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Contribution of health behaviors to the association between area-level socioeconomic status and cancer mortality

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ABSTRACT

Cancer mortality is higher among residents of low-socioeconomic status (SES) areas than those of high-SES areas; however, the contribution of modifiable risk factors to this disparity is not known. We used data from 54,737 participants in the VITamins And Lifestyle (VITAL) Study, aged 50–76 with no history of cancer at baseline (2000–2002). Of these, 1488 died of cancer over an average of 7.7 years of follow-up. Data on modifiable risk factors including body mass index (BMI), physical activity, diet, alcohol, smoking and screening were taken from baseline questionnaires. We constructed a block group-level SES index using data from the 2000 United States Census and fit Cox proportional hazards models estimating the association between area-level SES and total cancer mortality with and without control for modifiable risk factors. All statistical tests are 2-sided. Cancer mortality was 77% (95% CI: 50%, 111%) higher in the lowest-SES areas compared with the highest. Modifiable risk factors accounted for 45% (95% CI: 34%, 62%) of this association. Smoking explained the greatest proportion (29%; 95% CI: 22%, 40%) of the observed association, followed by diet (11%; 95% CI: 7%, 17%), physical activity (10%; 95% CI: 7%, 16%), screening (9%; 6%, 13%), and BMI (5%; 95% CI: 1%, 10%). Results were similar in models controlling for individual education and income. The association between area-level SES and cancer mortality is partially explained by modifiable risk factors, which could suggest the appropriate targets to reduce socioeconomic disparities.

Previous work has suggested an inverse, dose-response association between area-level socioeconomic status (SES) and total cancer mortality such that cancer mortality was approximately 80% higher among residents of the lowest-SES areas compared with residents of the highest-SES areas (Hastert et al., 2015). This association partially attenuated after accounting for individual education and income; however, cancer mortality remained 40% higher in residents of the lowest-SES areas relative to the highest (Hastert et al., 2015). Modifiable risk factors including diet, physical activity, body mass index (BMI), alcohol consumption, smoking, and cancer screening are all associated with cancer outcomes (Ballard-Barbash et al., 2006; Force, 2008; Hastert et al., 2015; Lee and Oguma, 2006; Marshall and Freudenheim, 2006; Nelson et al., 2009; Romaguera et al., 2012; Tang et al., 2010; Thun and Henley, 2006; Willett, 2006) and with SES, (Ball et al., 2006; Black et al., 2010; Chaix and Chauvin, 2003; Diez-Roux et al., 2000; Diez-Roux et al., 1999; Diez Roux et al., 2003; Duncan et al., 1999; Stafford et al., 2007; Zackrisson et al., 2007) and could contribute to the observed socioeconomic disparities in cancer mortality; however, their contribution to these socioeconomic disparities in cancer mortality is not clear.

Previous research has suggested that BMI, diet, physical activity, and smoking at least partially explained associations between individual SES and total mortality, (Stringhini et al., 2010) and between area-level SES and colorectal cancer incidence (Doubeni et al., 2012; Kim et al., 2010). Although substantial disparities in cancer mortality have been observed by area-level SES (Hastert

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et al., 2015), no previous work has examined the potential contribution of modifiable risk factors to this association.

The purpose of this paper is to test whether and to what extent the observed association between area-level SES and cancer mortality is explained by six modifiable risk factors. Body mass index (BMI), physical activity, dietary factors (energy density and consumption of fruits and vegetables and red and processed meats), and alcohol consumption were identified from the cancer prevention recommendations of the World Cancer Research Fund (WCRF) and American Institute for Cancer Research (AICR) ("Food, Nutrition, Physical Activity, and the Prevention of Cancer:a Global Perspective," 2007). Pack-years of smoking and cancer screening behaviors including colonoscopy or sigmoidoscopy, mammography in women and prostate-specific antigen (PSA) testing in men were also considered based on their associations with cancer incidence and mortality (Nelson et al., 2009; "Screening for colorectal cancer: U.S. Preventive Services Task Force recommendation statement," 2008; Tang et al., 2010; Thun and Henley, 2006). Ascertaining modifiable risk factors that contribute to socioeconomic disparities in cancer mortality could help identify points of intervention to reduce those disparities.

1. Methods

1.1. Study cohort

The VITamins And Lifestyle (VITAL) study is a prospective cohort study designed to investigate associations between behaviors, including dietary supplement use, and cancer risk and mortality. It has previously been described in detail (White et al., 2004). Participants were eligible to join the cohort if they were between the ages of 50 and 76 and lived in one of the 13 counties included in the Western Washington Surveillance, Epidemiology and End Results (SEER) cancer registry at baseline. Using names purchased from a commercial mailing list, baseline questionnaires were mailed to 364,418 men and women between October, 2000 and December, 2002 and were followed two weeks later by reminder postcards. A total of 79,300 questionnaires were returned, of which 77,719 passed quality control checks.

Overall, 54,736 men and women were included in the current analysis after excluding respondents with a history of cancer other than nonmelanoma skin cancer ($n = 11{,}259$) or whose history of cancer was unknown ($n = 214$) and respondents whose baseline addresses were post office boxes ($n = 1137$) or could not be geocoded ($n = 381$). Respondents missing data for one or more potential mediators ($n = 8716$) were also excluded. Participants missing either individual educational attainment or annual household income remained in the analysis, but 977 respondents were excluded for missing both items. Additionally, the first year of follow-up (including 43 cancer deaths and 531 persons with other censoring events), was excluded to avoid potential reverse causality. Participants entered the survival analyses one year after the date of the completion of the baseline questionnaire, and were followed until the date of death due to cancer or a censoring event. Numbers of exclusions reported are not mutually exclusive, with participants meeting multiple exclusion criteria counted in the total excluded for each exclusion criterion.

1.2. Area-level socioeconomic status

Respondents' baseline addresses were geocoded using GPS Visualizer and Yahoo! Maps. Addresses were used to identify respondents' census block groups using TIGER/Line shapefiles for the 2000 Census in ArcMap 10 (Esri, Redlands, CA). In order to validate this geocoding method, a 1% sample of addresses was geocoded again using Google Maps and more than 95% of the addresses in the 1% validation sample were geocoded within 400 m of one another using the two methods.

We measured area-level SES using a previously-developed index (Diez-Roux et al., 2001) which has been used in prior studies of area-level SES and cancer outcomes (Hastert et al., 2015; Kim et al., 2010). This index includes the log of median value of owner-occupied housing units; log of median household income; percent of households receiving net rental, interest or dividend income; percent of adults ages 25 and older who completed high school; percent of adults ages 25 and older who completed college; and percent of employed persons ages 16 and older in professional and managerial occupations. Standardized z-scores were calculated for each variable based on the 3346 block groups in the 13 counties of the Western Washington SEER registry and summed to create an index such that higher values corresponded with lower SES. Index values of participants included in these analyses ranged from -16.1 to 16.7 with a median of -1.2 and mean of -1.5.

Census block groups were chosen as an approximation of participants' neighborhood environments. Block groups were used because they represent small, relatively permanent statistical subdivisions of counties and of census tracts that are designed such that their populations are relatively homogenous with respect to population characteristics, economic factors, and living conditions. They do not cross county, state or census tract boundaries and most were delineated with input from local participants. Block groups in the catchment area covered a median of 3.3 square miles and included a median population of 1070. Block groups have been found to perform favorably in detecting socioeconomic gradients in cancer incidence and mortality (Krieger et al., 2002).

1.3. Data collection

Sex-specific baseline questionnaires were used to collect self-reported information on medical history, height and weight, physical activity, diet, alcohol consumption, smoking, and cancer screening behaviors.

BMI (kg/m^2) was calculated using respondents' self-reported height and weight. Physical activity was assessed by a one-page questionnaire covering participation in 14 types of activities over the previous 10 years, including years and days per week, plus intensity for walking. These data were used to calculate a continuous measure of average MET-hours per week of moderate or fast walking and moderate or strenuous physical activity.

Dietary variables included energy density of the diet and consumption of fruits and vegetables and of red and processed meats, selected based on the dietary factors the WCRF/AICR found to be associated with cancer incidence and mortality (Arab et al., 2013; Hastert et al., 2013; Hastert et al., 2014; Inoue-Choi et al., 2013; Romaguera et al., 2012; Vergnaud et al., 2013). Diet was assessed by a 126-item food frequency questionnaire (FFQ) covering the year before baseline. The FFQ was adapted from the questionnaire developed for use in the Women's Health Initiative and other studies. Measurement properties of earlier versions of the FFQ have been published previously (Patterson et al., 1999). The University of Minnesota's Nutrition Coordinating Center database was used to convert food frequency information into nutrients. Numbers of servings were based on the sex-specific medium portion size of each food and beverage (Schakel et al., 1997).

Energy density was calculated by dividing the energy (kcal) of foods consumed by the estimated weight (grams) of those foods. Beverages were excluded from the energy density calculations. Daily servings of fruits and vegetables included 25 foods and food groups, adjusted by portion size and by summary questions on total numbers of fruits and vegetables eaten to reduce over-estimation