6 show the observed SPM concentrations inside the jeepney from T.M. Kalaw to Philcoa. The concentrations are presented with respect to the travel time per minute.

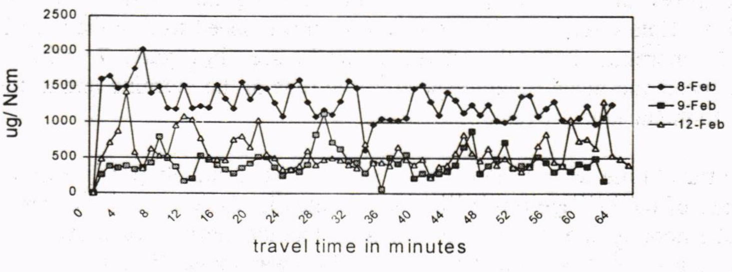

Figure 3. Observed SPM Concentration from Philcoa to T.M. Kalaw Avenue during the Morning Peak Runs

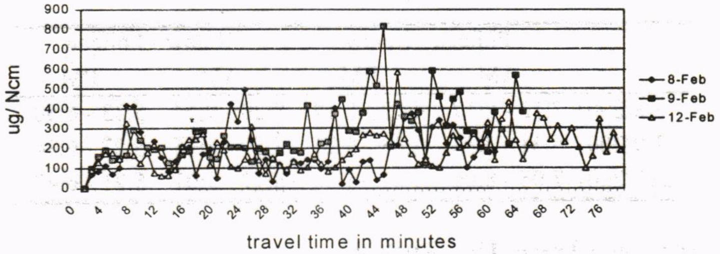

Figure 4. Observed SPM Concentration from Philcoa to T.M. Kalaw Avenue during the Afternoon Peak Runs

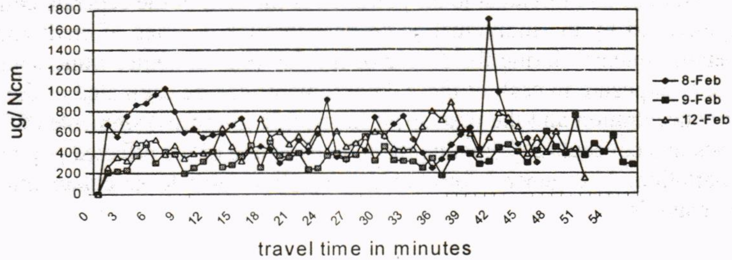

Figure 5. Observed SPM Concentration from T.M. Kalaw Avenue to Philcoa during the Morning Peak Runs

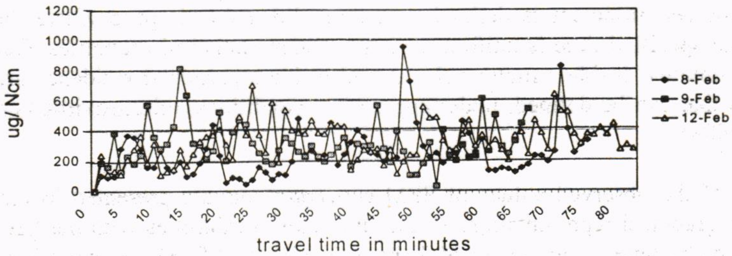

Figure 6. Observed SPM Concentration from T.M. Kalaw Avenue to Philcoa during the Afternoon Peak Runs

The average travel time was computed from the morning and afternoon runs to and from Philcoa to T.M. Kalaw Avenue. The variations of travel speed from Philcoa to T.M. Kalaw Avenue in the morning and in the afternoon can be seen in Figures 7 and 8 showing the mean travel speed and mean running speed of the runs in the morning and in the afternoon with respect to the distance covered.

The average travel time was computed from all the runs separately per direction and time of day. Summary of the average travel time is presented in Table 2. It was observed that runs during the afternoon took a relatively longer time than the morning runs. All runs were done during peak hours but it is evident that travel time was longer during the afternoon peak hours.

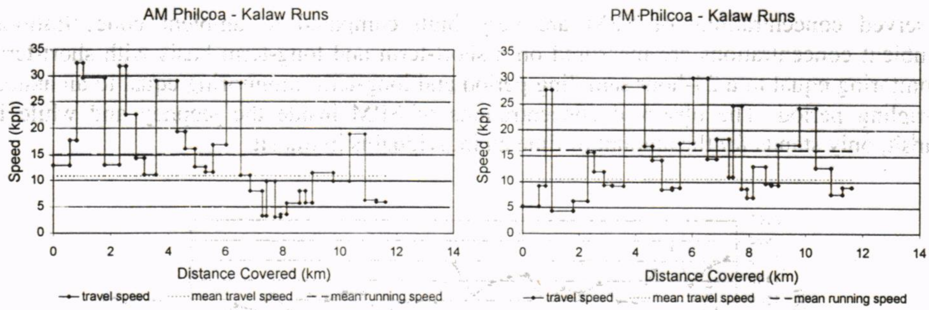

Figure 7. Travel Speed-Distance Diagram for AM and PM Runs from Philcoa to T.M. Kalaw Avenue

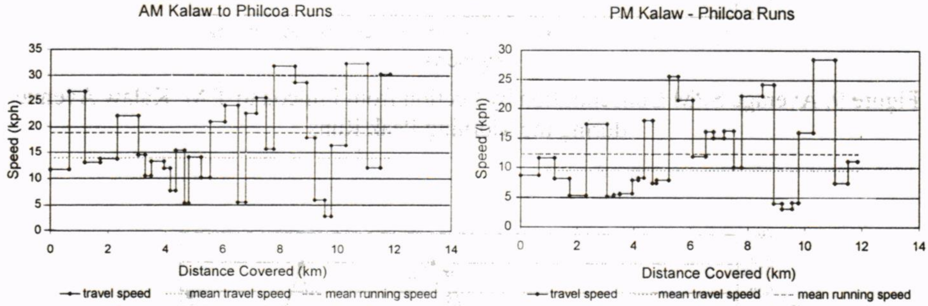

Figure 8. Travel Speed-Distance Diagram for AM and PM Runs from T.M. Kalaw Avenue to Philcoa

Table 2. Summary of Travel Time to and from Philcoa to T.M. Kalaw Avenue in Minutes

	Philcoa - Kalaw		Kalaw - Philcoa	
	AM	PM	AM	PM
2/8/2001	65	59	45	77
2/9/2001	62	63	56	67
2/12/2001	64	77	50	81
Average	64	66	50	75

The authors used different sections along the route with the observed delays to compute the average travel speed and running speed for each section. The sections identified were mostly between signalized intersections along the route.

Figures 9 to 12 show the variation in the measured SPM concentration with respect to the different sections along the route. There is high variation in the observed section concentrations. A probable reason is that the different sections chosen along the route are not equidistant from each other, however, as shown in the graphs, there are still sections that have very high disparities among the observed levels for the different runs. This signifies that the distances between the specified sections do not directly affect SPM concentrations. The sensitivity of the measuring instrument to SPM from direct emissions of jeepneys along the route is the reason for these erratic concentrations of SPM inside the jeepney while in transit. Smoke-belching vehicles near the ridden jeepney or the smoke emitted by the ridden jeepney itself increases the readings taken from the measuring instrument. Nonetheless, the observed concentrations of SPM are very high compared to ambient concentrations. Ambient concentrations are measured on a short-term and long-term basis with short-term monitoring equal to a 24-hour sampling period and long-term monitoring equal to an annual sampling period. The observed concentrations of SPM inside the jeepney and while in transit, only stands for the amount of time an individual is in transit.

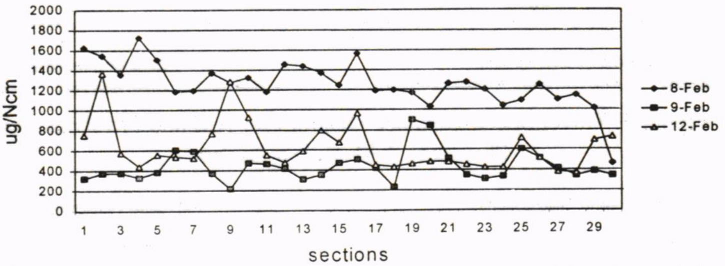

Figure 9. Average SPM Concentration by Section from Philcoa to T.M. Kalaw Avenue during the Morning Peak Runs

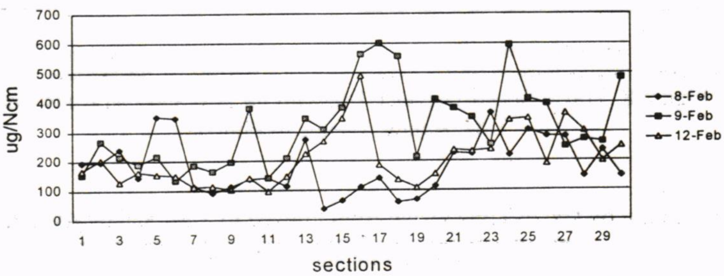

Figure 10. Average SPM Concentration by Section from Philcoa to T.M. Kalaw Avenue during the Afternoon Peak Runs

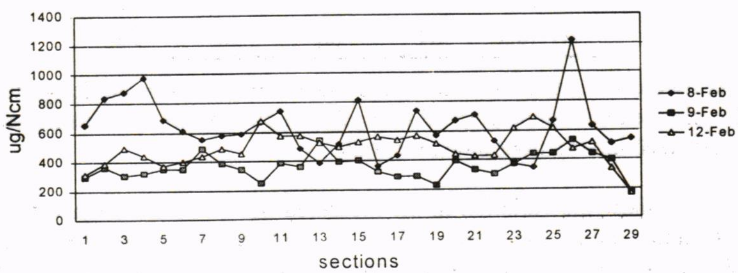

Figure 11. Average SPM Concentration by Section from T.M. Kalaw Avenue to Philcoa during the Morning Peak Runs

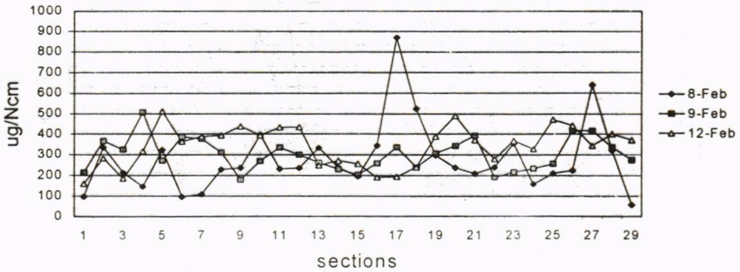

Figure 12. Average SPM Concentration by Section from T.M. Kalaw Avenue to Philcoa during the Afternoon Peak Runs

The travel time data and the observed values of SPM concentrations while in transit were used in estimating the levels of exposure of individuals while in transit. The 24-hour time-fraction of the time spent in each section throughout the route was used to get the levels of exposure of individuals while inside the jeepney and in transit.

Using equation (1), the levels of exposure of individuals inside jeepneys were computed. The average values are shown in Table 4.

Table 3. Estimated Levels of Exposure of Passengers inside Jeepneys (μg/Ncm)

	Philcoa - Kalaw		Kalaw - Philcoa	
	AM	PM	AM	PM
8-Feb	55.94	7.72	19.47	13.01
9-Feb	18.08	12.14	14.24	14.16
12-Feb	26.53	10.59	18.07	18.81
Average	33.52	10.15	17.26	15.33

Studies regarding time-activity patterns of individuals help in the over-all estimation of an integrated exposure assessment to air pollution for a 24-hour period. In a study by Szalai (1992) and Chapin (1974), they presented a 24-hour activity pattern for an individual. Both studies found that on most days people are inside their residences for an average of 65 to 70 percent of the time, and indoors at home, work, or elsewhere for more than 90 percent of the time. Although these values vary with age, gender, occupation, socio-economic status, and day of the week, it has become clear that indoor microenvironments must be taken into account for a realistic assessment of exposure to many air pollutants (Sexton and Ryan, 1988). Correspondingly, the concentration of respirable suspended particles was used to compute exposure levels. The study emphasized the importance of evaluating in-transit exposure since the results show that in-transit exposure contributes to 15% of the exposure for a 24-hour integrated period. Also, in-transit levels of respirable suspended particle concentrations were observed to be higher than other microenvironments. Respirable suspended particles, also synonymous with suspended particulate matter are those particles that can be inhaled by humans.

The level of exposure of the individual on each section of the trip was computed from the observed concentration of SPM and the time spent as shown in Figure 13. This was done in order to investigate the amount of exposure an individual takes along the trip.

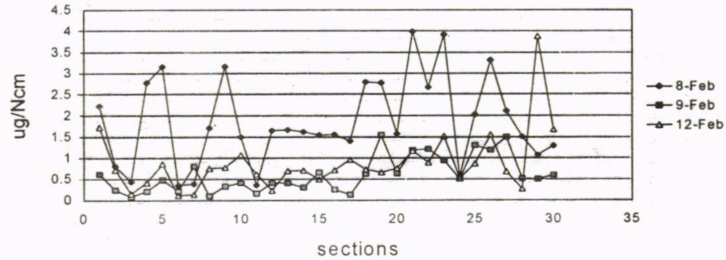

Figure 13. Levels of Exposure by Section along the Philcoa to Kalaw Route (AM Runs)

The results of the surveys show that the average travel time to and from Philcoa to T.M. Kalaw Avenue is approximately 1 hour. For the number of people who frequently use the Philcoa to T.M. Kalaw Avenue route, the time fraction they spend in transit is equal to 0.08 or 2 hours. The observed SPM concentrations and the time spent showed that average levels of exposure for one trip reached a maximum of 33.52μg/Ncm and a low of 10.15μg/Ncm (Table 3). This value is only representative of the individual's exposure to SPM while in-transit.

The daily limit set by the local Clean Air Act of 1999 is pegged at 230μg/Ncm for short-term monitoring of suspended particulate matter. Considering the results of the observed values of SPM concentrations while in transit, the possible levels of exposure yield a high amount. The average travel time for the Philcoa to T.M. Kalaw Avenue route was observed to be 2 hours for a round trip and the average level of SPM, regardless of time and direction is 19.07μg/Ncm. The exposure level is equal to 17.48μg/Ncm. This is just equivalent to the 2 hours the individual has spent while traveling.

The relationship of SPM and exposure with regard to the travel time and delay study were analyzed by regressing the SPM concentration and the computed exposure of the individual while in transit on variables such as running speed, running time, travel speed, and travel time. The regression result showed a better model by using the exposure data as the dependent variable as compared to using the observed SPM concentrations.

The variable with the most relevant relationship was found to be the travel time for each section indicated by SECTTIME. Other variables such as running speed, distance, travel speed, and delay showed very little significance in the regression. Results of the regression are shown below:

Table 4. Regression Results for Exposure and Travel Time

Parameter	Intercept	SECTTIME
Estimates	0.18613491	0.003528114
St. Error	0.04709825	0.000287613
t-statistic	3.95205562	12.2668888
p-level	9.3653E-05	4.81378E-29

Despite the low R^2 of 0.30, this model yielded the highest measure of significance as compared with and in combination to the other variables such as, running speed, running time, delay and travel speed. The positive sign of the SECTTIME variable indicates that as the travel time for a section increases, the exposure of the individual also increases. The relevance of this regression analysis is that the authors were able to look into the possible factors influencing SPM concentration while in transit. The regression result was able to conclude that the concentration of SPM is not affected by the running speed and delay of the jeepney.

3. WILLINGNESS-TO-PAY FOR THE IMPROVEMENT OF AIR QUALITY

Establishing the fact that passengers are exposed to higher levels of SPM as previously conceived by ambient monitoring, the authors employed a face-to-face interview on the jeepney passengers in transit and while waiting for a ride in order to know their perception and willingness-to-pay for improved air quality.

3.1 Data Collection

Simultaneous with the SPM and travel time and delay survey, another surveyor was tasked to conduct a face-to-face interview survey of passengers inside the jeepney while traveling the route. The passenger's travel behavior, socio-economic status, perception on health effects of SPM, perception on air quality inside jeepneys and on the roadside environment, and willingness-to-pay was gathered. Another face-to-face interview survey on jeepney passengers was done on June 13, 2001 at the Philcoa bus/jeepney stop. This time the target respondents were the people waiting for a jeepney ride.

3.2 Contingent Valuation Questionnaire

The discrete-response contingent valuation question introduces the relationship of motor vehicle emissions to human health, particularly suspended particulate matter. The interviewer clearly explained to the respondent that SPM emissions by jeepneys and other diesel-fed engines could affect their health. A strategy by the government by mandating jeepney drivers/operators to regularly comply with a monthly check-up of their vehicles with the proper authorities was also introduced to the respondent. Then the interviewer explains that the drivers/operators may not be able to comply with this policy due to their financial inadequacy.

The interviewer then asked the question on their willingness-to-pay for an additional increase in fare. For the first survey, the initial bid was fixed at PhP1.00. If the reply was 'yes' then interviewer follows it up with PhP2.00 bid and if the reply was 'no', the interviewer offers a lower cost, PhP0.50. The second survey employed the draw card technique in order to eliminate the initial bid bias. The first bid was randomly chosen by the respondent from a set of cards, after which, their reply was elicited. A higher bid was again offered by the interviewer, if the reply is 'yes' and a lower bid, if otherwise. The second bid was still drawn from the prepared set of cards.

3.3 Multivariate Analysis

Information regarding the individual's travel behavior, socio-economic status, air quality perception, perceived effect on human health, and willingness-to-pay in order to help regulate SPM emissions by jeepneys, were analyzed through a logit regression model. Table 5 shows the profile of the respondents from the interview-survey. Consequently, these also serve as the variables used in the regression model so as to investigate the possible effect of these variables in the individuals' decision to pay for improved air quality.

Table 5. Profile of Respondents

Variables	Description	Mean	St. Dev.
CHOICE	Dependent Variable; 1=Yes, 0=No	0.375	0.485
INITBID	Initial bid; P0.5, P1, P1.50, P2, P2.50, P3, P3.50	1.610	0.663
GEN	Gender; 1=Male, 0=Female	0.510	0.501
STAT	Status; 1=Single, 0=Married	0.550	0.499
AGE	Age; continuous data	28.425	10.696
CAROWN	Car ownership; 1=with car, 0=without car	0.158	0.366
EDUC	Educ. Attainment; 1=Elem., 2=Sec.,3=Vocational, 4=College, 5=Post College	2.900	0.962
HINC	Household Income; 1=<P3000, 2=P3001-6000, 3=P6001-10000, 4=10001-15000,...	3.995	2.014
FREQHLTH	Frequency of being afflicted with resp. disease; 1=always, 0=otherwise	0.620	0.487
JEEPTIME	Time spent inside the jeepney; continuous data	56.830	43.212
INSIDE	Perception on air quality inside jeepney; 1=v. good, 2=good, 3=fair, 4=bad, 5=v.bad	3.360	0.833
RDSIDE	Perception on air quality on the roadside; 1=v. good, 2=good, 3=fair, 4=bad, 5=v.bad	3.385	0.933

The dependent variable, CHOICE, was the respondents' answer to the first bid question, since it is here that the respondent is first asked to provide an answer to the introduced strategy in order to improve air quality. A set of independent variables was used in order to attempt to explain the respondents' choice to pay for improved air quality. The initial bid (INITBID) was the starting bid question given to the respondents. The results of the multivariate analysis yielded low t-statistics for all independent variables except INITBID. The initial bid has a negative sign in the regression, implying an indirect interaction with the dependent variable. Following logic and economic theory that as the initial bid increases, willingness-to-pay decreases, or in this case, the respondent will most likely reject the bid offered.

3.4 Quantifying Willingness-to-Pay of the Respondents

The contingent valuation provides an answer to whether the respondents were willing to pay for an additional increase in fare, thereby helping the drivers/operators in maintaining the good condition of their vehicles. By doing so, the vehicle-generated emissions of jeepneys would be lessened.

The double-bounded discrete response contingent valuation follows up on the initial question/bid, with a second question again involving a specific amount to which the respondent can respond with a yes or no (Bateman and Willis, 1999). There are four possible combinations of answers from the respondents, yes-yes, yes-no, no-yes, no-no. The probability for the discrete response follows the general formula for logit regression.

$$\Pr(Yes) = \frac{1}{1+\exp\{-[V(1,Y-C)-V(0,Y)]\}} = 0.5 \tag{2}$$

For this equation, Y is income, which may also represent other variables that may be included in the analysis and C is the cost introduced to the individual. The probability of getting a "yes" answer and a "no" answer is 0.5. The estimation approach used for the double-bounded model was maximum likelihood expressed in the formula below.

$$\max_{\beta^{SP}_{o}} : \ln L^{SP} = \sum_{i}\left(\delta^{i}_{yy}\ln P^{i}_{yy} + \delta^{i}_{yn}\ln P^{i}_{yn} + \delta^{i}_{ny}\ln P^{i}_{ny} + \delta^{i}_{nn}\ln P^{i}_{nn}\right) \tag{3}$$

where δ_{xz} = indicator function that equals one when the two responses are *xz*, and zero otherwise (Hanneman, 1999).

xz = represents the different combinations *yy*, *yn*, *ny*, and *nn*,
SP = stated preference/ answer of the respondents

The median willingness-to-pay may be computed from changing $V(1, Y\text{-}C)\text{-}V(0,Y)$ in the logit formula (2) to $\Delta V(C)$, in order to reflect the variations in cost. Equation 2 may be transformed to the formula below in deriving the median willingness-to-pay.

$$C^* = exp\,(\alpha / \beta) \qquad (4)$$

where C^* = median cost of the responses
α and β = parameter estimates

The median was used as the measure of central tendency representing the data because the bids were already preset, meaning it is not affected by extreme values in the response distribution. The mean is the conventional measure in benefit-cost analysis and from a statistical point of view, more sensitive than the median, however, the median may be more realistic in a world where decisions are based on voting and there is a concern for the distribution of benefits and costs (Hanneman, 1999). The results of the maximum likelihood estimation are shown below.

Table 6. Summary of Regression

	Survey 1		Survey 2		HHoldInc1		HHoldInc2		HHoldInc3	
Parameter	α	β	α	β	α	β	α	β	α	β
Estimates	0.36	1.66	0.19	1.45	-0.47	1.26	-0.02	1.89	0.26	1.21
Standard Error	0.24	0.26	0.16	0.16	0.33	0.32	0.22	0.27	0.21	0.18
t-statistic	1.45	6.45	1.21	9.28	-1.43	3.91	-0.10	7.05	1.25	6.64
No. of Samples	61		139		40		77		80	
Log of Likelihood =	-327.335		-860.839		-194.763		-433.145		-456.245	
C^* =	1.24		1.14		0.69		0.99		1.24	

Note:
HHoldInc1 = household income below 10,000 pesos/month
HHoldInc2 = household income 10,001-20,000 pesos/month
HHoldInc3 = household income greater than 20,000 pesos/month

Survey 1 was done simultaneously with the SPM and travel time survey. The respondents were inside the jeepney while in-transit. Survey 2, on the other hand, was conducted on passengers waiting for a jeepney along Philcoa. HHoldInc1, HHoldInc2 and HHoldInc3 stands for the aggregated respondents from survey 1 and 2, segmented according to the household income of the respondents.

The log of likelihood of the model is indicative of its significance and a higher probability of the dependent variable to occur in the sample. The log of likelihood is also dependent on the robustness of the data; the higher the value means the larger the sample size. The low t-statistics of α indicates that it is not that relevant at the 95% significance level.

Using the parameter estimates derived from the maximum likelihood estimation, the probability that the respondents will pay for the increase in fare was computed. Figure 13 shows a comparison of the two surveys, with the first survey having a slightly higher probability curve than the second survey. Although the disparity between the two is not big, it can be inferred that the respondents of the first survey, done inside the jeepney and in transit, obtained a higher median value for their willingness-to-pay and probability curve. Their direct exposure to higher SPM levels during the interview could affect the results.

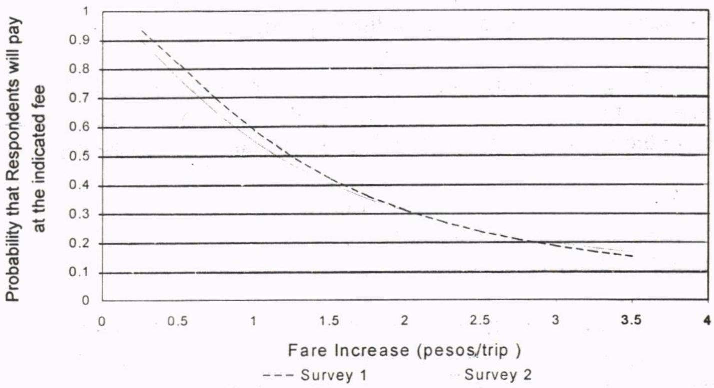

Figure 13. Probability of Respondents Paying for Improved Air Quality at the Indicated Fee

To be able to investigate the willingness-to-pay with respect to the economic status of the respondents with their willingness-to-pay, the probability curves for different income groups were also graphed as shown in Figure 14.

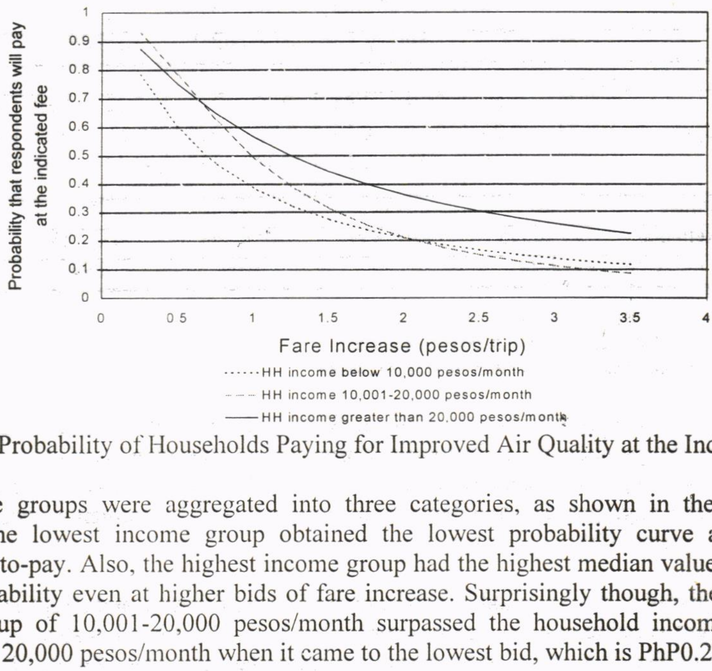

Figure 14. Probability of Households Paying for Improved Air Quality at the Indicated Fee

The income groups were aggregated into three categories, as shown in the graph. As expected, the lowest income group obtained the lowest probability curve and median willingness-to-pay. Also, the highest income group had the highest median value and posted a high probability even at higher bids of fare increase. Surprisingly though, the household income group of 10,001-20,000 pesos/month surpassed the household income group of greater than 20,000 pesos/month when it came to the lowest bid, which is PhP0.25.

4. CONCLUSIONS AND RECOMMENDATIONS

The study's analysis on in-transit levels of suspended particulate matter showed higher levels of SPM while in transit along a major trunk road, compared to the regular ambient concentrations in Metro Manila. Also, the levels of exposure of an individual were presented while in transit. The time-weighted 24-hour integrated exposure showed that the exposure levels are high considering the time fraction that an individual spends in transit for a day.

Given the current levels of SPM concentrations as reported by ambient monitoring stations of the Department of Environment and Natural Resources, roadside and area concentrations of SPM may also be very high, hence, further increasing the exposure of individuals to SPM for a 24-hour period, exceeding the limits prescribed.

The results of the contingent valuation on the respondents' willingness to pay have shown that the respondents were willing to pay for as much as a PhP1.24 pesos increase in fare for the improvement of air quality. A possible application of the policy would mean that the current minimum fare, which is PhP4.00, could be increased to a high of PhP5.24 as per the result of the survey. The results showed that the passengers in-transit have given a relatively higher cost than the respondents along the roadside waiting for a ride. This was probably due to the fact they were exposed to higher SPM levels during the interview-survey itself. The probability curve for the household income showed that the lower income group was more hesitant to pay for improved air quality than the higher income groups, following the economic theory.

Strategy is important for the success of any policies that the government may implement. Without proper education of the public regarding the health hazards posed by air pollution, the policy may not be as effective as expected. The values generated are considered as the value an individual is willing to pay per trip, in exchange for cleaner air, hence, better health. Aggregating this value for a one-day trip to and from work in a public transportation mode, it can be derived that an individual regularly riding a jeepney everyday may actually shell out an increase of approximately PhP2.50 per day or PhP50.00 per month for improved air quality. Moreover, implementation techniques should also be explored. A gradual increase in fare may be more favorable than an abrupt one.

Further studies should aim to investigate traffic volume and temperature as a factor in the observed levels of exposure to SPM in-transit. Also, health effects of SPM towards public transport passengers and other carriageway users should be further investigated in Metro Manila in order to correlate the observed levels of exposure with the incidences of respiratory diseases, aggravations of diseases, and mortality and morbidity rates in the metropolis. Further studies regarding levels of concentration of SPM and other pollutants in different microenvironments would be vital in the assessment of the total exposure of an individual per day. Possible health effects may then be more accurately anticipated and remedied. In terms of the publics willingness-to-pay, other fee collection techniques may also be looked at, aside from increasing the transportation fare.

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