Shortness of breath at night and health status in congestive heart failure: Effects of environmental conditions and health-related and dietary factors ☆

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ABSTRACT

Objectives: Recent studies suggest that persons with congestive heart failure (CHF) may be at higher risk for the short-term effects of air pollution. We carried out this daily diary panel study in Montreal, Quebec, to determine whether indicators of self-reported health status and shortness of breath at night were associated with selected health-related and dietary factors, weather conditions, and air pollution.
Methods: Thirty-one subjects with CHF participated in this study in 2002 and 2003. Over a 2-month period, they measured their oxygen saturation, pulse rate, weight, and temperature each morning and recorded these and other data in a daily diary. Every morning they recorded on visual analogue scales their assessments of their general health, shortness of breath, and weakness, their weight, temperature and other data in a daily diary. Air pollution and weather conditions were obtained from fixed-site monitoring stations. This paper deals only with the daily self-reported health outcomes of general health and shortness of breath. We made use of mixed regression models, adjusting for within-subject serial correlation and temporal trends, to determine the association between oxygen saturation and pulse rate and health-related, dietary and environmental variables. Depending on the model, we accounted for the effects of a variety of health-related and dietary variables as well as NO_2, ozone, maximum temperature and change in barometric pressure at 8:00AM from the previous day.
Results: Of the many associations for self-reported general health and shortness of breath, we found only a few statistically significant predictors, although increases in many variables showed decrements in self-reported general health and shortness of breath. The statistically significant associations with general health were increases in daily pulse rate and body weight, higher maximum ambient air temperature, higher relative humidity, and ozone (on the concurrent day). Statistically significant predictors of worsened shortness of breath at night were increases in blood pressure, body weight, and higher maximum ambient air temperature (lag 0 and 1 days). We also found that there was little confounding between environmental variables and health and dietary factors.
Conclusions: The findings from the present investigation suggest that certain health-related indices and environmental conditions affect self-reported health and shortness of breath in CHF patients, although larger studies are needed to confirm these findings.

1. Introduction

There is evidence that persons with congestive heart failure (CHF) have immediate adverse responses to increases in levels of ambient air pollution (Burnett et al., 1997; Goldberg et al., 2001, 2003; Koken et al., 2003; Kwon et al., 2001; Lee et al., 2007; Mann et al., 2002; Morris and Naumova, 1998; Morris et al., 1995; Schwartz and Morris, 1995; Symons et al., 2006; Wellenius et al., 2005, 2006). As well, daily weather conditions, such as higher ambient temperature, increase the risk of daily hospitalizations (Ebi et al., 2004; Koken et al., 2003; Morris and Naumova, 1998) and mortality (Kolb et al., 2008; Schwartz, 2005).

It can be hypothesized that changing environmental conditions may trigger exacerbations of symptoms, such as dyspnea, which is a hallmark of decompensated heart failure, and possibly changes in health status. To investigate these hypotheses, we conducted a daily diary panel study of individuals with CHF to determine whether daily exacerbations in essential signs, symptoms, and physiologic indicators are associated with daily variations in health-related and dietary factors, concentrations of ambient air pollution and weather patterns. We have reported recently results from this study for the outcomes oxygen saturation and pulse rate (Goldberg et al., 2008). In the present paper, we show results for the self-reported indices of general health status and shortness of breath at night.

2. Methods

2.1. Subjects

We included out-patients with CHF who attended the Heart Failure and Heart Transplant Center at the McGill University Health Center, Montreal, and who were between 50 and 85 years of age, had limitations in physical functioning (New York Heart Association (NYHA) severity classes II or III), had an ejection fraction equal to or below 35%, and were able to complete a daily diary of signs and symptoms. This study was approved by the McGill University Institutional Review Board and all subjects were informed of the study procedures and consented to participate.

We recruited subjects throughout the study period (July 2002–October 2003) and each were followed for approximately 8 weeks. A research nurse identified participants in advance of a planned clinic visit and placed an eligibility checklist on the patient's chart to be filled out by the treating physician. No more than eight subjects were followed at any one time.

2.2. Measures

2.2.1. Signs and symptoms for CHF

We asked participants to record selected physiological measures and to complete a diary at the same time every morning, before breakfast. Subjects were asked to be inactive for at least 5 min beforehand. The diary was recorded on a scannable form and it was used to record signs and symptoms, physiologic parameters (body temperature, weight, pulse rate, oxygen saturation, blood pressure), and indices of self-reported health (see below). (The daily diary can be downloaded from http://www.med.mcgill.ca/epidemiology/goldberg/.)

We asked subjects to complete a visual analogue scale for health states related to: (1) health in the morning, (2) shortness of breath at night, (3) shortness of breath while moving, (4) swelling of legs or ankles, (5) weakness or dizziness, and (6) fatigue. We asked the following question: "*To help people say how good or bad their health is, we have drawn a scale (rather like a thermometer) on which we would like you to rate six aspects of your health. The best imaginable state is 100 and the worst imaginable state is 0. We would like you to mark on each scale to indicate how good or bad your health is today. This mark corresponds to your opinion of your health.*"

Visual analogue scales have been used for at least four decades to assess a wide variety of symptoms and health states, including pain, shortness of breath, exertional dyspnea, fatigue, energy, sleepiness, nausea, heat, and anxiety as well as overall health (e.g., EuroQol EQ5D) (Edwards et al., 1991; Holmes, 1989; Kendrick et al., 1993; Kind, 1995; Melzack, 1987; Peterson et al., 1998). The usual format for assessment uses a line, either horizontal or vertical, of 10 cm in length that is anchored at each end with a descriptor indicating, at one extreme, the least possible level of the symptom or state and, at the other end, the highest possible level of the symptom or state. A ruler or ruled template is used to measure the distance from the bottom anchor point to the mark placed by the subject. Visual analogue scales have been shown to be reliable (Holmes, 1989) and to correlate with physiologic measures or responses to questionnaires of various constructs (Taube et al., 2000; Thomas et al., 1996).

In the construction of the scannable questionnaire we modified the usual 10 cm continuous line to one that was 17 cm wide (horizontal) and, because of limitations with regards to accuracy of scanning, instead of the scale being continuous, we asked subjects to rate their health in increments of five points (0, 5, 10, …, 95, 100). We did not validate this slightly modified version of the visual analogue scales as there was no reason to believe that validity or reliability should be affected.

2.2.2. Health-related and dietary covariates

Diminished health status of CHF patients and decompensated events are associated with deterioration of cardiac function (e.g., reductions in ejection fraction, arrhythmias, ischemia) and may be triggered by changes in certain lifestyle factors (e.g., salt and water consumption, infections, not adhering to therapy, dyspnea, edema, weight gain) (Feenstra et al., 1998; Michalsen et al., 1998; Schiff et al., 2003; Tsuyuki et al., 2001). We measured on a daily basis all of these variables except for compliance in therapy. In the statistical analysis, we computed a binary index representing possible infections the day before (from questions inquiring about a runny nose, sore throat, cough, taking antibiotics). Because of the difficulties in accurately measuring consumption of salt, we derived a simple dichotomous index based on the consumption of salt the day before (from questions inquiring about adding salt to meals the day before and eating certain foods known to be high in salt (e.g., pre-packaged soups, pickles)). We created a variable for the number of cups of liquid (including water, milk, coffee, tea) consumed the day before and treated it continuously.

2.2.3. Air pollution and weather conditions

As in previous papers from our group (Goldberg et al., 2000), we made use of hourly measurements of weather conditions, criteria gaseous pollutants, and fine particulates (aerodynamic diameter of 2.5 μm or under, $PM_{2.5}$) measured at fixed-site monitoring stations in Montreal operated by the National Air Pollution Surveillance Network of Environment Canada (http://www.etc-cte.ec.gc.ca/NAPS/index_e.html) and the City of Montreal (http://www.rsqa.qc.ca). The weather data (barometric pressure, temperature, relative humidity) were provided by the Meteorological Service of Canada from their monitoring station located at the Pierre-Elliott-Trudeau International Airport (latitude: 45°28′05″N; longitude: 73°44′29″W) situated approximately 30 km west of downtown Montreal. Change in barometric pressure from the previous day was defined as the value at 8:00 AM on the concurrent day minus the value at 8:00 AM on the preceding day. We used hourly measurements of criteria air pollutants at the fixed-site monitoring stations. Sulfur dioxide (SO_2) was measured at three stations using ultraviolet fluorescence; ozone (O_3) was measured at 10 monitoring stations using chemiluminescence; nitrogen dioxide (NO_2), was measured at nine stations using chemiluminescence; and carbon monoxide (CO) was measured at five stations using infrared absorption. Fine particle mass ($PM_{2.5}$) was measured every hour at eight stations using tapered element oscillating microbalances. Average daily concentrations of pollutants were derived by taking a simple daily