

Population Health Effects of Air Quality Changes Due to Forest Fires in British Columbia in 2003

Estimates from Physician-visit Billing Data

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ABSTRACT

Background: Major forest fires near populated areas during 2003 exacted a huge economic toll on communities in British Columbia. We designed a study to examine associations between $PM_{2.5}$ and PM_{10} levels and physician visits in two affected communities.

Methods: Measurements of 24-hour averages of particulate matter (PM_{10} and $PM_{2.5}$) obtained from the monitoring network of the BC Ministry of Water, Land and Air Protection were used to define weeks where forest fires resulted in increases in ambient PM. Weekly rates of physician visits for respiratory (ICD-9 codes 460-519), cardiovascular (390-459) and mental illnesses (290-319) obtained through the Medical Services Plan of BC, were compared for 2003 and aggregates of the 10 previous years.

Results: Both the Kelowna and Kamloops regions experienced five weeks of elevated 24-hour average PM levels, although maximum levels in Kelowna were greater. In the Kelowna region, increases in physician visits for respiratory diseases of between 46 and 78% above 10-year mean rates were observed for three weeks during the forest fire period. Similar effects were not observed in Kamloops. Effects on visits for cardiovascular diseases or mental disorders were not seen in either community.

Interpretation: Forest fire smoke was associated with an excess of respiratory complaints in Kelowna area residents. The lack of a similar effect in Kamloops is likely due to the population being exposed to lower levels of PM. The absence of apparent cardiovascular health effects may be due to selective effects of forest fire smoke on respiratory tract disease.

MeSH terms: Smoke; air pollution; respiratory tract diseases; cardiovascular diseases; mental health

La traduction du résumé se trouve à la fin de l'article.

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Acknowledgements: The authors thank Ramsay Hamdi and Wendy Vander Kuyl of the Ministry of Health Services for collecting the data, and the initial preparation of the graphs; and Ralph Adams of the Ministry of WLAP for providing the air quality data. We also thank Drs. Steve Marion, Rick Mathias and Kevin Craib, Benita Yip, and Kathy Li for their suggestions on the data analysis.

British Columbia experienced an unprecedented number and extent of forest fires in the summer of 2003 with over 260,000 hectares of forests destroyed and approximately \$700 million in property damage and other costs.¹ At the time of the fires, air quality monitoring indicated significant deterioration as a result of increased levels of fine particulate matter (PM). However, the public health impacts of these increases in PM have not been assessed.

The adverse population health effects of short-term increases in the levels of $PM_{2.5}$ and PM_{10} in ambient air are well established, but have been primarily studied in large urban centres in relation to industrial or motor vehicle sources.²⁻⁷ The health effects of increases in PM associated with burning vegetation have not been as extensively investigated. A study conducted in California in 1987 found that during a period of major forest fire activity, emergency room visits in six county hospitals for asthma and chronic obstructive pulmonary disease (COPD) increased by 30 to 40% over expected levels.⁸ Another North American study, one from Florida in 1999, found a 91% increase in emergency room visits for asthma, a 132% increase for acute bronchitis and a 37% increase in visits for chest pain during a period of extensive wildfire activity when compared to the previous year.⁹ Mott et al. found a 52% increase in self-reported visits to physicians for respiratory diseases in a community in California which was located in close proximity to the fifth largest wildfire in US history in 1999.¹⁰ A number of studies conducted during 1997 and 1998 in Southeast Asia when large forest fires had spread across tracts of Indonesia, showed some effects of the deterioration in air quality on the exposed populations.¹¹⁻¹⁶ Studies from episodes of bush fires in Australia have both shown¹⁷ and failed to show associations between vegetation fire air pollution and acute health impacts.^{18,19}

Despite the frequent occurrence of forest fires in Canada, to date, there have been no published studies on the health effects of these events in Canadian populations. The purpose of this study was to see if observed increases in $PM_{2.5}$ and PM_{10} which occurred during 2003 were associated with any changes in physician visits for specific disease categories in two fire-affected communities.

METHODS

Air quality monitoring data for $PM_{2.5}$ and PM_{10} were provided by the BC Ministry of Water, Land and Air Protection (WLAP). Data from the Medical Services Plan (MSP) of BC were used to assess health care utilization. MSP administrative databases were searched to locate physician visits billed under specific diagnostic codes, for patients residing in Local Health Areas (LHA) 23 (Kelowna and surrounding area) and 24 (Kamloops area) from April to October for each of the years 1993 to 2003. The specific ICD-9 disease codes of interest were: 1) Respiratory diseases (codes 460-519); 2) Cardiovascular disease (codes: 390-459) and 3) Mental disorders (codes 290-319). ICD-9 codes were in use at MSP throughout the study period.

Daily averages of $PM_{2.5}$ and PM_{10} concentrations were graphed over time for both Kelowna and Kamloops. Weeks with $PM_{2.5}$ concentrations higher than $10 \mu\text{g}/\text{m}^3$ for at least three days were considered to have elevated PM levels. MSP-billed physician visits were compiled by week for each year from 1993-2003. Incidence rates were calculated for 1993-2002 as an aggregate and for 2003 by dividing the number visits by the population at risk over each time period using LHA adjusted census population for each year. Standard errors and 95% confidence intervals for each week were calculated using the Poisson distribution. Point estimates and confidence intervals were plotted for each week. Physician visit incidence rates for 2003 were then examined for significant differences from the aggregate values for the 1993-2002 period, using a standard Normal test with a continuity correction.

RESULTS

The region of Kelowna had an average population of 146,199 people from 1992-2003. The Okanagan Mountain fire began on the outskirts of Kelowna on August 16, 2003 and eventually grew to a size of 25,912 hectares before being completely contained on September 29th.²⁰ The daily 24-hour time-weighted averages of $PM_{2.5}$ and PM_{10} for Kelowna and physician visit rates for respiratory diseases are shown in Figure 1. $PM_{2.5}$ and PM_{10} levels in Kelowna reached peaks of $200 \mu\text{g}/\text{m}^3$ and

TABLE I

Weekly Physician Visit Rates for Respiratory Diseases in Kelowna: 1993-2002 and 2003 in Visits per 10,000 Population

Week	1993-2002 Aggregate Rate	2003 Rate	Percent Change	p value
Aug 17	3.52	4.13	+17.5	0.250
Aug 24	3.25	4.76	+46.4	0.003
Aug 31	3.58	4.13	+15.4	0.307
Sep 07	3.66	5.65	+54.5	<0.001
Sep 14	3.83	6.80	+77.7	<0.001
Sep 21	4.60	5.34	+15.9	0.225

Note: Weeks are listed by the first day of the week over which physician visits were averaged.

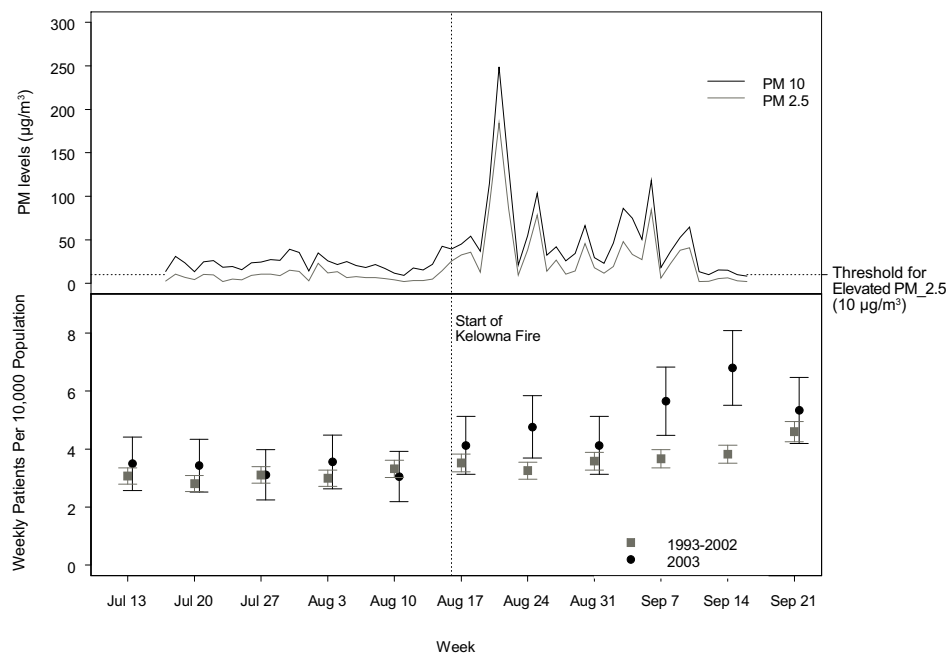


Figure 1. Daily time-weighted averages for ambient particulate matter (top panel) and weekly rates of physician visits (and 95% CI) for respiratory diseases (bottom panel) for Kelowna

$250 \mu\text{g}/\text{m}^3$ respectively, six days after the fire began. Elevated PM levels persisted until September 12th, when they returned to baseline levels. The 2003 weekly rates of visits for respiratory diseases were increased for six weeks following the start of the fire, compared to the aggregated values for the previous 10 years. However, only during the second, fourth and fifth weeks were the increases statistically significant. These represented increases of 46%, 54% and 78% compared to the aggregated values (Table I).

Kamloops and surrounding area had an average population of 100,548 people during the study period. The McClure/Barriere fire began in an area approximately 30 km northeast of the Kamloops on July 30, 2003 and grew to cover 26,420 hectares before it was contained on September 15, 2003.²⁰ (See Figure 2) A smaller fire, the Strawberry Hill fire, also

began on August 1st in closer proximity to Kamloops and likely also contributed to PM levels.²⁰ Recorded PM levels in Kamloops were generally much lower than those in Kelowna, reaching peaks of only $140 \mu\text{g}/\text{m}^3$ for $PM_{2.5}$ and $150 \mu\text{g}/\text{m}^3$ for PM_{10} , 10 days after the fire began. Elevated PM levels were recorded until September 8, for just over five weeks in total, when they returned to baseline levels. Weekly rates of physician visits for respiratory diseases in Kamloops in 2003 were not significantly different from the 1993-2002 aggregated rates.

Increases in physician visit rates for cardiovascular diseases in Kelowna, but not in Kamloops, were seen for some weeks in 2003 when compared to the mean rates for the previous 10 years. However, these increases occurred before, during and after the forest fires and therefore appear to be unrelated to the changes in air quality due

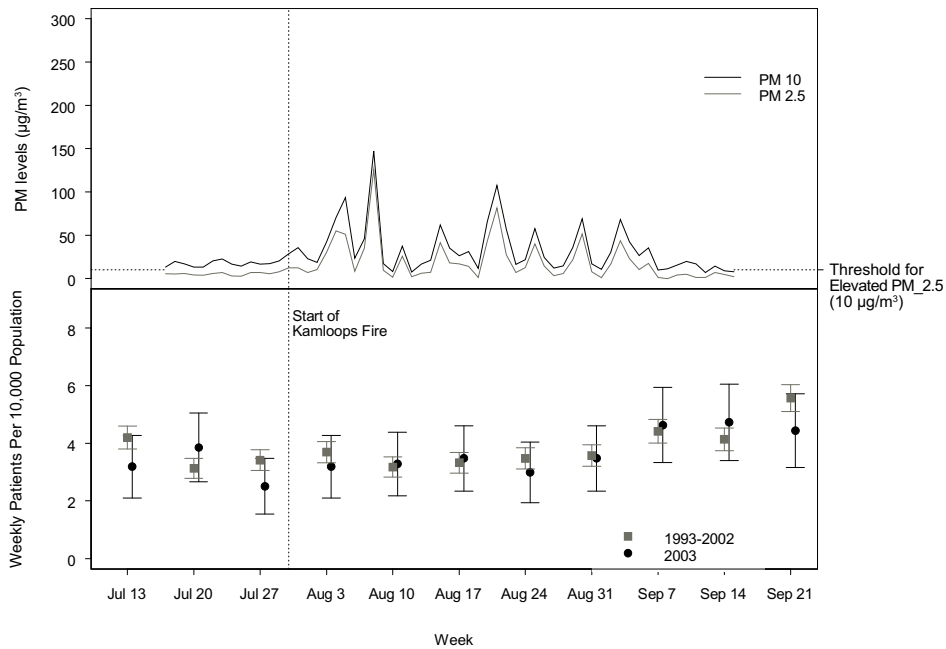


Figure 2. Daily time-weighted averages for ambient particulate matter (top panel) and weekly rates of physician visits (and 95% CI) for respiratory diseases (bottom panel) for Kamloops

to the fires (data not shown). Similar patterns were encountered in analyzing the data for mental illness. The confidence intervals around the means were very wide and 2003 data appeared to be generally elevated, but not in relation to the forest fires (data not shown).

DISCUSSION

This study is the first attempt to try to quantify the population health effects of the forest fires of the summer of 2003. We were able to show increases in physician visits in Kelowna for respiratory diseases for three weeks during the forest fire period of between 46 and 78% above aggregate rates for the same weeks in the previous 10 years. The use of population-based, long-term physician billing data gives this study a robust estimate of these effects and how they relate to the background variation in these data. We did not observe similar associations for cardiovascular diseases or mental disorders, two groups of diseases which had been postulated to be affected by changes in air quality or by the anxiety which the forest fires may have provoked in the affected populations. No health effects of the forest fires could be observed in these data for Kamloops area residents. This is likely related to the lower levels of ambient particulate matter to which

Kamloops was exposed, and the smaller population which increased the variability of the data and likely decreased the sensitivity of these methods to detect effects.

These levels of PM are within the range where one would expect to see health effects such as increased mortality and hospital admissions, based on studies from large urban centres in Europe and the US.^{2,4,6} Other common air pollutants being monitored in Kelowna and Kamloops, such as ozone, nitrogen dioxide and dioxide, reduced sulphur and sulphur oxides, failed to show any consistent relationship between ambient levels and the presence of forest fire activity (data not shown) and were not generally elevated.

This is the third North American study that has shown increases in visits for respiratory diseases but not for circulatory diseases from vegetation fires, suggesting that either physician visit data is not adequately sensitive to show such an effect, or that forest fire smoke, unlike other sources of PM, has a selective effect on the respiratory tract alone. The lack of an increase in mental health disorders, such as anxiety, argues that this increase in respiratory disease visits represents true increases in the prevalence of disease in Kelowna, and is not merely the result of an increased awareness of potential health effects on the part of residents. Also as respiratory virus epi-

demics are not known to occur in the summer months in BC, it is unlikely that this may have caused these observations.²¹

It is interesting to note that the largest increases in physician visits for respiratory diseases in Kelowna was not seen until the fifth week after the fires began, at a time when PM levels had returned to their previous low levels. This suggests either that the respiratory symptoms that patients developed as a result of PM exposure may take several weeks to develop, or that many patients with respiratory problems may try to manage their symptoms on their own for a period of time before visiting a physician.

This study has four major limitations. First, MSP billing data likely have some degree of coding error. The accuracy of disease coding is completely in the hands of the treating physician, and physicians may vary in the degree to which they apply specific codes. However, it is likely that these coding errors have remained consistent over time. Second, the MSP database was searched on the basis of patient place of residence and not the place of service. Therefore, it is possible that some of these visits occurred outside the Kelowna and Kamloops areas and involved patients who were not exposed to the forest fire smoke. Third, the exposure classification in this study was crude and all residents are assumed to be equally exposed during the fire period. In practice, gradients of exposure likely existed. It is possible that those most susceptible to respiratory or circulatory disease exacerbations may have evacuated the region, but we have no means of quantifying this effect. The result of these factors would likely be to underestimate the effect of PM on the health of the affected populations. Finally, we did not analyze historical air quality data from either site; therefore we only assume that the changes in air quality in 2003 were due solely to the effect of forest fires, and not to any seasonal variation in other sources of PM. For Kelowna, the peak levels of PM correlated well with the period of most rapid fire growth.²⁰

Given this information, it does seem prudent to warn the public regarding the potential for adverse respiratory health outcomes in these circumstances, although the severity of these increases in symptoms remains unmeasured. Several jurisdictions

have developed guidelines on public health measures that can be applied to reduce exposures to forest fire smoke,^{22,23} but there have been no studies published that have examined their effectiveness. While we now have a better understanding of how forest fires in Canada can affect populations, the best manner in which to manage these risks remains unclear.

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Received: October 25, 2004
Accepted: June 21, 2005

RÉSUMÉ

Contexte : Les grands feux de forêt qui ont menacé des zones urbaines en 2003 ont eu des répercussions économiques énormes sur les localités de la Colombie-Britannique. Notre étude porte sur les associations entre les niveaux de PM 2,5 et de PM 10 et les visites chez le médecin dans deux localités touchées.

Méthode : Nous avons utilisé les niveaux moyens de matières particulaires (PM 10 et PM 2,5) mesurés sur une période de 24 heures par le réseau de surveillance du ministère de la Protection de l'eau, de la terre et de l'air de la Colombie-Britannique afin de déterminer les semaines où les feux de forêt ont entraîné des hausses des matières particulaires ambiantes. Les taux hebdomadaires de visites chez le médecin en raison de maladies respiratoires (codes ICD-9 : 460-519), cardiovasculaires (390-459) et mentales (290-319) fournis par les services de santé de la province ont été comparés aux données de 2003 et aux données d'ensemble des 10 années précédentes.

Résultats : Dans la région de Kelowna et dans celle de Kamloops, il y a eu cinq semaines où les niveaux quotidiens moyens de matières particulaires étaient élevés, mais les niveaux maximaux enregistrés à Kelowna étaient plus élevés. Dans la région de Kelowna, on a observé une augmentation des visites chez le médecin en raison de maladies respiratoires (de 46 % à 78 % de plus que les taux moyens sur 10 ans) pendant trois semaines au cours de la saison des feux de forêt. Il n'y a pas eu d'effets semblables à Kamloops. On n'a observé aucun effet non plus sur les visites médicales en raison de maladies cardiovasculaires ou mentales, ni à Kelowna, ni à Kamloops.

Interprétation : La fumée des feux de forêt était associée à une exacerbation des troubles respiratoires chez les résidents de la région de Kelowna. L'absence d'effets semblables à Kamloops s'explique sans doute par une plus faible exposition de la population aux matières particulaires. L'absence d'effets cardiovasculaires visibles pourrait s'expliquer par l'effet sélectif de la fumée des feux de forêt sur les maladies des voies respiratoires.