Evidence Review:

Air Quality - Outdoor

Population Health and Wellness
BC Ministry of Health

March 2006

This is a review of evidence and best practice that should be seen as a guide to understanding the scientific and community-based research, rather than as a formula for achieving success. This review does not necessarily represent ministry policy, and may include practices that are not currently implemented throughout the public health system in BC. This is to be expected as the purpose of the Core Public Health Functions process—consistent with the quality improvement approach widely adopted in private and public sector organizations across Canada—is to put in place a performance improvement process to move the public health system in BC towards evidence-based best practice. Health authorities will develop public performance improvement plans with feasible performance targets and will develop and implement performance improvement strategies that move them towards best practice in the program component areas identified in the Model Program Paper. These strategices, while informed by the evidence in this review, will be tailored to local context.

This Evidence Review should be read in conjunction with the accompanying Model Core Program Paper.

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EXECUTIVE SUMMARY

Exposure to outdoor air pollution can have a negative human health impact. Air pollution can have wide ranging detrimental effects on health, from irritation of the respiratory tract to premature mortality. For this reason, government has allocated many resources to the improvement of outdoor air quality. Several interventions to reduce outdoor air pollution have been successfully implemented. Despite the effectiveness of these interventions in decreasing air pollution, the health gains as a result of air quality improvements have not been well clarified.

The goal of this report was to review the studies that evaluated the health benefits from outdoor air pollution interventions in order to recommend steps that could be taken by public health to effectively address outdoor air pollution concerns. A literature search was conducted on MEDLINE using the following criteria: 1) the intervention was done at the regional or community level; and 2) health impacts as a result of the intervention were studied.

A total of 11 studies were retrieved. The interventions evaluated in these studies included closures or upgrades of industrial emission sources and government-implemented policy interventions such as the restriction or banning of the use of toxic substances. The studies were reviewed according to the category of pollutant affected by the intervention.

Several interventions that succeeded in decreasing levels of particulate matter have resulted in a beneficial health impact. The closing of a steel mill during a labour dispute resulted in lower PM_{10} levels and was linked to a reduction in average deaths per day. The reduction of industrial and motor vehicle emission in East Germany led to a drop in total suspended particulate. An incremental decrease in total suspended particulate was associated with a positive change in pulmonary function tests in children. A study on the efficacy of intervention methods utilized during the Hoopa Valley, California wildfires reported that two methods appeared effective in decreasing respiratory symptoms. The two intervention methods included the greater duration of using high efficiency particulate air cleaners and the recalling (i.e., remembering) of public service announcements.

The reduction of airborne lead is an example of a successful intervention strategy. Government regulation on the phase-out of lead in gasoline drastically reduced airborne lead levels. The health benefits resulting from this intervention strategy are not discussed in this report. The interventions that were reviewed focused on reducing lead exposure from nearby point sources. The upgrading of a lead-zinc smelter in Trail, BC, was followed by a significant decrease in blood lead levels. Additional community interventions may have contributed slightly to the reduction in blood lead. The reduction in blood lead levels following the closure of a metals smelter was also evident in North Lake Mcquarie, Australia.

The third category of pollutant reviewed was the restriction of sulphur content in fuel in Hong Kong. Several studies examined the effect of this intervention on respiratory symptoms in children. Collected data from one study showed a reduction in bronchial responsiveness following implementation of the sulphur restriction. The results from the other study reviewed were difficult to interpret due to the common presence of environmental tobacco smoke in the homes of the children studied. This intervention was also reported to have resulted in a significant decline in annual trend deaths from all causes.

The implementation of alternative transportation strategies during the Atlanta Olympics resulted in a decrease in peak daily ozone, carbon monoxide and PM_{10} levels, and an increase in sulphur dioxide levels. During this time, the number of acute asthma events, including hospitalizations, emergency department visits and urgent care centre visits was determined and compared to previous time periods. An overall decrease in asthma-related visits to emergency care clinics was reported while the transportation alternatives were in place.

All of the outdoor air interventions presented resulted in positive health gains. There were several pre-conditions that were common to all intervention strategies prior to initiation. It is recommended that public health departments involved with outdoor air pollution in BC focus their efforts either on interventions that meet these pre-conditions, or on establishing these pre-conditions. The pre-conditions included: 1) officials could conclude that the levels present in their community were negatively impacting health as a result of monitoring ambient air pollutants; and 2) pollutants were at concentrations significantly above background levels. It is also recommended that sources of outdoor air pollution amenable to an intervention be identified.

1.0 OVERVIEW/ SETTING THE CONTEXT

In 2005, the British Columbia Ministry of Health released a policy framework to support the delivery of effective public health services. The *Framework for Core Functions in Public Health* identifies air quality as one of the 21 core programs that a health authority provides in a renewed and comprehensive public health system.

The process for developing performance improvement plans for each core program involves completion of an evidence review used to inform the development of a model core program paper. These resources are then utilized by the health authority in their performance improvement planning processes.

This evidence review was developed to identify the current state of the evidence based on the research literature and accepted standards that have proven to be effective, especially at the health authority level. In addition, the evidence review identifies best practices and benchmarks where this information is available.

1.1 An Introduction to This Paper

Previous studies have demonstrated that air pollution can have detrimental health impacts on the local population. In response, many governments and non-governmental organizations have dedicated their resources and efforts into the control and reduction of air pollution all in the name of preserving public health. For example, the US Environmental Protection Agency estimates an annualized cost of $25 billion/year from 1970-1990 (>$500 billion for 20 years) for pollution control (HEI Accountability Working Group 2003). Other interventions have included public education, air quality advisories, and outright bans on the use of known toxic substances.

In spite of the vast financial resources invested, few studies have been conducted determining the health gains as a result of air quality improvements, and whether these interventions have truly been efficacious. The purpose of report is to 1) review the studies that have evaluated the health benefits from outdoor air pollution interventions, and 2) in light of this review, recommend the steps to be taken by public health units in British Columbia to effectively address outdoor air pollution concerns.

2.0 METHODOLOGY

A literature search was conducted on MEDLINE, using the following criteria. A local expert in outdoor air pollution and health was also consulted to find other studies. Studies that met the following inclusion criteria were included in the review: intervention was done at the regional or community level, health impacts as a result of the intervention were studied.

3.0 RESULTS

3.1 Studies and Reviews Included

In total, 11 studies were retrieved (see Table 1 for a summary). The interventions evaluated in these studies include closures or upgrades of known industrial emission sources, government implemented policy interventions (though not necessarily always for the purpose of reducing air pollution) such as restrictions or bans on the use of toxic substances, or restricting sources of pollution. All of these studies concluded a resultant health benefit as a result of the intervention.

Table 1: Summary of Outdoor Air Pollution Intervention Studies

Reference	City	Intervention	Pollutant(s)	Health Outcome(s)	Confounding
Particulate Matter					
Pope et al. (1992)	Utah County, US	Steel mill closure	PM_{10} (50→35μg/m^3)	↓Mortality (↑5 day moving average 100μg/m^3 PM_{10}= ↑16% total mortality ↑43% respiratory deaths, ↑20% Cardiovascular deaths, ↑5% All Other)	
Heinrich et al. (2002)	Bitterfeld, Hettstedt, Zerbst East Germany	Reduction of coal burning emissions and motor vehicle pollution	TSP[2] (79→23μg/m^3) SO_2 (113→6μg/m^3)	↓Non-allergic respiratory disorders (bronchitis, sinusitis and frequent colds) (↑50μg/m^3 TSP= Bronchitis OR=3.0 Sinusitis OR=2.6 Frequent colds OR=1.9)	Recall bias Smoking, socioeconomic status, nutrition, poverty Temporal changes with reunification – changes to medical care, diet, housing conditions
Frye et al. (2003)	Zerbst, Hettstedt, Bitterfeld East Germany	Reduction of coal burning emissions and motor vehicle pollution	TSP (79→23μg/m^3) SO_2 (113→6μg/m^3)	↑lung function (FVC) in grade 6 boys and girls (↓50μg/m^3 TSP=↑4.7% FVC) (↓100μg/m^3 SO_2=↑4.7% FVC)	Smoking, socioeconomic status, nutrition, poverty Temporal changes with reunification – changes to medical care, diet, housing conditions
Clancy et al. (2002)	Dublin, Ireland	Coal sale ban	Black smoke (50→15μg/m^3) SO_2 (33→22μg/m^3)	↓Mortality ↓Non-trauma deaths=5.7% ↓Respiratory deaths=15.5% ↓Cardiovascular deaths=10.3%	Secular changes (could decrease death rates)
Mott et al. (2002)	Humboldt, CA, US	Intervention use during wildfire	PM_{10} (magnitude of change not applicable)	↓respiratory symptoms with longer use of HEPA filters (OR=0.54), or recall of PSA (OR=0.25)	Recall bias No randomization No control group Study only on those with pre-existing conditions - Severity of lower respiratory tract infection

Reference	City	Intervention	Pollutant(s)	Health Outcome(s)	Confounding
Lead					
Hilts (2002)	Trail, BC, Canada	Upgrade of lead-zinc smelter	Lead (1.1→0.3μg/m^3)	↓Blood lead levels in children (0.6→1.8μg/dL)	Participation bias Relocation of high exposure children Lead reduction from gasoline, other community efforts (small)
Morrison (2003)	North Lake Macquarie, Australia	Upgrade of lead smelter	Lead (92→15 tonnes/yr)	↓Blood lead levels in children, but not to objective levels (11→10 μg/dL)	Decreasing participation rates over study period (volunteer bias) No control group Smelter not adhering to emission regulations Lots of activity increases soil exposure
SO_2+other pollutants					
Peters et al. (1996)	Hong Kong	Restriction of sulphur content in fuels	SO_2 (Kwai Tsing 136→26μg/m^3) Sulphate on RSP[1] (Kwai Tsing 12.5→7.7μg/m^3 RSP[1]	↓odds ratios for respiratory symptoms in children living in Kwai Tsing (polluted area) post intervention (no difference from clean area, Southern)	Recall bias Exposure misclassification
Wong et al. (1998)	Hong Kong	Restriction of sulphur content in fuels	SO_2 (Kwai Tsing 136→26μg/m^3) Sulphate on RSP[1] (Kwai Tsing 12.5→7.7μg/m^3	↓Bronchial responsiveness and hyper-responsiveness in children post intervention	Autocorrelation within districts, within subjects Exposure misclassification
Hedley et al. (2002)	Hong Kong	Restriction of sulphur content in fuels	SO_2 (44→21 μg/m^3)	↓Mortality (↓All cause=2.1% ↓Respiratory=3.9% ↓Cardiovascular=2.0%)	
Ozone+other pollutants					
Friedman et al. (2001)	Atlanta, GA, US	Implementation of alternative transportation strategy	Ozone (81→59ppb) PM_{10} (37→31μg/m^3) CO (1.5→1.3ppm)	↓Paediatric visits to hospitals, clinics, for acute asthma (RR=0.48 for acute asthma attacks during Olympics significant for Georgia Medicaid files only)	Possible relocation or change in travel behaviour during Olympics

Note: [1]RSP=respirable suspended particulates ($PM_{2.5}$), [2]TSP=total suspended particulates

3.2 Summary of Findings

3.2.1 Particulate Matter

A. Steel mill closure and decrease in mortality

Pope, Schwartz, and Ransom (1992) evaluated the health impacts resulting from closure of a steel mill during a labour dispute in 1986. This mill is the primary source of PM_{10} pollution for Utah Valley. Mortality data for respiratory, cardiovascular, and all-other causes were collected from Apr 7, 1985-1989. PM_{10} ambient levels were determined by monitoring stations. A strong association was found between PM_{10} levels and mortality. PM_{10} concentrations averaged 35µg/m^3 during closure of the mill, and 50µg/m^3 when it was opened. They found the average deaths per day were higher during periods when the mill was open (+3.2 per cent) than when it was closed (closed for 13 months) following adjustment for confounding. For a 100µg/m^3 increase in 5 day moving average of PM_{10}, a 16 per cent increase in total mortality, and specifically, a 43, 20, and 5 per cent increase in respiratory, cardiovascular, and all other causes of death, respectively. This study was included in the HEI Accountability Report (2003).

B. Reduction of industrial and motor vehicle emissions due to economic restructuring

The reunification of East and West Germany in 1990 resulted in a tremendous improvement of ambient air quality in East Germany. Collapse of the industrial and agricultural structure, and change in the type of motor vehicle use in East Germany resulted in a decrease of emissions and ambient pollutant concentration levels (Ebelt et al. 2001). Two studies, Heinrich et al. (2002), and Frye et al. (2003), evaluated the health impacts on children resulting from the decline of combustion-derived emissions following reunification. 3 cross-sectional surveys were performed in 1992-1993, 1995-1996, and 1998-1999 on children in 3 communities of East Germany, Bitterfeld, Hettstedt, and Zerbst. Bitterfeld had many chemical and power plants. Hettstedt has been a major mining and smelting centre. Zerbst is mainly an agricultural and administrative centre, and the served as the control population. Prior to reunification, there were large differences in industrial emissions between the three sites. Post-reunification, ambient annual mean concentrations of TSP fell from 79µg/m^3 to 23µg/m^3 (monitored 1993-1998) and SO_2 fell from 113 to 6µg/m^3 (monitored 1991-1998), and, no significant difference in pollution levels between these three areas were found.

Heinrich et al. (2002) evaluated the impact of declines in TSP and SO_2 on the prevalence of non-allergic respiratory disorders in 1st, 3rd, and 6th grade children. Health outcomes were determined by questionnaire, and completed by parents of the subjects. A continuous decline in prevalence for bronchitis and frequent colds was found between the three surveys, and temporal changes followed similar trends in the three study areas. Adjusted odds ratios for a 50µg/m^3 increment in TSP were 3.0 (CI=1.7-5.3) for bronchitis, 2.6 (CI=1.0-6.6) for sinusitis, and 1.9 (CI=1.2-3.1) for frequent colds (the effect sizes for 100µg/m^3 increment in SO_2 were similar).

Frye et al. (2003) evaluated the impact of declines in TSP and SO_2 on lung function in children, 11-14 years of age. Pulmonary function tests (forced vital capacity – FVC, and forced expiratory volume in 1 second - FEV1) were performed in. FVC and FEV1 were found to increase in both boys and girls from 1992-1993 and 1998-1999. A 50µg/m^3 decrease of TSP resulted in a 4.7 per cent change in the adjusted FVC; for a 100µg/m^3 decrease in SO_2 4.9 per cent change was found.

C. Government ban on the sale of coal and effects on mortality in Dublin, Ireland

Clancy et al. (2002) evaluated the impact of a 1990 ban on the sale of coal in Dublin, Ireland, on the ambient air pollution levels and mortality. Changes in the ambient concentration of black smoke and SO_2, and age-standardized mortality (non-trauma, respiratory, cardiovascular, and other causes [=non-trauma – (resp+CV)] of deaths) were compared for 72 months prior and after the ban. Average black smoke concentrations fell substantially by 35.6μg/m^3 (70 per cent, greatest decline in winter), while average SO_2 concentrations fell by 11.3μg/m^3 (~35 per cent, greatest decline in winter) significantly after the ban. A significant decrease was found in mortality due to non-trauma (5.7 per cent), respiratory (15.5 per cent) and cardiovascular (10.3 per cent) following adjustment for confounders (temperature, humidity, day of week, respiratory epidemics, and death rates in rest of Ireland). 116 fewer respiratory deaths and 243 fewer cardiovascular deaths were seen per year following the ban in Dublin. These health improvements were much larger than those based on applying concentration-response factors from time series epidemiology studies (risk assessment). This study has been reviewed by the HEI and included in their accountability report (HEI, 2003).

D. Evaluating the efficacy of intervention methods utilized during wildfires

Mott et al. (2002) evaluated the intervention measures utilized during the Hoopa Valley forest fire in 1999 (Aug 23-Nov 3) and their impacts on health retrospectively. Smoke from the fire resulted in PM_{10} ambient concentrations to exceed the US EPA 24-hr air quality standard on 15 days, and in general, were considerably higher in 1999 than 1998. A survey on respiratory symptoms experienced prior to, during, and after the fire, was conducted on residents who have visited the reservation medical clinic for coronary artery disease, asthma, chronic obstructive pulmonary disease, or other lung diseases plus one control household member. Clinic visits for respiratory problems were correlated with PM_{10} levels (weekly), and increased by proportion of total visits, and overall (520 per cent). The interventions included: distribution of free filtered/non-filtered masks, vouchers for free hotel services in nearby towns to facilitate evacuation*, portable high efficiency particulate air (HEPA) cleaners*, and public service announcements (PSAs) released through local media outlets (*due to financial constraints, these were distributed only to those with adverse health effects). Respiratory symptom data (collected by questionnaire) and clinic visits were evaluated. Among the interventions, those with increased duration of using a HEPA cleaner (OR=0.54) or recalling a PSA (OR=0.25) had decreased odds to report lower respiratory symptoms (no confidence intervals were included in the publication).

3.2.2 Lead

A successful example of an intervention is that of airborne lead. Mobile sources were identified as a major contributor to airborne lead. Government regulation on the phase-out of lead in gasoline has decreased airborne lead levels drastically (HEI, 2003).

The following studies focus on interventions in communities with exposures to live from nearby point sources.

A. Smelter upgrade in Trail, BC and reduction in blood lead levels in children

Hilts (2003) investigated the impact of an upgrade to a lead-zinc smelter on the blood lead level of local children in Trail, BC in 1997. Previous studies have shown elevated blood lead levels in local children, leading to the formation of the Trail Community Lead Task Force. This Task force established regular blood lead screening in local children 6-60 months. Air (2 monitoring stations), indoor dustfall, soil and dust (floor and street from 32 homes) samples for lead were taken quarterly from 1994-1999. Following the upgrade to the smelter, a significant decrease in environmental [geometric mean air (73 per cent, from 1.1 to 0.3$\mu g/m^3$), street dust (45 per cent, from 220 to 120 mg/m^2), indoor dustfall (50 per cent, from 0.14 to 0.07mg/m^2), outdoor dustfall (50 per cent, from 61 to 31 mg/m^2)] and blood lead levels were found. An annual average decrease of 0.6μg/dL was found for 1989-1996 (5-6 per cent decline per year, similar to decline seen in US National Health and Nutrition surveys, attributed to the removal of lead from gasoline and diet), and of 1.8μg/dL for 1997-1999 (18-22 per cent decline per year, much greater than baseline fall), following the upgrade. Other community interventions that may have contributed to reduction in blood lead were in place in 1992 (Hilts et al. 1998), and may contribute to some of the reduction of blood lead, but did not show the same dramatic decrease as that shown with the upgrade.

B. Lead pollution reduction in Australia

Morrison (2002) evaluated the effectiveness of the lead accessibility reduction program (implemented in 1991) on blood lead levels in children in North Lake McQuarrie. This region has been exposed to environmental lead due to proximity to a nearby metals smelter. The reduction program sought to reduce lead by remediation of soil and dust (home environment) exposure, and the reduction of output from the smelter. Upgrade of the smelter resulted in a drop in lead emissions, from 92 tonnes per annum (1998) to 15 tonnes (2000), and blood lead levels. The average blood lead level of children under 13 fell from 11 to 7.5 μg/dL in 1991-June 2000. The blood lead level in children fell from 11.3ug/dL (May 1993) to 10.1μg/dL (November 1993) following closure of the plant, and then rose again to 11.0ug/dL in May 1994 when the plant reopened. Despite efforts to reduce lead exposure, 35 per cent of children still have levels greater than the national recommended level (10μg/dL). The persistence of high blood lead levels have been attributed to poor compliance of smelter to emission standards, failure of local governments to enforce air quality standards in communities, and failure of enforcement of the use of approved methodologies for remediation.

3.2.3 SO_2 and Other Pollutants

A. Restriction of sulphur content in fuel in Hong Kong

3 studies (Peters et al. 1996; Wong et al. 1998; and Hedley et al. 2002) were conducted to evaluate the health impacts the prohibition on the use of fuel with more than 0.5 per cent by weight of sulphur in July 1990.

Peters et al. (1996) and Wong et al. (1998) studied the health impacts on two regions of Hong Kong (one heavily polluted=Kwai Tsing, and one less polluted=Southern). Following the sulfur restriction, ambient SO_2 and sulphate levels fell (more markedly for Kwai Tsing). In Kwai Tsing, SO_2 levels fell from a peak of 113-136$\mu g/m^3$ (1990) to 23-26$\mu g/m^3$ (1991). In Southern, SO_2 levels, estimated to be 11$\mu g/m^3$ in 1989, fell from 7-9$\mu g/m^3$ (1990) to 2-4$\mu g/m^3$ (1991). Sulphate concentrations in respirable particles fell in Kwai Tsing from 12.5µg/m^3 (1989) to 7.7µg/m^3, and in Southern, estimated to be 9.9µg/m^3 (1989) was 5.8µg.m^3 (1990) and 6.4µg/m^3 (1991). These studies were reviewed by the HEI and were included in the accountability report (HEI, 2003).

Peters et al. (1996) studied the effect of the intervention on respiratory symptoms in repeated cross-sectional surveys of children. Respiratory symptoms (cough/sore throat, phlegm, wheeze/asthmatic diagnosis, wheezing, asthma, nasal symptoms/allergic rhinitis/sinusitis) experienced by school children were evaluated by self-administered questionnaires in the Kwai Tsing and Southern regions, and were followed for 3 years. Pre-intervention, after adjustment for confounders, children living in Kwai Tsing had higher odds ratios for cough/sore throat (OR=1.22, 95 per cent CI=1.05-1.42), any wheeze/asthmatic symptoms (OR=1.27, 95 per cent CI=1.04-1.54), and wheezing (OR=1.35, 95 per cent CI=1.10-1.66) compared to those children in the Southern district. Post-intervention, there was no district effect found for any respiratory symptoms (decline in reported symptoms in Kwai Tsing). However, environmental tobacco smoke (ETS) in the home posed greater risks on child health than air pollution, and therefore, fuel controls can have little impact on child respiratory health if ETS in the home is present.

Wong et al. (1998) examined the effect of the intervention on airway hyperreactivity. Bronchial hyper-reactivity and bronchial reactivity were determined by histamine challenge and compared in repeated cross-sectional surveys of primary school children – 1990-1991 (1 year post-intervention), 1991-1992 (2 years post-intervention), and 1990-1992 (overall) with children that have experienced asthmatic or wheezing symptoms excluded. 1990-1991, one year following the intervention, children in both districts showed improvements in histamine challenge responses, 1991, children in Southern district (less polluted) performed better than those from Kwing Tsai, but in 1992, children Kwing Tsai improved such that there was no difference between the polluted and less polluted district (Southern). Data show that reductions in bronchial responsiveness (markedly in Kwing Tsai) occurred following implementation of the sulphur restriction. One year following the intervention, both BHR and BR slope declined from 29 to 16 per cent and 48 to 39 per cent (Kwing Tsai), and 21 to 10 per cent and 42 to 36 per cent (Southern) respectively. Two years after intervention, only Kwing Tsai showed a significant decrease for BHR and BR from 28 to 12 per cent and 46 to 35 per cent respectively.

Hedley et al. (2002) examined the impacts on daily mortality (all cause, cardiovascular, respiratory, neoplasms, and all other cause) from 1985-1995 monthly, stratified by age (1990 was year of intervention). Air pollution data were obtained from local monitoring stations, along with estimates of population catchment for each station. Within the first year post-intervention, SO_2 fell by 53 per cent (44.2 to 20.8µg/m^3), and reduction was sustained between 35-53 per cent (mean 45 per cent) over 5 years. Sulphate in respirable particles reduced for 2 years only following intervention (8.9 to 6.9 µg/m^3 after the first year), and rose again. 5 years prior to intervention (1985-1990), the monthly death rate showed a stable seasonal pattern for all cause and cardiorespiratory diseases. In the year following the intervention, a substantial reduction in (winter) deaths was noted, followed by a peak in cool-season death rate in 13-24 months, and then back to expected pattern for years 3-5, indicating the intervention extended the lives of some individuals, displacing their deaths by a year. Compared with prediction, the intervention led to a significant decline in average annual trend deaths from all causes (2.1 per cent), respiratory (3.9 per cent) and cardiovascular (2.0 per cent). Greater declines in mortality were found in areas with greater reduction in SO_2 during the first 2.5 years.

3.2.4 Ozone and Others

A. Implementation of Alternative Transportation strategies

Friedman et al. (2001) evaluated the acute health impacts due to implementation of the alternative transportation strategy (24 hr public transit, addition of 1000 buses for park-and-ride services, local business use of alternative work hours, ad telecommuting, closure of downtown sector to private automobile travel, altered downtown delivery schedules, and public warnings of potential traffic and air quality problems) during the 1996 summer Olympics in Atlanta, Georgia. The 17 days of the Olympics (July 19-August 4, 1996) were compared to the summertime baseline period of 4 weeks before and after the Olympics. The number of hospitalizations, emergency department visits, and urgent care center visits for asthma were determined for those aged 1-16 years of age, and are residents of metropolitan Atlanta. Results found an overall decrease in asthma-related visits to emergency department clinics (41.6 per cent for Georgia Medicaid claims file, 44.1 per cent for health maintenance organization database, 11.1 per cent in 2 pediatric departments, and 19.1 per cent in Georgia Hospital Discharge database), and a reduction in Atlanta air pollution levels (peak daily ozone by 27.9 per cent from 81.3 to 58.6 ppb, CO, significantly, by 18.5 per cent from 1.54 to 1.26 ppm, and PM_{10} significantly by 16.1 per cent, from 36.7 to 30.8$\mu g/m^3$) was found during the Olympics. However, SO_2 levels, increased by 22.1 per cent, from 3.52 to 4.29 ppb (increased number of diesel buses). Traffic counts decreased 2.8 per cent overall, and use of public transportation increased 217 per cent. Adjusted relative risk of acute asthma events during the Olympics was significant only for the Georgia Medicaid claims file of 0.48 (95 per cent CI=0.44-0.86). This study was reviewed by the HEI and is also included in their accountability report (HEI, 2003).

4.0 CONCLUSION

The outdoor air interventions presented all concluded health gains as a result. Based on these interventions, there were several pre-conditions that were met prior to initiating:

1) As a result of monitoring ambient air pollutants, officials could conclude that the levels present in their community were negatively impacting health.
2) Pollutants were at concentrations significantly above background levels.
3) A source, contributing significantly to the ambient levels, could be identified and was amenable to an intervention.

The study conducted by Hilts (2003) is strong local example that showed that the time and resources put into upgrading the local smelter drastically reduced blood lead levels in children above and beyond the baseline reduction.

The recommended steps to be taken by public health departments focused on outdoor air pollution in BC includes:

1) Determining the character and concentrations of air pollutants that are present in the community by monitoring, AND
2) Determining whether current levels of air pollution are impacting public health, AND
3) Identifying sources of outdoor air pollution in communities that may be amenable to an intervention.

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