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From: Commanding Officer, Navy and Marine Corps Public Health Center
To: Commander, Navy Region Europe, Africa, SW Asia

Subj: NAPLES PUBLIC HEALTH EVALUATION UPDATED ASTHMA EPIDEMIOLOGICAL STUDY

Ref: (a) COMNAVREG EUR NAPLES IT ltr 5100 Ser 00/173 of 13 Jun 07

Encl: (1) Executive Summary for Updated Asthma Epidemiological Study
(2) Naples Public Health Evaluation Updated Asthma Epidemiological Study

1. Per reference (a), enclosure (1) is provided as the executive summary of the subject epidemiological study and should be included with the full report in enclosure (2).

2. Please direct any questions to Dr. Chris Rennix, Ph.D. at commercial: (757)953-0664, DSN: 377-0664, or via e-mail at christopher.rennix@med.navy.mil.

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Executive Summary for Updated Asthma Epidemiological Study
Naples Public Health Evaluation
Navy and Marine Corps Public Health Center
07 June 2010

For more than a decade, Naples and the Campania region of Italy have experienced numerous environmental crises resulting from inadequate trash collection, burning of trash in the streets, illegal disposal of hazardous wastes, and reported contamination of some foods produced in the region. In 2007 these concerns peaked, in part due to Italian health publications citing an increase in cancer rates and long-term health effects in certain locales of the Campania region due to environmental conditions. This prompted the Navy to initiate a Public Health Evaluation to assess potential health risks to U.S. military and civilian personnel and their families living in the this region. The Public Health Evaluation, directed by the Navy and Marine Corps Public Health Center (NMCPHC), included three primary efforts:

1. Three epidemiology studies: asthma, cancer, and birth outcomes;
2. A human health risk assessment based on air, tap water, soil, and soil gas sampling;
3. Limited testing of commissary foods.

NMCPHC determined asthma was the best health outcome to study as an indicator of illness associated with exposure to smoke from illicit trash burning and general urban and agricultural air pollution. Asthma is a reversible obstructive airway disease and is associated with allergies, exposure to very fine particulates, and some industrial chemicals. NMCPHC completed the first asthma epidemiology study in October 2008, which did not find any significant trends with regards to asthma severity or asthma medical visits during the study period. The October 2008 study lacked both the population sample size and the air pollution exposure data necessary to draw meaningful conclusions about the relationship between asthma and air pollution. For this reason, a second study, reported here, was conducted to investigate any changes in asthma burden that might be associated with exposure to ambient air pollution.

This study linked the medical visit records of U.S. personnel living in Naples who were seen for asthma, with air quality data collected from July 2008 to July 2009 from the regional ambient air monitoring study conducted for the Naples Public Health Evaluation. The updated asthma study included all U.S. Department of Defense (DOD) beneficiaries who received care at U.S. Naval Hospital (U.S. NH) Naples or its branch medical clinics (BMC Capodichino and BMC Gaeta), from 01 July 2008 to 31 July 2009. Naval Support Site Gaeta was included because, until recently, some people lived in Gaeta but worked or attended school at Naval Support Site Gricignano and/or Naval Support Activity Capodichino. The study also included civilians and other non-military healthcare beneficiaries treated at Naval Hospital Naples or its clinics.

Patient asthma medical information was obtained from a central Navy medical data repository that records diagnosis codes. Each medical visit that resulted in a diagnosis of asthma was assigned a severity score:

1 – Mild Intermittent
2 – Mild Persistent
3 – Moderate Persistent
4 – Severe Persistent

In this study, study participants were categorized as persistent or non-persistent. The proportions for each category were compared within the study period to look for changes in asthma severity over time.

Air quality measurements were obtained from nine separate ambient air monitoring stations that were set up to collect air quality data for the Naples Public Health Evaluation (PHE). Based on current scientific and medical literature for asthma and the levels detected for each contaminant in the ambient air monitoring study, two contaminants were selected for analysis in the study – particulate matter less than 10 microns in diameter (PM10) and acrolein. PM10 was selected because it is a common measure of ambient air pollution and is associated with increased asthma symptoms and severity. Acrolein was selected because it exceeded the U. S. Navy Risk Management Criteria, established for the Naples PHE, in 100% of the samples and it has some properties that may exacerbate asthma.

To further investigate asthma burden, data from an asthma case management program were obtained. This program, called the Population Health Navigator, tracks patients that meet a case definition for persistent asthma to ensure they obtain routine preventive care for their condition. Data from October 2006 through July 2009 and the results for Naples were compared to Navy data for U.S. personnel stationed in Rota, Spain, and Sigonella, Italy.

In summary, this study found a weak, positive association between increasing PM10 levels and a person being categorized as a persistent asthmatic in the U.S. Naval Hospital Naples population. It also found an increased risk of being categorized as a persistent asthmatic in adults 20 years and older when compared to children under 20 years old among the U.S. Naval Hospital Naples population. This study also observed a statistically significant linear trend in the proportion of persistent asthmatics since 2006, while similar trends were not observed in Rota, Spain, or Sigonella, Italy. Based on the results of the study, it is recommended that U.S. Naval Hospital Naples consider the impact of the air quality on those with documented respiratory problems, especially persistent asthma, prior to granting an overseas medical screening waiver.

Navy and Marine Corps Public Health Center

Naples Public Health Evaluation

Updated Asthma Epidemiological Study

June 2010

Enclosure (2)

Study Title: Updated analysis of asthma burden among U.S. Department of Defense beneficiaries located in Naples, Italy, between October 2006 and July 2009

Study Question: Are there observable increases in asthma burden (measured by the number of asthma visits and severity) for U.S. Department of Defense beneficiaries living in Naples, and is asthma burden related to exposure to air pollution?

Background

For more than a decade, the Campania region of Italy has experienced numerous problems with inadequate trash collection, burning of trash in the streets, and reports of illegal disposal of hazardous wastes. In 2007, concerns over these incidents peaked, in part due to Italian health publications citing an increase in cancer rates and long-term health effects in certain locales of the Campania region due to environmental conditions. These events prompted Commander, Navy Region Europe, Africa, Southwest Asia (CNREURAFSWA) to request a Public Health Evaluation (PHE) from the Navy and Marine Corps Public Health Center to assess the public health risk to U.S. military and civilian personnel and their families living in the greater Naples area. The PHE included three separate epidemiologic analyses of health outcomes among U.S. service members stationed in Naples: asthma, cancer, and birth defects.

As part of the effort to assess the public health risk of air pollution to U.S. military and civilian personnel and their families in the region, a second asthma study was conducted as a follow-up to an earlier study of asthma in Naples conducted in October 2008. The October 2008 study lacked the air pollution exposure data necessary to draw meaningful conclusions about the relationship between asthma and air pollution. This second study was designed to include air quality data collected from July 2008 through July 2009 as well as medical encounter data from that same time period to identify and describe trends in asthma and to determine if those trends were influenced by air pollution.

Asthma is a reversible obstructive airway disease that is associated with exposure to allergens, very fine particulates, urban air pollutants, and some industrial chemicals. Asthma burden is defined (in this study) as the frequency and severity of asthma-related occurrences in the population. For the purposes of this study, asthma burden was measured in two ways: the rate of medical encounters coded for asthma (asthma visit rate) and the asthma severity score associated with each asthma visit. These measures and how they were calculated are described in more detail in the Methods section of this report.

Air pollution released by the burning of various organic and inorganic materials, including trash, is known to increase concentrations of particulate matter and other pollutants in ambient air. There are many other potential sources of air pollution in Naples, including exhaust from automobiles and other vehicular traffic, industrial activity, agricultural burning and harvesting, and construction. Ambient particulate matter of various chemical compositions and physical properties less than 10 microns in diameter (known as PM10) is small enough to be inhaled and accumulate in the respiratory system. A 10-micron particle is about 0.0004 inches in diameter or

about one-seventh the width of a human hair. PM10 is widely recognized as a primary component of air pollution that is associated with poor health outcomes, and has been the focus of many studies of the effects of air pollution on lung function. Studies suggest that PM10 is associated with an increase in asthma burden, specifically, as PM10 concentrations increase, asthma symptoms worsen and the number of medical encounters resulting in a diagnosis of asthma increase (Anderson, 1998; Atkinson et al., 1999; Choudhury, 1997; Donaldson, Gilmour, & MacNee, 2000; Lipsett, Hurley, & Ostro, 1997; Peters, Dockery, Heinrich, & Wichmann, 1997; van der Zee et al., 1999).

Exposure to PM10 usually results in increased asthma symptoms within a very short time period, typically within one day of exposure (Fadel, 2000; Keiding, 1995; Choudhury, 1997). The relationship between PM10 concentration and asthma exacerbation appears to be linear, with increasing PM10 resulting in a corresponding increase in asthma medical visits and asthma severity. There is no clear threshold of PM10 at which asthma severity dramatically increases (Baldi, 1999; Donaldson et al., 2000; Johnston, 2002; Whittemore, 1980). One review found that for each 10 microgram per cubic meter ($\mu g/m^3$) increase in PM10 concentration, asthma hospitalizations and related visits increased by 2% and asthma symptoms increased by 3% (Pope, 1999). The U.S. Environmental Protection Agency (U.S. EPA) National Ambient Air Quality Standard (NAAQS) for PM10 is 150 $\mu g/m^3$ for a 24-hour average, however there is no monthly or yearly NAAQS for PM10. The 24-hour standard of 150 $\mu g/m^3$ was exceeded in 3% of the samples detected in the PHE Phase I and Phase II year-long ambient air monitoring study. NAAQS are standards set by the U.S. EPA that apply to outdoor air and are designed to protect human health.

Other pollutants are also associated with asthma, including particulate matter less than 2.5 microns in diameter (PM2.5), sulfur dioxide, oxides of nitrogen, carbon monoxide, acrolein and formaldehyde (Kieding and Rindel, 1995; Woodruff et al., 2007). Acrolein was also evaluated in this study because all 299 samples exceeded the U.S. Navy (USN) Risk Management Criteria established for the Naples PHE in the Phase I and Phase II ambient air monitoring studies (NMCPHC, 2009). Other pollutants including sulfur dioxide, oxides of nitrogen, carbon monoxide, and ozone were not found in exceedance of U.S. EPA NAAQS in the Phase I and Phase II ambient air monitoring studies and were therefore not studied (AAQMSR 2010).

Methods

Study population

The primary study population included all U.S. Department of Defense (DOD) beneficiaries who received care at U.S. Naval Hospital (U.S. NH) Naples or its branch medical clinics (BMC Capodichino and BMC Gaeta), from 01 July 2008 to 31 July 2009. Throughout this report, the abbreviation "U.S. NH Naples" will refer to all three medical facilities. A secondary population was also examined in order to provide a historical perspective of asthma visits and the number of persons with persistent asthma. This secondary population included all persons who were stationed in Naples from October 2006 to July 2009.

Air quality measurements

As part of the Naples PHE, regional ambient (outdoor) air monitoring was conducted for 12 consecutive months, from July 2008 to July 2009. Air samples were collected from each of nine air monitoring stations established for the Naples PHE. These locations are represented as blue stars in Figure 1. Measurements of the following seven contaminants were generally taken three to five times per month at each air monitoring station:

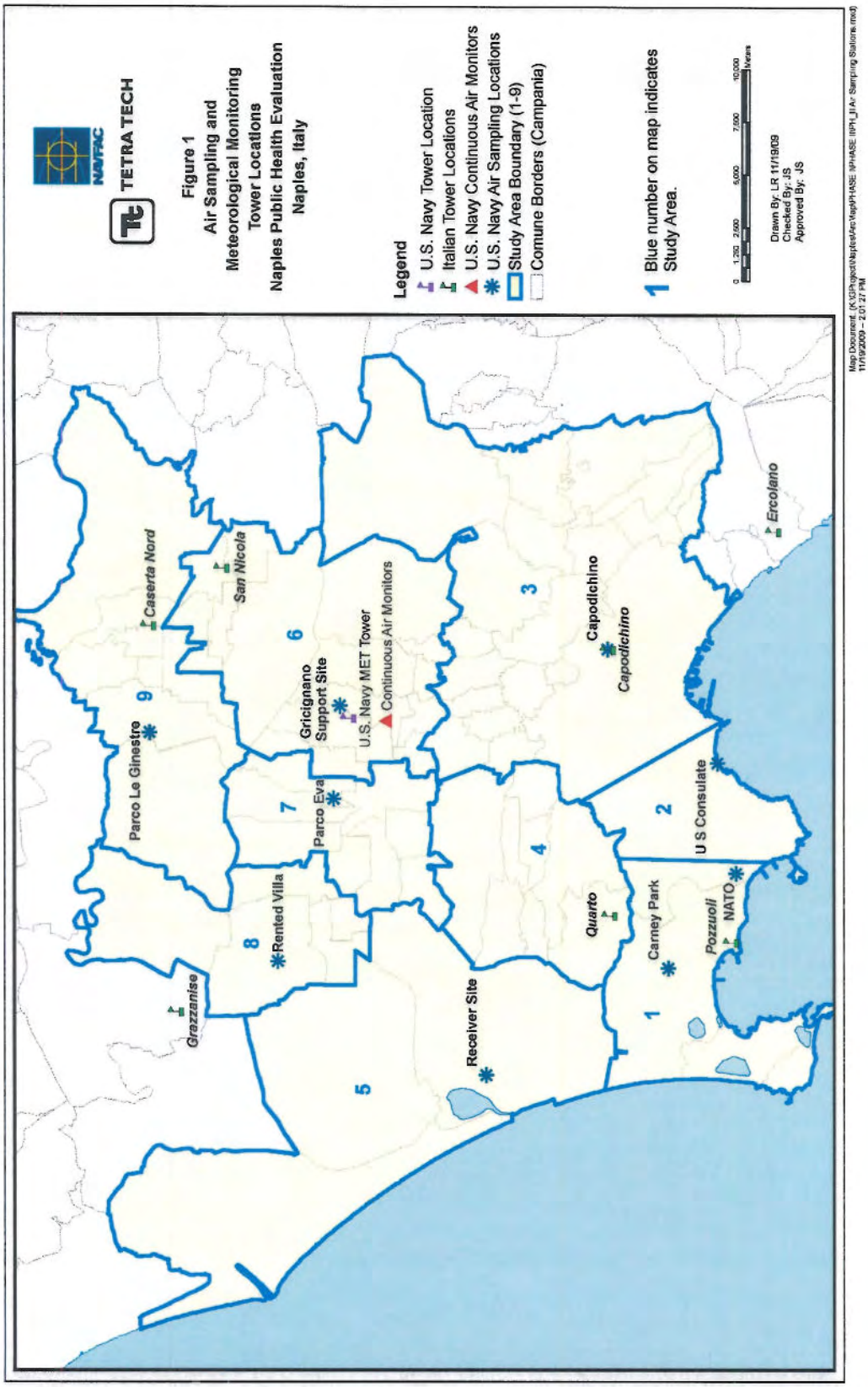
- PM10 metals
- Mercury vapor
- Volatile organic compounds
- Semi-volatile organic compounds
- Aldehydes and ketones
- Pesticides and polychlorinated biphenyls (PCBs)
- Dioxins and furans

While many pollutants have been associated with asthma, two were selected for analysis in this study: PM10 and acrolein. PM10 was chosen because it is a common measure of ambient particulate air pollution, and because previous studies found PM10 to be associated with increased asthma symptoms and severity (Anderson, 1998; Atkinson et al., 1999; Choudhury, 1997; Donaldson et al., 2000; Lipsett et al., 1997; Peters et al., 1997; van der Zee et al., 1999). Although PM10 is often associated with increased asthma symptoms, only 13 out of 431 total samples detected (3%) in the PHE Phase I and Phase II ambient air monitoring study were higher than the U.S. EPA NAAQS of 150 $\mu g/m^3$ for PM10 for a 24-hour average (U.S. EPA 2009-1).

Acrolein has also been found to be associated with aggravation of asthma symptoms (Woodruff et al., 2007), although the association is not as well established in the scientific literature as that of PM10. Acrolein exceeded the USN Risk Management Criteria established for the Naples PHE, of 0.021 $\mu g/m^3$, in 299 out of 299 (100%) total samples detected. The USN Risk Management Criteria was based on U.S. EPA Regional Screening Levels (U.S. EPA 2010). The Agency for Toxic Substances and Disease Registry (ATSDR) has established an acute minimal reference level (MRL) of 7 $\mu g/m^3$ for exposure to acrolein at which acute respiratory effects would be observed in humans (U.S. EPA 2009-2). The MRL is an estimate of the level of daily human exposure to a hazardous substance, below which excess risk of adverse non-cancer health effects is not likely to occur (U.S. EPA 2009-2). The MRL for acrolein was exceeded in 9 out of 299 (3%) samples detected.

Monthly averages of both acrolein and PM10 were calculated for the entire region (all nine study areas) by adding all measurements for each pollutant taken at all Naples PHE air sampling locations in a given month and dividing by the total number of measurements taken that month. Because daily air monitoring results could not be linked to individuals in each air sampling location, average monthly PM10 and acrolein concentrations for the entire Campania region were used.

Figure 1: Locations of Air Monitoring Stations in Campania Region of Italy



Assessment of asthma burden

Medical encounter data were obtained from the Military Health System (MHS) Management Analysis and Reporting Tool (M2), which creates a record of every visit within the MHS using codes that indicate the reason for the visit. Inpatient and outpatient medical encounter records were used to identify medical visits resulting in an asthma diagnosis and the asthma severity associated with each of those visits. The two primary measures of asthma evaluated in this study were the asthma visit rate and the severity of asthma.

1. Asthma visit rate: Unique asthma visits were defined as any inpatient or outpatient medical visit resulting in an asthma diagnosis. Duplicate asthma visits for the same person on the same day were deleted; however, visits for the same person on different days were retained. Inpatient and outpatient medical encounter records were obtained from M2. All inpatient and outpatient records with diagnoses for asthma, identified by International Classification of Disease-9th Edition-Clinical Modification (ICD-9) codes from 493.0x to 493.9x, were included in the study. The number of asthma visits each month was divided by the total number of beneficiaries enrolled at Naples medical treatment facilities each month to come up with a monthly asthma visit rate per 1000 enrollees.

2. Asthma severity: Each asthma ICD-9 diagnosis code is appended with a severity code represented by a number ranging from 0–4. Each of these values represents an asthma severity category that was assigned by the health care provider at the time of diagnosis. The values of each severity code category are as follows:

0 = unspecified/unknown severity
1 = mild intermittent
2 = mild persistent
3 = moderate
4 = severe

Because an individual with multiple visits on the same day would likely have repeated coded encounters with similar severity scores, retaining these extra visits could bias the results toward people with multiple visits. In order to represent each person's severity score equally, individual asthmatics were used as the unit of measurement for analyses of asthma severity. Records of multiple visits by the same person during the study period were removed and only the visit for each person with the highest severity was retained. By including only the highest recorded severity score for each person, it was assumed that air pollution and asthma severity were compared at the time of the visit with the worst severity. People with unknown severity were also removed from the analysis of asthma severity (however they were retained in the asthma visit rate analysis).

After discussions with health care providers regarding the clinical treatment of asthma, the asthma severity score was classified into two groups, *non-persistent* and *persistent*. Individuals with a severity score of 1 in their medical encounter record were classified as non-persistent. People in the non-persistent category typically experienced symptoms 2 times per week or less and were most likely to be treated with short-term asthma medication or no medication

(VHA/DOD 1999). Individuals in the persistent group had a severity score of 2, 3, or 4. People in the persistent category typically experienced asthma symptoms more than 2 times per week and were more likely to be treated with long-term asthma medications or multiple medications (VHA/DOD 1999). Severity scores are intended for use as clinical tools, and although several studies examining the relationship between asthma severity and various risk factors exist (Ortega et al. 2001), the use of severity scores has limitations. Although it is assumed that U.S. DOD guidelines for diagnosing asthma were followed when providers assigned severity scores (VHA/DOD 1999), it is likely that there was some degree of misclassification depending on the provider and regional differences in the use of these guidelines. Providers may assign severity scores differently based on local clinic guidelines, training, or other factors. These limitations may be mitigated in this study by the collapsing of the severity into non-persistent/persistent categories, in which non-persistent asthmatics are generally not treated with long-term medications and experience less frequent asthma symptoms.

Health Plan Employer Data Information Set (HEDIS) asthmatics

Additional data were available from the Population Health Navigator, a case management system that tracks persons with persistent asthma as part of the managed care program for U.S. NH Naples. Analyses of HEDIS asthmatic data included all HEDIS asthmatics who received treatment at U.S. NH Naples, as well as U.S. NH Sigonella and U.S. NH Rota, from October 2008 to July 2009.
Population Health Navigator uses HEDIS definitions to identify persons with persistent asthma. To be identified as a HEDIS asthmatic individual, a person must have been continuously enrolled at a military treatment facility (MTF) for the past 24 months, and have met at least one of the following four criteria in each of the previous two 12-month periods:

1. At least four outpatient asthma visits with asthma as one of the listed diagnoses and at least two asthma medication dispensing events
2. At least one acute inpatient discharge with asthma as the principal diagnosis
3. At least one Emergency Department (ED) visit with asthma as the principal diagnosis
4. At least four dispensing events of specified asthma medications

It is important to note that this measure is a clinical care metric and has not been validated as a surveillance tool. While the intent of this metric is to ensure that individuals with chronic asthma receive quality treatment, HEDIS can also provide an estimate of the persistent asthma burden. For this study, the HEDIS asthma metric was used to determine if there were any trends in the number of persons with persistent asthma over time. The HEDIS asthma counts and denominators for Rota, Spain, and Sigonella, Italy, were used as comparisons for Naples. While the environmental exposures in Rota and Sigonella may be different from Naples, the process for medically screening persons prior to assignment overseas was the same for all three locations.

Statistical analyses

All data analyses were completed using SAS version 9.2 statistical software. Asthma visit rates were calculated by adding the total number of unique medical encounters at U.S. NH Naples in a given month and dividing by the total number of service members enrolled at Naples for that

month. To evaluate the relationship between the asthma visit rate and ambient air pollution using PM10 and acrolein as exposure surrogates, two linear regression models were used with the monthly asthma visit rate as the outcome: one with the monthly mean PM10 concentration as the exposure variable and the other using the monthly mean acrolein concentration as the exposure variable. The two variables were considered significantly associated if the R-squared value was greater than or equal to 0.60.

Analyses of the relationship between the asthma severity category and PM10, and between the asthma severity category and acrolein, were conducted independently of one another. Bivariate analyses were conducted to determine if the asthma severity category was independently related to the demographic variables of age category and gender. Variables that were significantly associated with asthma severity category at the $p \leq 0.20$ level were included in the multivariate analysis. The relationship between the asthma severity category and the air pollution was assessed using logistic regression models for asthma severity as an outcome and monthly mean PM10 or acrolein as the exposure. Both logistic regression models were adjusted for age. Odds ratios (OR) in which the 95% confidence interval (CI) did not capture 1.00 were considered statistically significant, indicating a significant association between the outcome and exposure variables.

HEDIS asthmatic prevalence was calculated by obtaining the total number of HEDIS asthmatics reported for each location in a given month and dividing by the total number of service members enrolled at that specific MTF in that month. Both of these values were obtained from the MHS Population health portal.

Results

Mean PM10 concentrations from July 2008 to July 2009 had peaks in October 2008 and February 2009, but no significant increasing trend was observed over this time period (Figure 2). Mean acrolein concentrations peaked in September 2008, December 2008 and March 2009. No significant increasing trend in acrolein concentrations was observed over the time period from July 2008 to July 2009 (Figure 3).

Figure 2: Monthly Mean PM10 Concentrations in Campania Region (Jul 2008-Jul 2009)

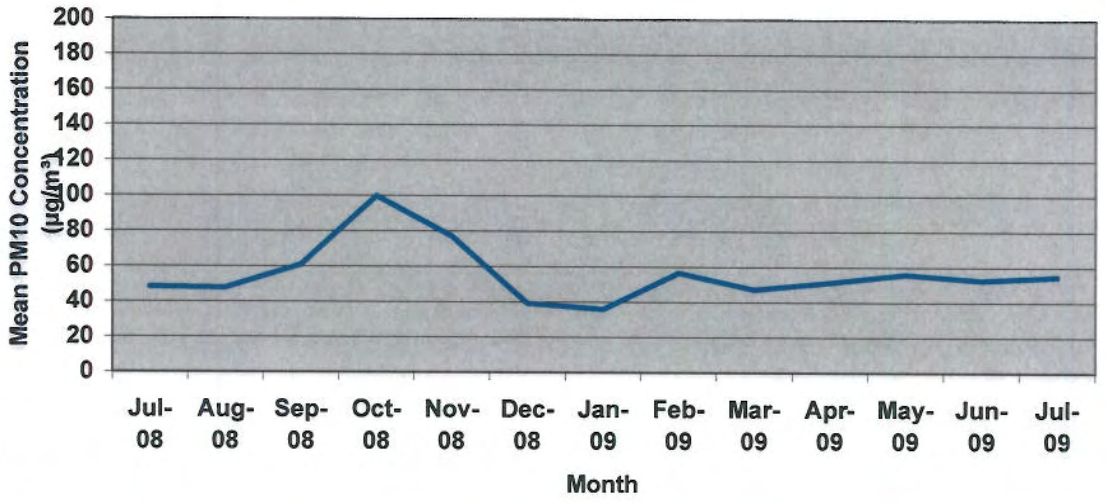
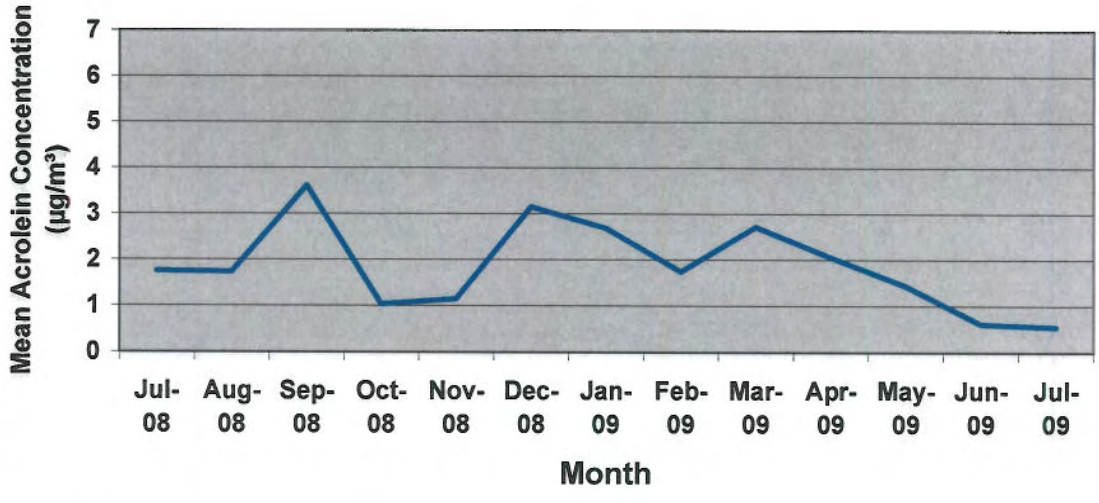


Figure 3: Monthly Mean Acrolein Concentrations in Campania Region (Jul 2008-Jul 2009)

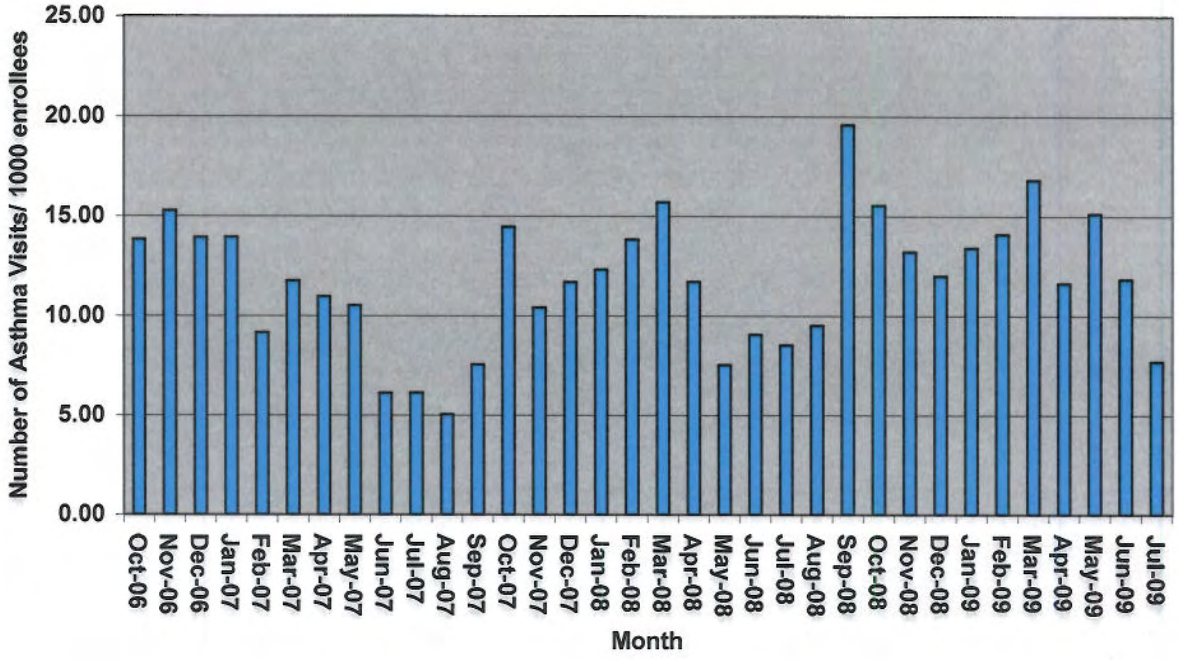


Asthma visit rate analyses

Historical Trend:

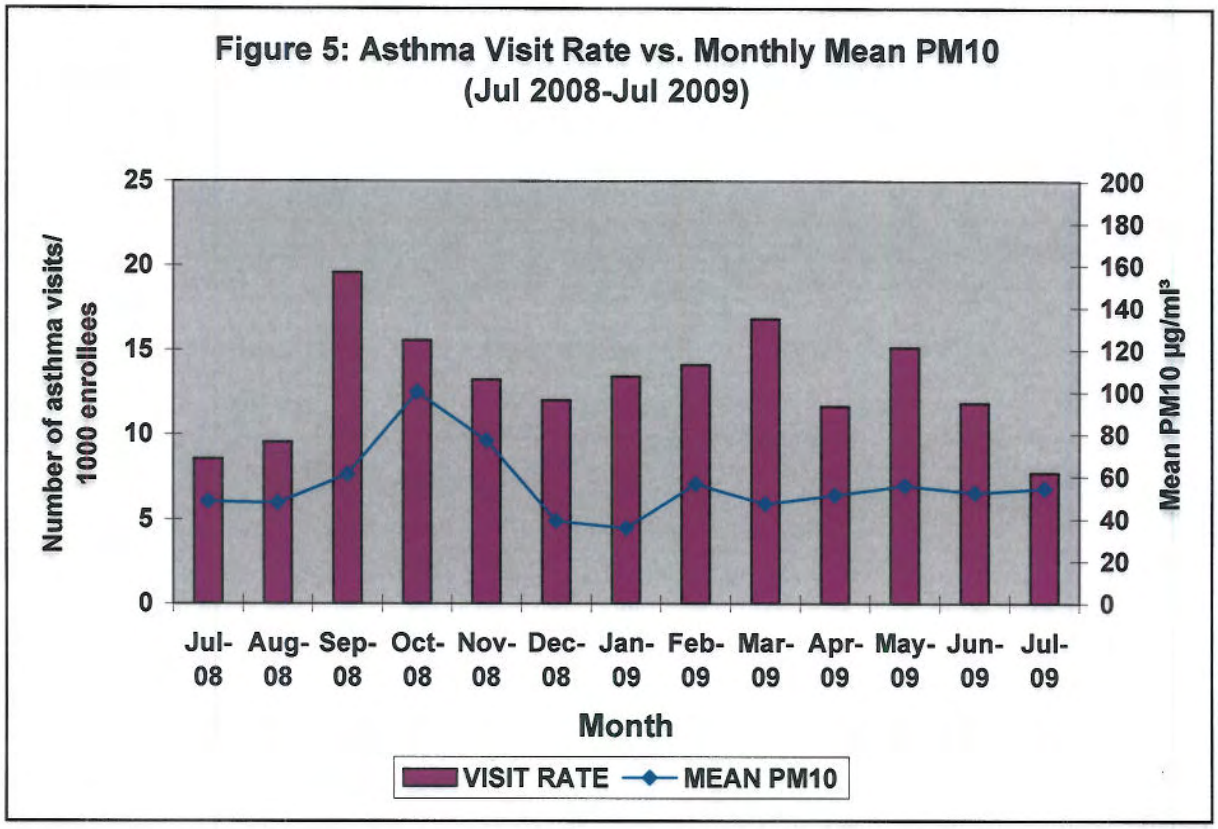
Figure 4 illustrates the number of MTF visits that resulted in a diagnosis of asthma per 1000 people enrolled at U.S. NH Naples by month. The mean visit rate per month over the period from October 2006 to July 2009 was 11.8 asthma visits/1000 enrollees. The number of enrollees was relatively constant over this period, with a mean of 6039 enrollees per month and a range of 5669–6562. A seasonal variation was observed in the asthma visit rate over the period from October 2006 to July 2009, with peaks in the fall and low points in the summer. This asthma trend has been observed in other studies, and asthma is widely considered to vary seasonally with peaks in fall and low points in the summer (Khot et al., 1984; Gergen et al., 2002). Despite normal cyclical variation in asthma visits, there was no significant linear trend in the asthma visit rate during this period.

Figure 4: Asthma Visit Rate by Month at U.S. NH Naples (Oct 2006 - Jul 2009)



Asthma Visit Rate vs. PM10 Concentration:

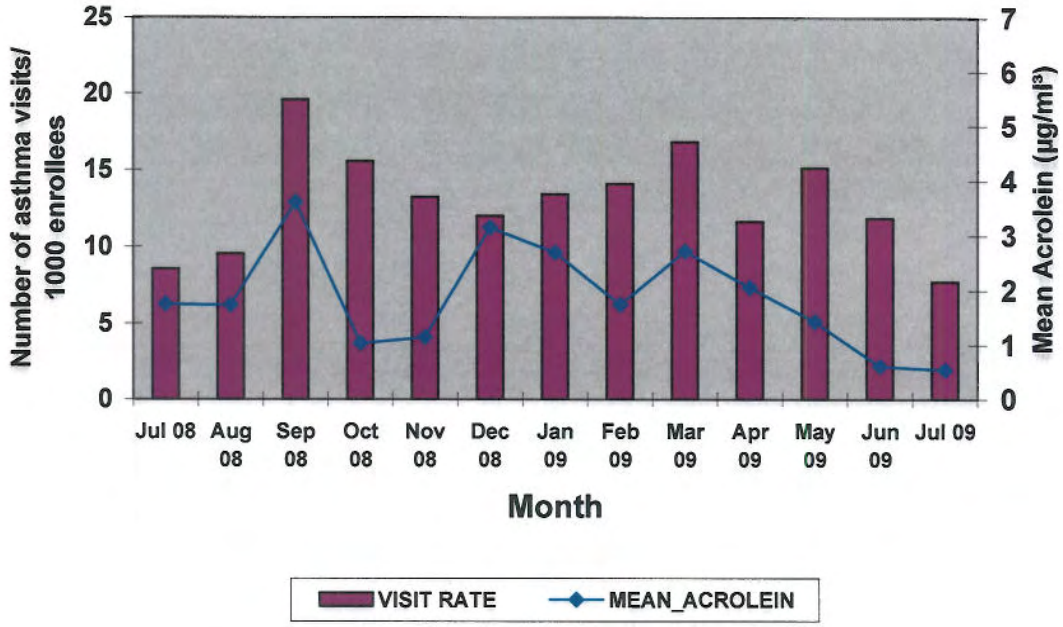
Figure 5 shows the monthly asthma visit rate at U.S. NH Naples represented as bars, and the monthly mean PM10 concentration represented by the line. The monthly asthma visit rate did not significantly vary over the 13 month period. There was one notable peak in the asthma visit rate in September 2008. The mean PM10 concentrations also did not significantly vary over this period, but showed a peak in October 2008. Linear regression was used to assess the significance of the association between the asthma visit rate and monthly mean PM10. The relationship between the average monthly PM10 concentrations and monthly asthma visit rate was not statistically significant.



Asthma Visit Rate vs. Acrolein Concentration:

Figure 6 shows the monthly asthma visit rate at U.S. NH Naples represented as bars, and the line represents the monthly mean acrolein concentration. The mean acrolein concentrations also did not significantly vary over this period, but showed a peak in September 2008. Linear regression was used to assess the significance of the association between the asthma visit rate and monthly mean acrolein concentrations. The relationship between the average monthly acrolein concentrations and monthly asthma visit rate was not statistically significant.

Figure 6: Asthma Visit Rate vs. Monthly Mean Acrolein (Jul 2008-Jul 2009)



Asthma severity analyses

Bivariate Analyses:

There were 439 total unique people with an asthma diagnosis that had a severity score ranging from 1–4 at U.S. NH Naples from July 2008 to July 2009 (some of them having multiple visits). Of these individuals, 219 were categorized as non-persistent, while 220 were categorized as persistent. Age was divided into two categories: "Adult" included all individuals 20 years and older; "Child" included all individuals less than 20 years of age. About 60% (263) of the participants were in the Child category, with about 40% (176) in the Adult category. Bivariate analyses showed that age category was significantly associated with the asthma severity category, but gender was not. For this reason, both multivariate logistic regression models for PM10 and acrolein were adjusted for age category, but not for gender.

Asthma Severity vs. PM10:

A logistic regression model was used to assess the relationship between asthma severity and PM10 concentration, with asthma severity category as the binary outcome variable and two independent variables: mean PM10 concentration and age category. After adjusting for age category, mean PM10 was weakly but significantly associated with the asthma severity category (OR= 1.02, 95% CI 1.00-1.03), with increased average PM10 concentration resulting in increased risk of being classified as having persistent asthma. Age category was also significantly associated with the asthma severity category (OR=2.32, 95% CI 1.57-3.45), with adults having approximately 2.3 times greater risk of being categorized as having persistent asthma than children.

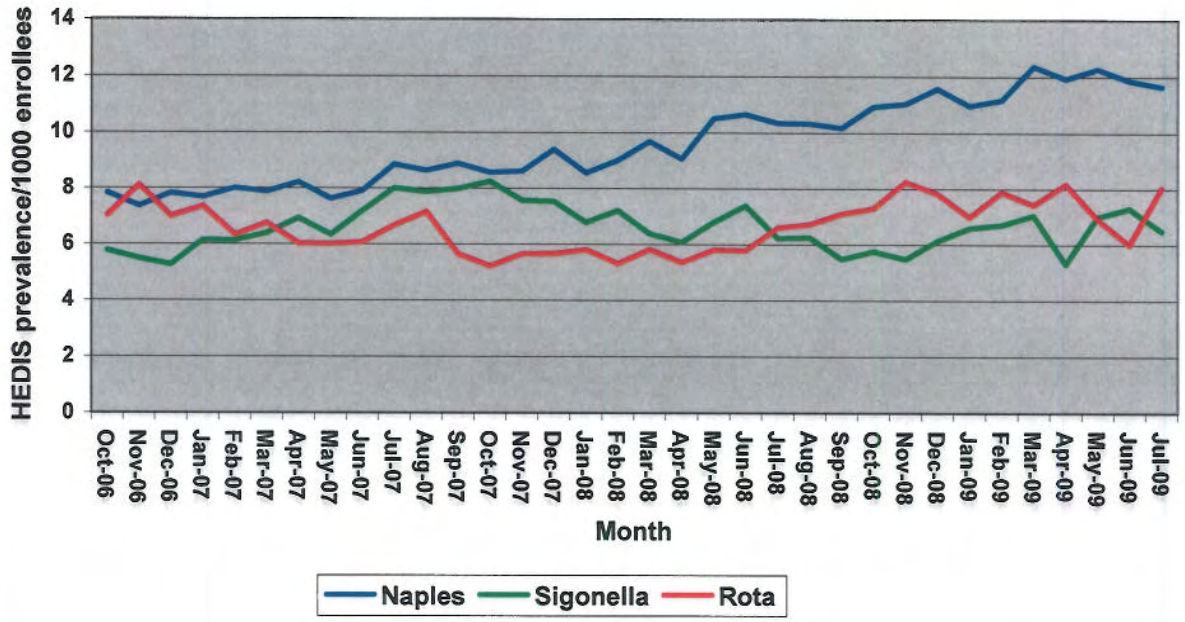
Asthma Severity vs. Acrolein:

In the logistic regression model assessing the relationship between asthma severity category and acrolein concentration, asthma severity category was the binary outcome variable with two independent variables: mean acrolein concentration and age category. After adjusting for age category, mean acrolein was not significantly associated with the asthma severity category (OR= 0.97, 95% CI 0.80-1.18). Age category was again significantly associated with the asthma severity category (OR=2.317, 95% CI 1.567-3.427), with adults having approximately 2.3 times greater risk of being categorized as having persistent asthma than children.

HEDIS asthmatic analyses

Figure 7 depicts the number of HEDIS asthmatics per 1000 enrollees by month at U.S. NH Naples, U.S. NH Rota, and U.S. NH Sigonella from October 2006 through July 2009. The monthly prevalence of HEDIS asthmatics at Naples increased linearly over this time period (R-squared = 0.93), while the monthly prevalence at Rota and Sigonella remained relatively constant (R-squared = 0.00 and 0.08 respectively).

Figure 7: HEDIS Monthly Asthma Prevalence at Naples, Sigonella, and Rota (Oct 2006-Jul 2009)



Discussion

The purpose of this study was to identify trends in medical visits for asthma and asthma severity, and to determine if those trends were associated with air pollution in Naples. While there are many air pollutants known to be associated with exacerbation of asthma, two were selected for this study. PM10 was selected because evidence on the association between PM10 and asthma is well established in the scientific literature. Acrolein was selected because it has been found to be associated with asthma (Woodruff et al. 2007), and because it was found to exceed U.S. EPA NAAQS in 100% of the samples detected in the PHE Phase I and Phase II year-long ambient air monitoring study (AAQMSR 2010). Other pollutants found in the scientific literature to be associated with asthma exacerbation were not studied because they did not exceed U.S. EPA NAAQS in any samples detected.

The rate of medical visits resulting in a diagnosis of asthma fluctuated seasonally in Naples enrollees, but did not increase or decrease linearly over the period from October 2006 to July 2009. This seasonal fluctuation is typical with asthma, with peaks for asthma medical visits in fall and winter and low points in summer months (Khot et al., 1984; Gergen et al., 2002). The monthly asthma visit rate was not significantly associated with monthly mean ambient PM10 or acrolein concentrations over the period from July 2008–July 2009. These results suggest that neither PM10 nor acrolein significantly influenced the total number of asthma visits at Naples MTFs during the time period observed. Seasonal variation was observed and it is possible that specific seasonal allergens (e.g., pollen, ragweed) may have played a part in driving the asthma visit rate in this population. About 70% of all asthma cases are related to exposures to allergens (Bousquet, 2007).

Another measure of asthma exacerbation evaluated was the asthma severity category, in which people were categorized into two groups, persistent or non-persistent. Persistent asthma was not significantly associated with gender or with the mean acrolein concentration, but was significantly associated with adult age (20 years and older) and with increased mean PM10 concentration. The positive, but weak, association between the mean PM10 concentration and being in the persistent asthma category was consistent with the scientific literature (Anderson, 1998; Atkinson et al., 1999; Choudhury, 1997; Donaldson et al., 2000; Lipsett et al., 1997; Peters et al., 1997; van der Zee et al., 1999). Because the study was limited to using average PM10 concentrations, it is possible that the true effect of PM10 was attenuated and the association is actually stronger than reported here. PM10 has many sources, including agricultural burning, trash burning, vehicle exhaust, construction work, and agricultural harvesting. These sources are all found in abundance in Naples and the surrounding areas of Campania, making it difficult to determine the primary driver of PM10 concentrations in the region.

A strong, positive linear trend was observed in the percentage of HEDIS asthmatics enrolled at U.S. NH Naples over the period from October 2006 to July 2009. The same trend was not observed in two other overseas Navy hospitals in Europe. It is possible that this difference is due in part to differences in the environments between Naples and the other two locations, as Naples is more urban and industrial than either Rota or Sigonella. However, for Rota and Sigonella, air quality data were not available as they were for Naples, so the levels of air pollution could not be directly compared. Also, the trend may be influenced by increased awareness and attention to

asthma-like symptoms by the medical providers and community in Naples due to the ongoing PHE. Asthma is a condition that can rapidly progress to a serious medical situation, encouraging some providers to treat the condition aggressively. One treatment objective may be to prevent a serious asthma event, typically through preventive medications. In an environment with high levels of allergens, a diagnosis of asthma will most likely be treated as a chronic condition, hence the increasing HEDIS asthmatic metric.

In summary, this study found a weak, positive association between increasing PM10 levels and being categorized as a persistent asthmatic in the U.S. NH Naples population. It also found an increased risk of being categorized as a persistent asthmatic in adults 20 years and older when compared to children under 20 years old among the U.S. NH Naples population. This study also observed a statistically significant linear trend in the proportion of HEDIS asthmatics since 2006, while similar trends were not observed in Rota, Spain or Sigonella, Italy.

Recommendations

U.S. NH Naples should consider the impact of the air quality on those with documented respiratory problems, especially persistent asthma, before granting an overseas screening waiver.

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