Asthma and Air Pollution: Associations Between Asthma Emergency Department Visits, PM2.5 Levels, and Temperature Inversions in Salt Lake County, Utah

Project Summary

Background: Wintertime inversions are common in Salt Lake County, Utah, primarily during the months December – February. Inversions occur when a layer of cold air becomes trapped at the earth's surface beneath a level of warmer air, which acts as a lid to trap pollutants at the earth's surface (UDEQ 2009). Inversions can last as long as several days and are especially exacerbated by topographical features such as valleys.

Levels of $PM_{2.5}$ vary throughout the year but tend to be high during the winter months when strong temperature inversions are most likely (NWS 2010). Inversions contribute to poor air quality, primarily increased levels of particulate matter (UDEQ 2009; NWS 2010) caused by contributors like vehicles, fireplaces, and industry during the winter months. Thus, during temperature inversions, people, especially sensitive groups like asthmatics, are at increased risk for unsafe levels of exposure to $PM_{2.5}$ (UAP 2010).

Exposure to particulate matter with an aerodynamic diameter of ≤ 2.5 μm ($PM_{2.5}$) has been shown to cause decreased lung function in people with asthma (Lewis et al. 2005; Delfino et al. 2008), though effects can differ based on personal characteristics of those who are exposed (Lewis et al. 2005). In Salt Lake County, the degree to which people with asthma are affected by exposure to increased pollution levels during inversions, including $PM_{2.5}$, has previously been unknown. Emergency department (ED) visits are one way to measure health outcomes for people with asthma. The aim of this analysis was to better understand pollution levels during inversions, and also to determine if a correlation exists between inversions, associated $PM_{2.5}$ levels, and ED visits for asthma.

Objectives: The main objectives were threefold and included the following:

1. Understand changes in $PM_{2.5}$ levels during temperature inversions and implications for people with asthma.
2. To assess the risk of ED visits for asthma associated with wintertime inversions.
3. To assess the risk of ED visits for asthma associated with increases in ambient levels of $PM_{2.5}$.

Methods: This study used ED records of visits for asthma, as identified by ICD-9 code 493 (1,373 records using the primary diagnosis and 4,407 records using the secondary diagnosis), for residents of Salt Lake County during December-February, 2006-2007 and 2007-2008. Demographic information including each person's age, sex, and ZIP code was obtained from ED and U.S. Census records. Daily 24-hour averages of $PM_{2.5}$ were obtained from the Environmental Protection Agency (EPA 2010), as well as daily measurements for pollutants CO, SO_2, NO_2, PM_{10}, and O_3 to account for possible confounding. Inversion days, as well as data on temperature and humidity, were identified and provided by the National Weather Service.

We used a time-stratified case-crossover design (Lumley and Levy 2000; Levy et al. 2001) to identify index and referent times for each asthma visit. We used conditional logistic regression adjusted for temperature, NO_2, SO_2, and O_3 to derive odds ratios for asthma ED visits due to inversions and $PM_{2.5}$ levels. This study was approved by the IRB of the Utah Department of Health.

Results: On average, $PM_{2.5}$ levels were significantly higher during inversions, compared to non-inversions. Data showed that $PM_{2.5}$ levels increased as the length of inversion increased, and they primarily reached unhealthy levels for sensitive groups during inversions lasting 3-4 days or longer. After adjustment for temperature and air pollutants (NO_2, SO_2, O_3), an ED visit with a primary diagnosis of asthma showed no association with increases in ambient $PM_{2.5}$ levels. We did find an association between prolonged inversions and primary ED visits for asthma. The odds of an ED visit for asthma during the 5^{th}-7^{th} day of a continuous inversion were 1.42 (1.02-1.96) times the odds of an ED visit for asthma on a day when there was no inversion. This suggests a 42% increase in the odds of going to the emergency department during a prolonged inversion, compared to a non-inversion day. No correlation was found between days 1-2 or 3-4 of an inversion and primary ED visits for asthma. Results were similar using a secondary diagnosis of asthma.

Conclusions: In Salt Lake County, Utah, $PM_{2.5}$ reaches levels that are considered to be unhealthy for sensitive groups primarily during inversions lasting 3-4 days or longer. We found no evidence of an association between increases in ambient $PM_{2.5}$ levels and ED visits for asthma. An association was found between the length of an inversion and ED visits for asthma, with a 42% increase in the odds of an ED visit with a primary diagnosis of asthma during the 5^{th}-7^{th} day of an inversion, compared to a day with no inversion.

Discussion: The results of this analysis have contributed to an increased understanding of the impact of inversions for people with asthma. From these results, the Utah Asthma Program and partners plan to improve the educational tools and guidance available to the local asthma community regarding air quality and health outcomes for people with asthma. Though no association was found between increases in $PM_{2.5}$ and ED visits for asthma, results clearly showed that $PM_{2.5}$ levels tend to reach unhealthy levels for people with asthma during inversions, particularly those lasting 3-4 days or longer. ED visits are only one measure of health outcomes for people with asthma, and we do not know from these analyses in what other ways people with asthma may be affected. Until the impact on other health outcomes is known (e.g. doctors office visits, increased medication use, etc.), recommendations will include that people with asthma be especially vigilant in checking $PM_{2.5}$ levels during inversions and that they take precautions to avoid exposure as much as possible on poor air quality days. During prolonged inversions, people with asthma should also take measures to avoid exposure to asthma triggers and manage their symptoms.

Several resources are available to help people with asthma be aware of air quality levels, including hourly air quality updates available the Department of Environmental Quality's (DEQ) website, http://www.airquality.utah.gov/, and red air day alerts when $PM_{2.5}$ levels are close to exceeding standards. The Utah Asthma Program has also developed recess guidance for schools, available on the Asthma Program website at *http://www.health.utah.gov/asthma/air%20quality/pm25.html*. Air quality

tutorials are currently being developed jointly by the Utah Asthma Program and DEQ, and should be available to the public by December 2010.

References

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