



Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

Anemia prevalence and hemoglobin levels are associated with long-term exposure to air pollution in an older population

Trenton Honda^{a,*}, Vivian C. Pun^a, Justin Manjourides^a, Helen Suh^b

^a Department of Health Sciences, Northeastern University, Boston, MA, United States

^b Department of Civil and Environmental Engineering, Tufts University, Medford, MA, United States

ARTICLE INFO

Article history:

Received 7 September 2016

Received in revised form 24 January 2017

Accepted 25 January 2017

Available online xxxx

Keywords:

Air pollution

Anemia

Hemoglobin

Elderly

ABSTRACT

Background: Anemia, a highly prevalent disorder in elderly populations, is associated with numerous adverse health outcomes, including increased mortality, impaired functional status and cognitive disorders. Approximately two-thirds of anemia in American elderly is caused by chronic inflammation or is unexplained. A potential contributing factor may include air pollution exposures, which have been shown to increase systemic inflammation and affect erythropoiesis. Few studies, however, have investigated the associations of air pollution on hemoglobin levels and anemia.

Methods: We used linear regression models and modified Poisson regression with robust error variance to examine the associations of particulate matter (PM_{2.5}) and nitrogen dioxide (NO₂) on hemoglobin concentrations and prevalence of anemia, respectively, among 4121 older Americans enrolled in the National Social Life, Health, and Aging Project. We estimated participant-specific exposures to PM_{2.5} using spatio-temporal models, and to NO₂ using nearest measurements from Environmental Protection Agency's Air Quality System. Hemoglobin levels were measured for participants in each of two data collection waves from dried blood spots. Anemia was defined using World Health Organization hemoglobin-based criteria of <13 and <12 g/dL for men and women, respectively. Models were adjusted for age, sex, smoking status, race, income, education, neighborhood socioeconomic status, region, urbanicity and medication use. Mediation by C-reactive protein (CRP), a marker of systemic inflammation, was also investigated.

Results: An inter-quartile range (IQR, 3.9 μg/m³) increase in the one-year moving average PM_{2.5} was positively associated with anemia prevalence (prevalence ratio, or PR 1.33, 95% CI: 1.23, 1.45) and decreases in average hemoglobin of 0.81 g/dL (p < 0.001). Similarly, an IQR (9.6 ppb) increase in NO₂ was associated with anemia prevalence (PR 1.43, 95% CI: 1.25, 1.63) and a decrease in average hemoglobin of 0.81 g/dL (p < 0.001). Strong dose-response relationships were identified for both pollutants. Mediation of the effect of PM_{2.5} by CRP was also identified (p = 0.007).

Conclusions/interpretations: Air pollution exposures were significantly associated with increased prevalence of anemia and decreased hemoglobin levels in a cohort of older Americans. If causal, these associations could indicate that chronic air pollution exposure is an important risk factor for anemia in older adults.

© 2017 Published by Elsevier Ltd.

1. Introduction

Anemia, a disorder defined by a lack of hemoglobin in the blood, is highly prevalent in elderly populations, with between 2.9% and 60.1% of older adults estimated to have anemia, depending upon the population studied (Beghe et al., 2004). Older adults with anemia have been found to be at higher risk for a number of severe adverse health

outcomes including: mortality (Ezekowitz et al., 2003; Wu et al., 2001), impaired functional status (Lipschitz, 2003; Denny et al., 2006), impaired cognitive function (Denny et al., 2006), and cognitive disorders such as Alzheimer's disease (Beard et al., 1997; Atti et al., 2006). Common causes of anemia in older adults include micronutrient deficiencies (i.e. iron, cyanocobalamin and folate), renal insufficiency, and anemia of chronic inflammation (ACI), with up to one third of anemia in American elderly unexplained or not readily attributable to a single cause (Guralnik et al., 2004). The large fraction of unexplained anemia (UA) in this age group together with anemia's high prevalence and potentially severe health consequences points to the need to identify additional, potentially modifiable causes.

One potential cause of anemia is exposure to air pollutants, such as fine particulate matter (PM_{2.5}) and NO₂. Exposures to PM_{2.5} and NO₂

Abbreviations: ACI, anemia of chronic inflammation; CRP, C-reactive protein; IL-6, interleukin-6; NO₂, nitrogen dioxide; PM_{2.5}, particulate matter with an aerodynamic diameter of ≤2.5 μm; Ppb, parts per billion; PR, prevalence ratio; UA, unexplained anemia; WHO, World Health Organization.

* Corresponding author.

E-mail address: t.honda@northeastern.edu (T. Honda).

<http://dx.doi.org/10.1016/j.envint.2017.01.017>

0160-4120/© 2017 Published by Elsevier Ltd.

Please cite this article as: Honda, T., et al., Anemia prevalence and hemoglobin levels are associated with long-term exposure to air pollution in an older population, *Environ Int* (2017), <http://dx.doi.org/10.1016/j.envint.2017.01.017>

have been shown to increase systemic inflammation (Cliff et al., 2016; Dabass et al., 2016; Mirowsky et al., 2015; Orona et al., 2016; Thomson et al., 2016; Viehmann et al., 2015) and affect bone marrow stimulation (Mukae et al., 2000), particularly in those individuals who have conditions associated with chronic inflammation, such as diabetes or obesity (Kramer et al., 2010). While much of this evidence examines short-term changes in the levels of circulating inflammatory markers, several recent studies suggest that long-term air pollutant exposures may also lead to chronic and self-sustained systemic inflammation (Brook et al., 2010; Pope et al., 2004a, 2004b). Given the central role of systemic inflammation in the pathogenesis of anemia in the elderly, these findings suggest that air pollution, through its impacts on systemic inflammation, may trigger a cascade of events – including (1) down-regulation of erythropoietin production, (2) exacerbation of refractoriness of hematopoietic precursors to endogenous erythropoietin (Ferrucci and Balducci, 2008), and (3) chronic and sustained upregulation of hepcidin, an iron regulatory protein (Quay et al., 1998) – each of which can lead to diminished hemoglobin and/or red blood cell production and, eventually, anemia (Bárány, 2001).

Despite these plausible mechanisms, the impact of air pollution exposures on hemoglobin levels and anemia has been little studied, with the few studies conducted to date focused on the impacts of short-term air pollutant exposures on red blood cell indices or anemia primarily in young adults (Seaton et al., 1999; Sorensen et al., 2003; Nikolić et al., 2008; Stanković et al., 2006; Krishnan et al., 2013). To our knowledge, no studies have yet investigated the effect of long-term air pollution on hemoglobin levels and anemia prevalence in a nationally representative sample of older Americans.

2. Methods

2.1. Population

The study sample is from the National Social Life, Health, and Aging Project (NSHAP), a nationally representative cohort of 4121 older adults (born between 1920 and 1947) selected from eligible households identified in the Health and Retirement Study (HRS) in 2004. The study was designed to measure and evaluate determinants of wellbeing in older, community-dwelling Americans (Waite et al., 2014a, 2014b). African-Americans, Latinos, men and the oldest old (individuals between 75 and 84 years) were oversampled to allow for meaningful statistical inference. Demographic, social, health data, biometric measurements and blood spot collections were obtained for 3005 NSHAP participants in Wave 1 (2005–2006) and for 3377 participants in Wave 2 (2010–2011), while 2261 individuals participated in both waves while 744 participants from Wave 1 were either too sick to participate in Wave 2 or deceased. Additional Wave 2 participants were selected from eligible households originally identified from the HRS probability sample (Waite et al., 2014a, 2014b). Response rates were high for both Wave 1 (75%) and Wave 2 (74%).

2.2. Exposure assessment

Moving averages of PM_{2.5} were estimated from spatio-temporal generalized additive mixed models (GAMMs) that estimated PM_{2.5} concentrations along a 6 × 6 km grid using methods previously described in detail (Yanosky et al., 2014). Briefly, spatio-temporal GAMMs of monthly PM_{2.5} mass from 1999 to 2007 were constructed using PM_{2.5} measurements obtained from the U.S. Environmental Protection Agency (EPA) Air Quality System (AQS) database and Interagency Monitoring of Protected Visual Environments (IMPROVE) network (EPA, U.S., 2009; IMPROVE, 2013), and using meteorological (wind speed, temperature and total precipitation) and geospatial (population density from the 2000 US Census, point-source PM_{2.5} emissions, line-source traffic density and annual-average PM_{2.5} from EPA's Community Multiscale Air Quality model) data. PM_{2.5} exposures for each NSHAP participant

were assessed using the PM_{2.5} concentrations estimated at the grid point closest to the participant's residential address (mean distance 2.23 km). The PM_{2.5} model has been previously validated (10-fold out-of-sample cross validation R² of 0.76) and shown to have low bias (normalized mean bias factor = −1.6%) and high precision (normalized mean error factor = 14.3%) (Yanosky et al., 2014).

Nitrogen dioxide (NO₂) exposures were estimated using measurements from the nearest AQS monitor within 80 km of NSHAP participants' residential addresses, with the median distance to a monitor being 11.4 km (IQR 32.2). For both NO₂ and PM_{2.5}, one to five-year moving averages from the date of interview were calculated and considered valid if ≥75% of the daily values within each month were available. Every NSHAP participant had valid PM_{2.5} measurements for each exposure window. For NO₂ the number with valid exposure estimates varied by exposure window (between 83.7% and 79.4% for the one and five-year moving averages, respectively) due to limiting estimates to monitors within 80 km of residential addresses. Correlations between PM_{2.5} and NO₂ ranged from 0.12 to 0.44 across the five regions (Supplement Table 1).

2.3. Outcome assessment

Hemoglobin was collected via dried blood spots captured and transported on filter paper to centralized laboratories. Colorimetric analysis was conducted using Drabkin's solution, which converts hemoglobin to cyanmethemoglobin. Color development in the sample is directly proportional to hemoglobin concentration and can be read photometrically (Waite et al., 2014a, 2014b; Nallanathan et al., 2008). Dried blood spot hemoglobin measurement using colorimetric analysis has been shown to be highly correlated with venous samples (R² = 0.96) and have high precision, with an intra-assay coefficient of variation (CV) of 2.1 and an inter-assay CV of 3.4 (O'Broin and Gunter, 1999; Yang et al., 2013; Williams and McDade, 2009; McDade et al., 2007).

Hemoglobin measurement in Wave 1 was randomized to 83.3% of the 3005 participants (N = 2494). Of those randomized to undergo blood spot collection, 2105 participated. No significant differences were identified between those who did and did not participate with respect to sex, race/ethnicity, age, educational attainment, income level, or self-reported physical health (Nallanathan et al., 2008; Fomovska et al., 2008). Hemoglobin measurements were invalid for an additional 246 participants due to collection and/or analytical challenges. In sum, hemoglobin levels were available for 1859 of the 2494 (74.5%) eligible participants (Nallanathan et al., 2008; Fomovska et al., 2008). Data completeness for Wave 2 was approximately 90%, with 2037 of the 3377 participants having valid hemoglobin measurements. Anemia was defined using the World Health Organization definition of hemoglobin concentrations <13 g/dL and 12 g/dL in men and women, respectively (World Health Organization, 2015).

2.4. Covariates

Information describing the demographic and behavioral characteristics of our NSHAP participants was obtained via participant responses to technician-administered questionnaires. Covariates included Race/ethnicity (categorized as White, Black, Hispanic or other), individual level socio-economic status (SES) using four levels of self-reported educational attainment, and neighborhood level SES using median census tract household income and percent of households living below the poverty line. Smoking status (categorized as current, historical or none) and physical activity (classified based on the frequency of self-reported, vigorous exercise as follows: 1) never, 2) less than one time per month, 3) 1–2 times per week, 4) 3–4 times per week, and 5) 5 or more times per week) were also controlled. Geographic region of residence was categorized as residing in one of five distinct geographic regions (North Atlantic, South, Great Lakes region, Plains States, Pacific);

Download English Version:

<https://daneshyari.com/en/article/5748282>

Download Persian Version:

<https://daneshyari.com/article/5748282>

[Daneshyari.com](https://daneshyari.com)