Short-term effects of air pollution on medical treatment-seeking among soldiers of the IDF

ABSTRACT

Background – Air pollution is recognized as a growing health hazard worldwide. Major pollutants associated with health outcomes include sulfur dioxide (SO_2), nitrous oxides (NO_x), ozone (O_3) and suspended particulate matter. These pollutants can be traced to numerous sources, including petrochemical and other industrial emissions, vehicle exhaust, and coal- and oil-burning power plants. Several studies conducted in Israel found correlations between ambient air pollution levels and emergency room visits, and found a higher prevalence of respiratory symptoms among children exposed to air pollutants. Most of these studies, however, have concentrated on the effects in children, and have looked at a limited range of health outcomes. We have identified no studies that examined the effects of air pollution on young adults in Israel, and no studies to date have examined the effects on IDF soldiers stationed in proximity to major sources of air pollution.

Study objective – to study the association between overall and source-specific air pollution levels and short-term health consequences among the sub-population of IDF soldiers serving on the Nitzanim, Zikim and Ashdod military bases.

Methods – Continuous half-hourly air pollution data, including SO_2, NO_x, O_3, particle concentrations, wind velocity and wind direction, are available from 15 sampling stations in the greater Ashkelon-Ashdod area for the period between January 2002 and June 2004. Simultaneous Ashkelon and Ashdod power plant data will allow source-specific identification of pollution originating from these sites. Computerized patient records (CPR), including diagnostic codes, emergency referrals and sick leave orders, are available for all clinic visits at the Nitzanim, Zikim and Ashdod military bases during the study period. This historical prospective study will attempt to quantify the association between varying types and levels of air pollution in the Nitzanim, Zikim and Ashdod areas, and the short-term health consequences experienced by soldiers of these units.

Keywords: air pollution, epidemiology, adolescents, health outcomes

השפעות קצרות-טווח של זיהום אויר על פניות לטיפול רפואי בקרב חיילי צה״ל

תקציר

רקע- זיהום אויר מוכר ברחבי העולם כסיכון לבריאות. חומרים הקשורים לתוצאות בריאותיות שליליות כוללים דו-תחמוצת הגופרית (SO_2), תחמוצות החנקן (NOx), אוזון (O3), וחלקיקים מרחפים. לחומרים מזהמים אלה מקורות רבים, כולל פליטות ממפעלי התעשיה הפטרוכימית, פליטות מרכבים ממונעים, ותחנות כח ששורפות פחם ונפט. מחקרים אחדים שבוצעו בישראל מצאו קשר בין רמות זיהום האויר ובין הפניות לחדר המיון, וכן נמצאה המצאות גבוהה יותר של תלונות נשימתיות בקרב ילדים שנחשפו למזהמי אויר. עם זאת, רוב עבודות אלה התרכזו בהשפעות בקרב ילדים בלבד, ובחנו תחום מצומצם בלבד של תוצאות בריאותיות בקרב האוכלוסיה הנבדקת. לא זיהינו בספרות מחקרים אשר בדקו את השפעות זיהום האויר על מבוגרים צעירים בישראל, וכן לא מצאנו בדיקה של השפעות זיהום האויר על חיילי צה״ל המשרתים בקרבת מקורות זיהום ראשיים.

מטרת המחקר – לבחון את הקשר בין רמות זיהום אויר ממקורות שונים על תוצאות בריאותיות קצרות-טווח, בקרב אוכלוסיית חיילי צה״ל המשרתים בניצנים, זיקים ואשדוד.

שיטות – רמות זיהום אויר ייקבעו על פי מדידות חצי-שעתיות של SO_2, NO_x, O_3, ריכוז חלקיקים מרחפים, מהירות הרוח וכיוון הרוח מ- 15 תחנות מדידה באזור אשקלון-אשדוד רבתי בתקופה שבין ינואר 2002 ליוני 2004. מדידות מקבילות מתחנות הכח באשקלון ואשדוד תאפשרנה זיהוי מזהמי אויר שמקורם ממקומות אלה. מאפייני הפניות למרפאות ניצנים, זיקים ואשדוד בתקופה המקבילה ניתנים לבדיקה באמצעות מערכת הרשומה הרפואית הממוחשבת של חיל הרפואה (CPR), לרבות קוד אבחנה, הפנייה לחדר מיון ומתן ימי מחלה. מחקר היסטורי-פרוספקטיבי זה ינסה לכמת את הקשר בין רמת זיהום האויר לסוגיו באיזור ניצנים, זיקים ואשדוד לבין התוצאות הבריאותיות קצרות-הטווח בקרב החיילים שמשרתים בבסיסים אלה.

STUDY PLAN

Study objectives

1. To quantify the association between air pollution levels and short-term health consequences among IDF soldiers, including overall and diagnosis-specific clinic visits, emergency department referrals, and sick leave.
2. To develop a quantitative model for defining health-significant levels of air pollution among soldiers of the IDF.
3. To differentiate between the effects of overall and source-specific air pollution on short-term health consequences among IDF soldiers.
4. To serve as a feasibility study for future air pollution research in the IDF, including the Hadera and Ramat Hovav regions.

Background

Air pollution is recognized worldwide as a major population health hazard. Several leading pollutants have been linked to adverse health outcomes. Sulfur dioxide (SO_2) is a pollutant that arises from the combustion of sulfur-containing fuels such as coal and oil. In developed countries, emissions of SO_2 tend to be predominantly from major point sources such as power stations that burn coal or oil, industrial combustion plants, and sulfuric acid works. [1] Emission from these point sources are in the form of concentrated plumes of pollution which can lead to highly elevated ground-level concentrations over a short period of time. Oxides of nitrogen (NO_x) are the result of high-temperature combustion, and are present in two major forms: nitric oxide (NO) and nitrogen dioxide (NO_2). NO_x are ubiquitous urban air pollutants whose main sources include exhaust of benzene and diesel motor engines, boilers fired by coal, oil and gas such as power stations, and industrial processes that produce NO. A third major group of pollutants are airborne particles of various sizes, not all of which are associated with adverse health effects. Inhalable particles less than 10 μm in diameter (PM_{10}) include the majority of atmospheric particles, excluding the upper range of coarse particles, such as those found in dry, dusty areas, and which are believed to be of little health significance. Smaller particles, which are not only inhaled but which can also penetrate into the alveolar region of the lung, are designated $PM_{2.5}$. Ozone (O_3) is a pollutant which differs from the others in that it is secondary in origin rather than being emitted directly by a primary source. Ozone is the product of a photochemical reaction wherein sunlight converts the oxygen

components of NO_x into O_3 in the presence of volatile organic compounds such as hydrocarbons.

The different pollutants have various effects on the human respiratory system. Acute episodes in which particulates and acid aerosols are at high levels increase mortality from respiratory disease in all age groups. [2] Exposure to 10 parts-per-million (ppm) of SO_2 for more than a few minutes results in irritation of the eyes, throat and mucous membranes. While exposure to 5 ppm for up to 4 hours may have little or no effect on the pulmonary function indices of normal, healthy individuals, asthmatics and others with hyperreactive airways show a striking response of bronchoconstriction, increased airway resistance, decreased expiratory flow rates, wheezing and shortness of breath at SO_2 concentrations as low as 0.25-0.5 ppm. When accompanied by moderate exercise, bronchoconstriction will occur in asthmatics within minutes at even lower SO_2 levels. [3,4] Inhalation of ozone has been shown to cause lung inflammation, acute decrease in lung function and exacerbation of asthma. Large studies of hospital admission data have shown a significant association between O_3 levels and hospital admissions for acute respiratory disease, [2] and several studies have shown a significant association between exposure to elevated ambient O_3 levels and emergency room visits for asthma. [5-7] In addition to these short-term effects, at least one study has indicated a possible association between lifetime ozone exposure and a significant reduction in terminal airflow velocity. [8] Controlled human exposure to NO_2 has been shown to result in increased levels of inflammatory mediators and changes in cell counts and distributions in the lung after short exposures to levels as low as 1 mg/m^3 [9,10] Much evidence accrued over recent years has established an association between PM_{10} particles and adverse health effects. This data, which showed an association between daily mortality and PM_{10} levels, has been validated in studies conducted in over 30 populations and under varying weather conditions, even in the absence of SO_2, ozone and acid aerosols. Furthermore, PM_{10} levels have been shown to be associated with hospital admissions for respiratory disease, aggravation of asthma, increased school absence and lower lung function in children. There is evidence that these associations are stronger if $PM_{2.5}$ is considered instead of PM_{10}. [2]

Atmospheric concentrations of air pollutants can be measured using a variety of sampling systems located in monitoring stations. In general, sampling stations can be situated either to observe the overall air quality, without the immediate effects of any single

source of pollution ("background stations"), or to observe areas where air pollutant concentrations are known or suspected to be especially high ("hotspot stations"). Most often, a number of stations designed to measure both backround and hotspot pollution are connected to a single network, and provide supplementary data on various aspects of pollution in a given area.

Several methodological approaches can be taken in measuring the adverse health effects of air pollution. One time-proven method is the investigation of air pollution episodes. This method is carried out in several steps, which include: (1) defining a "pollution episode" and collecting pollution data; (2) defining a health outcome and collecting relevant health outcome data; (3) determining whether an excess of the health outcome occurred in association with the pollution episode; and (4) evaluating the role of pollution in causing any of the observed excess health outcome. There is no standard way of describing the intensity of an air pollution episode. Pollution levels may be reported as the maximum at a single monitoring station, as the mean of all the station maxima, or as a mean pollution level over the duration of the episode. The main categories of health outcomes include mortality, direct measures of morbidity, and indirect measures of morbidity, such as health care utilization patterns. Mortality studies generally have low statistical power due to the small number of daily deaths even in large cities, and the analysis of subgroups, such as respiratory deaths, further reduce statistical power. Data on the use of medical services are a readily-available source of information on morbidity, including emergency department visits, hospital admissions, and community clinic visits. Direct measures of morbidity include specific symptoms relevant to air pollution, such as eye and respiratory tract irritation, the use of certain medications, and reductions in lung function. Once the health outcome has been chosen, the next step is to determine its expected incidence in the absence of the pollution episode. This can be achieved by comparing the outcome rates to those seen immediately prior to the episode period; by comparing the episode period to equivalent dates in adjacent years; by comparing the episode period to the post-episode period; and by using geographical control populations. Statistical analysis is then used to determine if the frequency of outcomes during the pollution episode differs significantly than that expected to occur in the absence of an episode. The final step in the study process includes evaluating the role of air pollution for causality, namely whether the observed increase can be said not only to have coincided with the episode but to actually have been caused by it, at least in part.

Air pollution in Israel

Several studies on the health effects of air pollution have been conducted in Israel. Areas that have drawn special attention include the Haifa-Krayot area, home to several petrochemical factories and oil refineries [11,12]; the Hadera District, home to a large coal-burning power plant; the greater Tel Aviv-Gush Dan area, which experiences a large volume of daily motor vehicle traffic [13,14]; and the Ashkelon District, home to coal- oil- and gas-burning power stations, oil refineries and additional heavy industries. [15] Several of these studies, including one that employed the novel use of artificial neural networks to predict the effects of pollution on health, found correlations between ambient air pollution levels and emergency room visits among children and adults [14,15], and found a higher prevalence of respiratory symptoms among children exposed to air pollutants [12]. Most of these studies, however, have concentrated on the effects in children, and have looked at a limited range of health outcomes. Air pollution in Israel and its effects on health are far from being understood, and the role of air pollution on respiratory health remains unclear [16]. As recently as 2002, the Israeli Public Health Service and the Ministry of Health's Department of Environmental Epidemiology cited air pollution as an increasing problem in Israel, and called publicly for "an intensification of applied research in this field in Israel, in order to establish a better data platform required for defining the national health policy in this field." [17]

Health effects of air pollution in the IDF

We have identified no studies that examined the effects of air pollution on young adults in Israel, including the specific effects of air pollution on young adults in the Ashkelon-Ashdod area during the 15 years since the coal-burning power station has been operational in this district. Furthermore, the effects of air pollution on soldiers have not been studied. This aspect of effects on health is of special importance in terms of adherence to training schedules, the seeking of medical care, and overall troop preparedness.

Importance of study findings

Air pollution is a growing concern among the the Israeli population, evidenced by a growing public awareness to the topic and increasing pressure by the public on responsible authorities at all levels to take a more proactive approach to protecting the public health against potential adverse effects of environmental pollution of all types. However, intensified study of the health effects of air pollution are necessary in order to

enable authorities to make well-informed, evidence-based public health policy decisions. The present study's results will provide information on the short-term health effects of air pollution on IDF soldiers in the Nitzanim, Zikim and Ashdod area. This study will also serve as a pilot and lay a framework for additional air pollution studies in the IDF, including the study of pollution from the Hadera power plant and its effects on the health of soldiers stationed at the nearby Machane 80 training camp, and possibly longitudinal followup of soldiers' health in the Ramat Hovav or other potentailly polluted areas. Finally, the study results will serve to illuminate not only IDF policy, but will provide important information for public health planners for the general population of the State of Israel, as the effects of air pollution on young adults has yet to be studied in this country.

Initial results of the proposed study

No results are currently available for presentation. Given the results of studies carried out among children, we could expect to find an association between heavy air pollution episodes and demand for medical care among the study population.

Study outline

Study design: we propose to study the short-term health effects of air pollution events on IDF soldiers in Nitzanim, Zikim and Ashdod using a historical-prospective cohort study design. These bases were selected due to their location in an area potentially under the influence of pollutants originating from sources in Ashkelon and Ashdod. The study population will be the population of soldiers that served at these two bases between January 2002 and June 2004. The exposure under study will be the level of air pollution on each of the days during this 2½ year period. Each day will be classified according to the presence or absence of a pollution event, and the severity of the pollution events will be scored. The outcome under study will be the demand for medical attention at the two bases, as measured by the number of clinic visits, their diagnosis, and their disposition. A positive correlation between the exposure and outcome variables will show that on days when a pollution event occurred, there was a significant increase in the volume and of clinic visits and in primary complaints indicative of exposure to pollutants.

Air pollution (exposure) data: Two independent Unions of Towns for Environmental Protection (UTEP), located in Ashkelon and Ashdod, operate in the district under study. These unions are companies owned jointly by several municipalities and regional councils, and are under the direction and guidance of the Ministry of the Environment.

The UTEPs' charter is to inspect, supervise, monitor, prevent and minimize environmental threats within their regional jurisdictions. Areas of activity and intervention covered by the UTEPs include air and water quality, industrial and solid waste treatment, agroecology and noise pollution. The UTEPs in the Ashkelon and Ashdod areas maintain air sampling stations located throughout the regions under their respective jurisdictions. Additional sampling stations are maintained by the Israel Electric Company and other industrial sites. These data are routinely transferred to the UTEPs, where they are monitored for violations of air pollution standards. In total, data is available from over 15 sampling stations, several of which serve individually and collectively as indicators of air pollution in the Nitzanim, Zikim and Ashdod areas. The available data includes half-hourly measurements of SO_2, NO_x, O_3, PM_{10}, $PM_{2.5}$, wind speed, wind direction, and ambient temperature and barometric pressure. These measurements are available continuously from January 2000 through June 2004, and provide the basis for measuring exposure to air pollution in the proposed study. In total, over 5 million data entries are available for quantification of pollution.

Health effect (outcome) data: The Nitzanim and Zikim training bases administer basic training to general service (i.e. non-combat) personnel immediately upon their induction into the IDF. Each base maintains a medical clinic which provides around-the-clock medical support for the basic trainees, cadre and support staff on post. The Ashdod military base is a large Navy facility, which houses an on-post medical clinic. During the period under study, these clinics treated a combined monthly average of nearly 4,000 soldiers, or some 120,000 total visits over the span of the study period. A computerized patient record (CPR) has been in use throughout this period, so that data on individual patient visits can be retrieved. The patient record includes date and time of visit, underlying medical conditions, current diagnosis category and disposition data, such as referral to a hospital emergency department and length of sick leave ordered. The computerized records can be linked with IDF personnel files to complete demographic information such as gender and length of service, and for a subset of soldiers linkage with an ongoing health surveillance survey can provide data on self-reported smoking status.

Statistical analysis: The incidence rates of various health effects will be compared between the pollution episodes and non-pollution intervals, using a univariate approach. Multivariate regression analysis will provide the basis for establishing the presence and strength of associations between individual and combined air pollutant levels and health

outcomes, while controlling for environmental variables such as season, temperature and barometric pressure.

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