Science of the Total Environment 496 (2014) 624–634

Contents lists available at ScienceDirect

Science of the Total Environment

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

Predictors of serum polychlorinated biphenyl concentrations in Anniston residents

M. Pavuk [a,*], J.R. Olson [b], W.A. Wattigney [a], N.D. Dutton [c], A. Sjödin [d], C. Shelton [e], W.E. Turner [d], S.M. Bartell [f], for the Anniston Environmental Health Research Consortium Members of the Anniston Environmental Health Research Consortium Steering Committee include S. Carter, community representative S. Bartell [1], D.O. Carpenter [2], J. Cash, R. Foushee [3], A. Percy [3], H. Frumkin [4], M. Lavender [5], K. Moysich [6], J. Olson [7], M. Pavuk [8], P. Rosenbaum [9], A. Silverstone [9], R. Weinstock [9], C. Shelton [10]

[1] University of California–Irvine
[2] University at Albany
[3] University of Alabama–Birmingham
[4] University of Washington
[5] Center for Domestic Preparedness
[6] Roswell Park Cancer Institute
[7] University at Buffalo
[8] Agency for Toxic Substances and Disease Registry/Centers for Disease Control and Prevention
[9] State University of New York Upstate Medical University
[10] Jacksonville State University

[a] Agency for Toxic Substances and Disease Registry, Atlanta, GA, USA
[b] School of Medicine and Biomedical Sciences, University at Buffalo, State University of New York, Buffalo, NY, USA
[c] Oak Ridge Institute for Science and Education (ORISE) Research Participant, Agency for Toxic Substances and Disease Registry, Atlanta, GA, USA
[d] National Center for Environmental Health, Centers for Disease Control and Prevention, Atlanta, GA, USA
[e] College of Nursing, Jacksonville State University, Jacksonville, AL, USA
[f] Program in Public Health and Department of Statistics, University of California, Irvine, CA, USA

HIGHLIGHTS

- We examined factors associated with serum PCB levels in 765 adult ACHS participants.
- Demographic, behavioral, dietary, and occupational characteristics were analyzed.
- Linear regression models with stepwise selection were used to examine predictors.
- Age and race were the most influential predictors of serum PCB levels.
- Variables for consumption of locally produced foods were also important predictors.

ARTICLE INFO

Article history:
Received 6 March 2014
Received in revised form 30 May 2014
Accepted 25 June 2014
Available online 9 August 2014

Editor: Adrian Covaci

ABSTRACT

The Anniston Community Health Survey was a community-based cross-sectional study of Anniston, Alabama, residents who live in close proximity to a former PCB production facility to identify factors associated with serum PCB levels. The survey comprises 765 Anniston residents who completed a questionnaire interview and provided a blood sample for analysis in 2005–2007. Several reports based on data from the Anniston survey have been previously published, including associations between PCB exposure and diabetes and blood pressure. In this study we examine demographic, behavioral, dietary, and occupational characteristics of Anniston survey participants as predictors of serum PCB concentrations. Of the 765 participants, 54% were White and 45% were

Abbreviations: PCB, polychlorinated biphenyls; ACHS, Anniston Community Health Survey; LOD, limit of detection; OR, odds ratio; CI, confidence interval.

* Corresponding author at: Division of Toxicology and Human Health Sciences, Agency for Toxic Substances and Disease Registry, Center for Disease Control and Prevention, 4770 Buford Highway, Mail Stop F-57, Atlanta, GA 30341, USA. Tel.: +1 770 488 3671.
E-mail address: MPavuk@cdc.gov (M. Pavuk).

http://dx.doi.org/10.1016/j.scitotenv.2014.06.113
0048-9697/Published by Elsevier B.V.

Keywords:
Polychlorinated biphenyls
Linear regression
Anniston

African-American; the sample was predominantly female (70%), with a mean age of 55 years. Serum PCB concentrations varied widely between participants (range for sum of 35 PCBs: 0.11–170.4 ng/g wet weight). Linear regression models with stepwise selection were employed to examine factors associated with serum PCBs. Statistically significant positive associations were observed between serum PCB concentrations and age, race, residential variables, current smoking, and local fish consumption, as was a negative association with education level. Age and race were the most influential predictors of serum PCB levels. A small age by sex interaction was noted, indicating that the increase in PCB levels with age was steeper for women than for men. Significant interaction terms indicated that the associations between PCB levels and having ever eaten locally raised livestock and local clay were much stronger among African-Americans than among White participants. In summary, demographic variables and past consumption of locally produced foods were found to be the most important predictors of PCB concentrations in residents living in the vicinity of a former PCB manufacturing facility.

Published by Elsevier B.V.

1. Introduction

Polychlorinated biphenyls (PCBs) are persistent synthetic organochlorine chemicals that were mass-produced in the United States from 1929 to 1977 (ATSDR, 2000a). Starting in 1935, Monsanto Chemical Corporation was the sole US producer (under the trade name "Aroclor") and operated two facilities: one in Sauget, Illinois, and another in Anniston, Alabama. The Anniston plant ceased production in 1971, before the official ban on PCB production in 1977, because of concerns over the toxicity of PCBs and their persistence in the environment (ADPH, 1995, 1996; EPA, 1976). Although the levels of PCBs in humans has decreased over time (Longnecker et al., 1997), the potential for exposure to PCBs can continue in some instances because of the presence of products and waste materials containing PCBs in landfills, hazardous waste sites, and contaminated soils and sediments (Nisbet and Sarofim, 1972; ATSDR, 2000b). PCBs accumulate in the food chain (Startin, 1994) and can be detected in virtually all humans (Patterson et al., 2009).

Ingestion of contaminated food products, especially fish and livestock, is often an important pathway of exposure to PCBs (Burns et al., 2009; Hovinga et al., 1992; Humblet et al., 2010; Humphrey and Budd, 1996; Kreiss et al., 1981; Schecter et al., 2001; Sjödin et al., 2000; Startin, 1994). Demographic factors such as age, sex and body mass index (BMI) have also been shown to be important predictors of PCBs in non-occupationally exposed populations (Agudo et al., 2009; Bräuner et al., 2011; Choi et al., 2006; Garabrant et al., 2009; Laden et al., 1999; Tee et al., 2003). In women, age, alcohol consumption, parity and lactation have been found to be important determinants of PCB concentrations (Rogan et al., 1986; Schwartz et al., 1983). Among young Akwesasne adults (17–21 years old), breastfeeding status, BMI, and consumption of fish in the last year were associated with serum PCBs (Gallo et al., 2011). In addition to ingestion of contaminated food products, other routes of exposure, including inhalation and dermal contact, have also been studied (DeCaprio et al., 2005; Löffler and van Bavel, 2000). Occupational exposure, mainly from work with capacitors and electrical transformers, is historically an important predictor of PCB levels (Ouw et al., 1976; Seegal et al., 2011; Wolff et al., 1982; Wolff, 1985).

Risk factors for non-occupational exposure vary among populations, as the use of PCBs varied by time and geographical location (Nicholson and Landgrigan, 1994). Community studies of residents living in proximity to a contaminated site can help elucidate exposure pathways and related socioeconomic or behavioral risk factors (Choi et al., 2006; Fitzgerald et al., 2007).

In addition to the former PCB production facility, the Anniston area also includes two landfills containing PCB waste (capped and closed in early 1980s), as well as several drainage channels and water streams with contaminated sediments. Decades after PCB production ended, analyses revealed high concentrations of PCBs in soil persisting in Anniston soil samples (ATSDR, 2000b; Orloff et al., 2003). Historical contamination of locally raised hogs, chickens, and other animals was presented during litigation in Anniston (Chemical Industry Archives, Environmental Working Group, 2001; Love, 2007), while contamination of local fish has been thoroughly documented over many years (ADPH, 1995, 1996, 2011). Starting in the 1990s, when Anniston residents brought lawsuits against Monsanto over releases of PCBs into the environment, high concentrations of PCBs began to be documented in some Anniston residents (ADPH, 1996; ATSDR, 2000b; Hansen et al., 2003).

The Anniston Community Health Survey (ACHS) was a cross-sectional study conducted in 2005–2007 in response to concerns among community members over whether exposure to PCBs had increased their body burden of these contaminants and negatively affected their health. Previous analyses of the ACHS dataset focused on PCB exposure among participants (Pavuk et al., 2014) and on associations of serum PCB concentrations with hypertension and diabetes (Goncharov et al., 2010, 2011; Silverstone et al., 2012). Results from the analysis of PCB exposure among ACHS participants showed that the median summed concentration of 35 PCB congeners (ΣPCBs) was 528 ng/g lipid (range: 17.0–27,337 ng/g lipid). In all age groups, the geometric mean ΣPCBs was about two to three times higher for African-American participants than for White participants. When contrasted with similar age and race groups reported from the National Health and Nutrition Examination Survey (NHANES) 2003–2004, serum PCB concentrations in ACHS participants were about three times higher for African-Americans and two times higher for White participants of age 40 and older (Pavuk et al., 2009, 2014; Patterson et al., 2009).

The goal of the present study was to examine the determinants of PCB exposure in Anniston, focusing on residents of the neighborhood closest to the former PCB production facility. Identification of predictive factors for PCB levels in Anniston residents could aid the development of strategies to limit further exposure in communities with high PCB exposure.

2. Methods

2.1. Study population

The ACHS was designed to examine serum PCB concentrations and health outcomes in residents of Anniston, Alabama, a city of about 24,000 people. Questionnaire data and blood samples were collected in 2005 through 2007. Anniston residents aged 18 years or older were eligible and were selected through a stratified random sample of housing units, with oversampling (two-thirds of all eligible) from in west Anniston. Oversampling in west Anniston facilitated enrollment of residents who lived closer to the plant and thus had higher potentials for PCB exposure. A pool of 3320 eligible addresses was randomly selected from a commercial list of all residential properties in Anniston (2224 in west Anniston). One adult resident was randomly selected from each of the 1823 households that were successfully contacted. A survey questionnaire was administered by trained interviewers in participants' homes or a local study office. Fasting blood samples were collected and height and weight were measured at the local study office. All participants provided written informed consent prior to participation. In total, 1100 residents completed the survey, and 774 volunteered to