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Environmental hazards and stress: evidence from the Texas City Stress and Health Study

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Abstract

Background—Substantial research has suggested that exposure to environmental health hazards, such as polluting industrial activity, has deleterious effects on psychological and physiological well-being. However, one gap in the existing literature is comparative analysis of objective and subjective exposure's relative association with various measurable outcomes of exposure.

Methods—These relationships were explored within a community sample of 2604 respondents living near a large petrochemical complex in Texas City, Texas, USA. Objective exposure was investigated using distance of residence from a cluster of petrochemical plants and subjective exposure using residents' concern about potential health effects from those plants. Regression models were then used to examine how each type of exposure predicts perceived stress, physiological markers of stress and perceived health.

Results—Results suggest that objective exposure was associated primarily with markers of physiological stress (interleukin-6 and viral reactivation), and subjective exposure (concern about petrochemical health risk) was associated with variables assessing perceived health.

Conclusions—From the analysis, it can be inferred that, in the context of an environmental hazard of this type, subjective exposure may be at least as important a predictor of poor health outcomes as objective exposure.

Environmental health hazards, such as polluting industrial activity, may have a number of negative effects on psychological and physiological well-being. There are two major causal pathways through which such effects may work. One is exposure that directly damages health; the other is an indirect pathway that works through perception of risk, chronic stress and the sequelae of that stress in poorer health outcomes. These “objective” and “subjective” approaches to the problem of environmental health are not mutually exclusive, but they tend to structure analyses associated with various research agendas. For instance, environmental justice perspectives tend to focus on objective risk factors, such as differential proximity to hazards and assumed correlated health outcomes. Research on environmental risk and health continues to evolve, and the mechanisms and pathways of exposure, stress and health are not fully understood.

Hallman and Wandersman[1] argued that the perceived risk of environmental threats translates into chronic stress for exposed populations because of fear of potential health problems, the

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uncertainty of the threat, lack of control, actions of others perceived to cause the threat or reacting against it and stigmatisation. A recent meta-analysis of research examining a broad array of stressors and the immune system indicated that chronic stressors had detrimental effects on many aspects of immune system functioning, including viral reactivation through downregulating T-cell responses to viruses (eg, Epstein–Barr, herpes simplex, cytomegalovirus), whereas other research suggests that negative emotions, such as depressive symptoms, and stressors increase inflammatory system sensitivity, such as increased production of interleukin (IL)-6.[23]

Most studies on environmental hazards, however, have been conducted on toxic waste sites — where researchers have uniformly discovered psychosocial distress among nearby residents.[4–10] In addition, other studies have focused on physiological stress. For example, one study focused on populations living near the damaged Three Mile Island nuclear reactor (a chronic stressor) and discovered lower levels of lymphocytes, higher cortisol levels and higher levels of reactivated viruses compared with a control group.[11] Thus, the proximity of environmental health hazards may act as stressors that affect both psychological and physiological responses.

Petrochemical production sites are also associated with increased stress and self-reported illness. Burby and colleagues' investigation of populations in the petrochemical corridor in Louisiana tied risk perception to stress.[1213] Using quantitative and qualitative methods, Luginaah and colleagues reported similar findings in a predominantly non-Hispanic white population living around a single petroleum refinery in Ontario, Canada.[14–16] While not studying petrochemical facilities, Downey and Van Willigen discovered that increased numbers of industrial facilities and average pounds of toxic releases were significantly associated with increased depressive symptoms, increased neighbourhood social disorder and increased feelings of powerlessness even after adjusting for standard demographics and neighbourhood stability measures[17].

What is missing in the literature to date is a more comprehensive comparison of the association of objective exposure (eg, proximity to hazards) and of perceived risk (eg, concern about a hazard's risk to health) with perceived stress, biological stress responses and health outcome measures. We investigated these linkages through models that examined the association between residential distance from a cluster of petrochemical plants, concern about health effects from those plants, perceived stress, various physiological markers of stress and perceived health measures. We explored these relationships within a community sample of 2604 respondents living near a large petrochemical complex in Texas City, Texas, USA. Our primary purpose was to understand the relative association of objective exposure (distance) and subjective exposure (concern about petrochemical health risk) with the objective and subjective expressions of stress and self-rated health. We hypothesised that, after controlling for many factors known to be related to perception of risk, stress and health, both objective and subjective measures of exposure to the environmental hazard will be: (1) associated with increased psychological stress and markers of physiological stress; and (2) associated with poorer perceived health outcomes.

Methods

Study design

The data for this study come from the Texas City Stress and Health Study, part of a larger Center for Population Health and Health Disparities study focusing on the health of Hispanic people. The original purpose of the study was to evaluate sociobiological patterns in a population living in close proximity to a cluster of oil refineries and other petrochemical processing plants, with a special focus on Hispanic people, as little is known about ethnicity

and stress processes.[18] The study began with an exhaustive listing of housing units in Texas City. From this listing, housing units were classified as Hispanic or other households. Hispanic households had at least one adult who self-identified as Hispanic. The households were divided into three strata:

1. One in eight non-Hispanic white or non-Hispanic black households were selected, and one adult aged 25+ was randomly selected for interview.
2. One adult aged 25–64 was selected from all Hispanic households with no older adults (65+).
3. All Hispanic adults aged 65 and over were selected for interview.

This stratification was accounted for by including age and ethnicity in all regression models.

Selected and consenting residents were interviewed at baseline in their homes. The baseline survey instrument contains scales and items measuring a wide array of demographic, behavioural, social and health indicators. The institutional review board at the University of Texas Medical Branch approved the study protocol, and informed consent was obtained from all participants. A trained phlebotomist drew blood in the subject's home or at a centrally located clinic in the morning between 09.00 and 12.00. Blood samples were centrifuged to obtain plasma, which was stored at −70°C until testing. Plasma levels of IL-6, IL-10, C-reactive protein (CRP) and tumour necrosis factor (TNF)-alpha were analysed using standard enzyme-linked immunosorbent assay (ELISA) methods. Samples were batch analysed to minimise interassay variation. Weight and height were assessed either in the clinic or during the interview.

Baseline interview rates in the main study were 80%. This yielded a sample size of 2706. However, there were 22 respondents who did not identify as non-Hispanic white, non-Hispanic black or Hispanic. In addition, as there were only 80 Hispanic respondents who did not self-identify as being of Mexican descent, they were eliminated from the analyses to simplify interpretations as pertaining to Mexican–Americans. Thus, the final sample size contains respondents who self-identified as white, black or Mexican–American (n = 2604). This sample size will be used for the non-biological outcomes (ie, perceived health).

Blood samples were received from 1410 of the 2604 participants (54%). The respondents who elected to give blood samples constituted the sample for the biological outcomes in the current study. Demographic and health comparisons of those who gave blood samples and those who did not revealed that, in the group that gave blood, there was a slightly higher percentage of women than men (55.7% versus 52.0%, $p = 0.06$) and a higher percentage of whites (57.9%) than Mexican– Americans (46.0%) or blacks (53.6%) ($p<0.001$). In addition, people who participated by giving a blood sample were older (51.9 years versus 45.7 years, $p<0.001$) and had more chronic health conditions (2.7 versus 1.9, $p<0.001$). Finally, although there were no differences in educational levels, those who elected to give blood were more likely to reside in a lower income bracket (59.3% versus 51.3%, $p<0.001$).

Measures

Physiological markers

Inflammatory markers and viral reactivation measures reflect physiological measures of stress that the body experiences.[19–21] We assessed four markers of inflammation and three markers of viral reactivation. Logged IL-1, IL-6, CRP and TNF-receptor 1 were used individually to represent inflammatory stress markers. Commercially prepared substrate slides and control sera (Microgen Laboratories, La Marque, TX, USA; Bion Enterprises, Park Ridge, IL, USA) were used for determining immunoglobulin G (IgG) antibody titres to

Epstein–Barr virus-viral capsid antigen (EBV-VCA), -early antigen (EBV-EA) and herpes simplex virus-1 (HSV-1). Plasma was tested in the following dilutions for EBV-EA: 1:10, 1:40, 1:160 and 1:640. The EBV-VCA and HSV-1 test used 1:10, 1:40, 1:160, 1:640, 1:2560 and 1:10 240. To assess "reactivation", we established cut-offs for each of the antibody titres. EBV-VCA and HSV-1 were defined as titres ≥1280, whereas for EBV-EA, it was ≥80. Finally, we created a dichotomous variable that aggregates the viral markers and reflects being positive or reactivated on one or more of HSV-1, EBV-EA and EBV-VCA.

Perceived stress and health

The Perceived Stress Scale is a 10-item global measure of perceived stress where higher scores indicate greater perceived stress.[22] Perceived health is assessed through the physical (PCS) and mental (MCS) components of the Medical Outcomes Study (MOS) 36-Item Short-Form Health Survey (SF-36). The SF-36 assesses functioning in eight domains, and the scores are transformed to a 1–100 scale, where the higher scores reflect better health. In addition, a measure of depressive symptoms was addressed with the revised version of the Center for Epidemiologic Studies Depression scale (CESD-R),[2324] in which higher scores reflect greater depressive symptomatology.

Exposure variables

There are two exposure variables of interest in the current research. The first is how far the respondents live from the nearest point on the fence line surrounding the petrochemical plant cluster. The distance measure was calculated using geographical information system software and an algorithm that determined the shortest distance from the participant's home address and the boundary of the petrochemical complex (assessed in kilometres). The second is a measure of concern about the petrochemical plant risks. Project staff created the Concern about Petrochemical Health Risk Scale, the score in which is hereafter referred to as petrochemical concern, to measure individual concern about the nearby petrochemical plants' potential to harm personal or family health. The scale was translated into Spanish and back-translated to ensure fidelity to the English instrument. The final four-item scale included concern about the health risk from pollution (air, soil and water), accidents (explosions, toxic spills), stored waste and the health risk in general from nearby oil and chemical industries. The five-point response scale provides a total scale score ranging from 5 to 20 with higher petrochemical concern scores indicating a greater concern. Analysis of the scale's properties showed good reliability ($\alpha = 0.96$), and that reliability was consistent for Hispanics, non-Hispanic blacks and non-Hispanic whites.[25]

Other covariates

Consistent with research by Crimmins and colleagues on biological risk profiles, we account for sociodemographic and health behaviour variables in the multivariate models.[19] Thus, nativity, age, education, income, race/ethnicity, health insurance, lack of exercise and smoking status are included as covariates in the models. Income was split into three categories: less than $25 000, $25 000–50 000 and more than $50 000. Education and age were coded as continuous variables. Current health insurance was coded as yes/no; lack of exercise was measured as no vigorous or moderate activity in the last week and, finally, current smoking compares respondents who are former and current smokers with those who have never smoked.

Analysis Plan

In order to examine the association of proximity to the plants as well as concern about petrochemical health risk with stress and health, a combination of ordinary least squares (OLS) and logistic regression models was evaluated. All stress biomarkers, with the

exception of EBV-EA, were transformed logarithmically because of skewed distributions. OLS models were used to estimate the associations of both types of exposure with inflammatory and viral reactivation markers. OLS models were employed for the perceived stress and health outcomes. To determine not only the level of viral markers, but also severity, logistic regression models estimated the associations between exposure variables and being positive for one or more of EBV-VCA, HSV-1 and/or EBV-EA. In each model, associations of both types of exposure with outcome variables were estimated while adjusting for the covariates. This yielded a total of 12 models. Models were assessed for multicollinearity through examining the variance inflation factor, and no multicollinearity was found. All analyses were conducted using SAS 9.1.3 and STATA 9.2.

Results

Fig. 1 shows the focus area of the research. Texas City is home to a major petrochemical complex of four chemical plants and three oil refineries, as well as a major port. The British Petroleum refinery is one of the largest in the United States. Note that the entire southern boundary of the study area abuts the petrochemical complex.

Tables 1A and B show the descriptive statistics for the Texas City Stress and Health Study sample. Table 1A indicates that 52% of the sample self-identified as Mexican–American, with a mean age of 49 years, and about 59% of the sample is female. Almost 70% of the sample has a mean income below $50 000. Focusing on factors related to health behaviours, only 60.1% of the sample has health insurance, and 27.5% of the sample reported no moderate or vigorous activity in the last week. The average body mass index (BMI) in the Texas City sample is slightly over 30. Table 1B shows the descriptive statistics on selected physiological markers from the study.

Table 2 shows the multiple regression models estimating the association of (1) distance of residence to the nearest point along the petrochemical plants' fence line, in kilometres, and (2) petrochemical concern scores, with markers for inflammation and viral reactivation, as well as perceived stress and perceived health, after adjusting for covariates. Table 2 indicates that residential distance from the plants is inversely associated with logged IL-6. Residents who live further away from the plant have decreased values of IL-6. In addition, increased distance from the plants is associated with a lower likelihood of testing positive on one or more markers for HSV-1, EBV-VCA and EBV-EA. Each kilometre further from the fence line is associated with a 21% decreased odds of having viral reactivation on one or more of HSV-1, EBV-VCA and EBV-EA. Although the models accounting for confounders are depicted in table 2, we also investigated age- and gender-adjusted models before including socioeconomic status, ethnicity and health behaviours. Essentially, the relationships remain unchanged, with two exceptions. First, the relationship between IL-6 and distance is somewhat attenuated (about 30%) by the inclusion of income and BMI. Second, the relationship between HSV-1 and distance is significant in the age- and gender-adjusted models ($p<0.05$), but is completely attenuated by the inclusion of BMI and income. Residential distance from the plants is not significantly associated with perceived stress or health, with one exception. Contrary to expectations, living further away from the fence line of the petrochemical activity is associated with lower perceived physical health.

Petrochemical concern, on the other hand, is not significantly associated with stress biomarkers, with one exception, but is associated with self-reported health measures. Although greater petrochemical concern is associated with a slightly smaller risk of having one or more positive results for reactivated viruses, higher petrochemical concern is associated with more depressive symptoms and poorer perceived mental and physical health.

Additional analyses

To assess whether there is a possible "threshold" effect of how far respondents live from the plants and levels of inflammatory cytokines and viral markers, we used linear and quadratic polynomial contrasts to assess the properties of the relationship between IL-6 and distance and between percentage positive on one or more of the viral markers and found evidence of nonlinear relationships. To investigate further, we explored mean values of IL-6 and percentage positive on one or more viral markers by kilometre increments using analysis of variance. Figs 2 and 3 show the relevant findings. Fig. 2 indicates that, for IL-6, the primary significant differences are between residents within 1 km of the petrochemical complex fence line and residents 3 km and more from the fence line, with respondents furthest away having the lowest levels of IL-6 ($p<0.01$). In addition, fig. 3 shows that, for percentage of respondents who tested positive on one or more viral markers, the primary significant difference is between respondents who live the furthest away from the plant line and everyone else ($p<0.05$). These findings suggest preliminary evidence of a threshold effect with those living the closest having highest levels and those living the furthest away having the lowest levels of IL-6 and viral reactivation markers.

Discussion

Our primary purpose in this research was to address the relationship between objective and subjective exposure to an environmental hazard and the objective and subjective expressions of stress and perceived health in a sample of adults living near petrochemical activity. We hypothesised that both objective and subjective measures of exposure to the environmental hazard would be associated with increased perceived stress and biological stress and with poorer perceived health. This general hypothesis was partially supported in that objective exposure, measured here as residential distance from the petrochemical plants' fence line, was associated with one objective marker for physiological stress (IL-6) and with testing positive for one or more of the viral reactivation measures. Furthermore, in additional analyses, there is evidence that living further away from the plant fence line is associated with lower physiological stress markers (HSV-1 and viral reactivation).

Focusing on subjective exposure (concern about petrochemical health risk), our hypothesis was partially supported in that increased concern was associated with poorer perceived physical health and more depressive symptoms. However, neither objective nor subjective exposure measures were associated with perceived stress. We argued that one way in which environmental hazards could affect health is indirectly through perception of risk, chronic stress and the sequelae of that stress, expressed in poorer health outcomes. The findings from this study are consistent with this line of reasoning, although we did not expect the stronger alignment of subjective exposure with subjective outcomes and objective exposure with objective outcomes.

The relationship in our data between the risk perception and perceived health is consistent with previous research suggesting that petrochemical production sites are associated with increased stress.[1213] Moreover, the finding that residential distance from the plants is associated with lower levels of IL-6 and viral markers is similar to a study that found higher levels of reactivated viruses in populations living near the damaged Three Mile Island nuclear reactor.[11] However, although consistent with the two aforementioned studies, a more recent study on industrial facilities and depressive symptoms and powerlessness suggested that objective measures, such as number of industrial facilities and average pounds of waste, were associated with subjective measures of health, such as depressive symptoms.[17]

The fact that our objective exposure variable, distance, was not associated with subjective stress, self-reported health and depressive symptoms as in the study by Downey and Van Willigen could be explained by different objective measures from the two studies.[17] As a measure of exposure, the number of pollution-emitting facilities in an area is not the same as residential distance from a concentrated industrial zone. On the other hand, objective exposure in the form of distance, and the noise and smells of the facilities that vary with it, might be subjectively downgraded by those living closer because of habituation, even as the body responds accordingly in the form of some increased stress biomarkers. The finding of non-association between petrochemical concern and markers of a biological stress response was also unexpected. One hypothesis about this particular finding is that concern about health risk is a relatively lower intensity form of chronic stress that may shape perceptions of stress and health but is physiologically subclinical. In addition, defining objective exposure as distance from the petrochemical plant fence line is a somewhat crude measure of objective exposure. We did not have other ways of assessing objective exposure, which is a limitation of the paper. The original intention of the study was not to address objective exposure, but rather ethnic differences in subjective feelings of risk and risk perception and the potential connection to stress and health. Thus, we do not have information on "true" personal exposure, such as personal monitors would provide.

Other findings that were unexpected include the association of the petrochemical concern with decreased likelihood of being positive on one or more of the viral markers and the finding that living closer to the fence line is associated with better perceived physical health. One explanation is that increased concern about living near petrochemical activity could be associated with increased concern about health in general, potentially resulting in better health behaviours that might lead to the decreased likelihood of viral reactivation. In terms of living closer to the plants being associated with better perceived physical health, it is possible that a positive health selection effect may be part of the explanation. Additional analyses (not shown) indicated that respondents living closest to the plant fence line (<1 km) are significantly younger, have fewer chronic conditions and include a higher percentage of foreign-born Mexican–Americans than respondents who live further away. Previous literature has indicated that foreign-born Mexican– Americans tend to have a healthier profile than their US-born counterparts.[2627] These may also be the respondents who tend to be more mobile. Thus, it may simply be that those respondents who perceive their health as better are the ones living closest to the plants.

We also explored the possibility that working in the plants or having a household member who worked in the plants may have influenced the relationship between petrochemical concern and outcome measures. We included this variable in the models, and it did not affect any of the substantive relationships discussed in table 2 (results not shown). Interestingly, the only thing that working in the plants was associated with after accounting for covariates was a slight increase in depressive symptoms ($p<0.05$).

The current research extends the work of others by examining the relationships of objective and subjective exposures and objective and subjective outcomes in the context of an ongoing environmental health hazard. Although findings from these analyses provide valuable information, there are several limitations that should be noted. First, as mentioned earlier, we have a limited measure of objective exposure. It is possible that other measures would be more strongly associated with inflammatory cytokines and viral markers. Second, the group that elected to give blood represented 54% of the total sample and was composed of slightly higher percentages of women, whites, older adults and adults who had more chronic conditions. How this affects relationships in the study is unknown. Having older adults and less healthy adults overrepresented in the blood sample data may lead to overestimations of relationships between exposure and inflammatory cytokines and viral markers.

In conclusion, the results from this analysis suggest that subjective exposure in the form of concern about petrochemical health risk is more strongly associated with negative subjective measures of well-being than objective exposure in the form of residential distance from the environmental hazard. Previous research suggests that living near petrochemical activity is hazardous to health, but few studies have investigated the question by assessing together the objective and subjective dimensions of exposure and their relationships with perceived stress, biological stress and self-reported health. Moreover, by controlling for important confounding variables such as ethnicity, education and health behaviours, the results are more compelling evidence that an environmental hazard of this type is associated with health both through the subjective experience of its potential harm and through proximal exposure.

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What is already known on this subject

- Environmental health hazards, such as polluting industrial activity, may have a number of negative effects on psychological and physiological well-being. They may damage health directly, or operate indirectly through perception of risk, chronic stress and the sequelae of that stress in poorer health outcomes.
- The literature has not yet provided a comprehensive comparison of the association of objective (eg, proximity to hazards) and subjective risk (eg, concern about a hazard's risk to health) with perceived stress, biological stress responses and health outcome measures.

What this study adds

- We found that objective exposure was associated primarily with markers of physiological stress (IL-6 and viral reactivation) and that subjective exposure (concern about petrochemical health risk) was associated with variables assessing perceived health.
- From the analysis, we infer that, in the context of an environmental hazard, subjective exposure (concern) may be at least as important a predictor of poor health outcomes as objective exposure (distance from petrochemical plants).

Figure 1.
Texas City study area and Texas City Industrial Complex (TCIC).

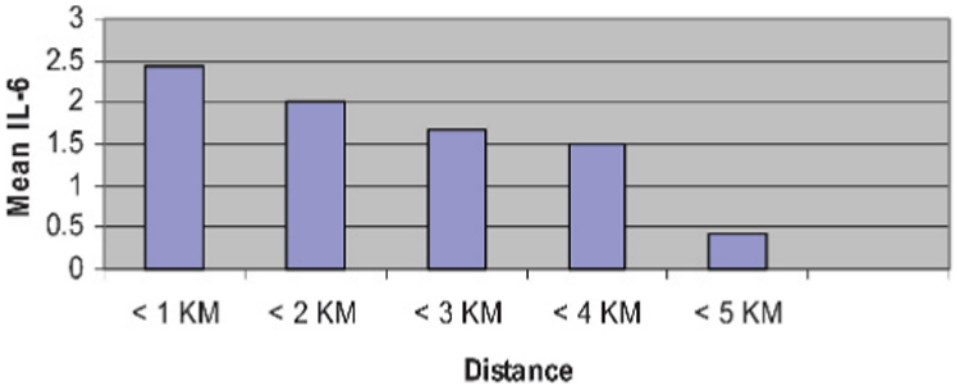

Figure 2.
Mean IL-6 by kilometres from the fence line of the petrochemical complex.

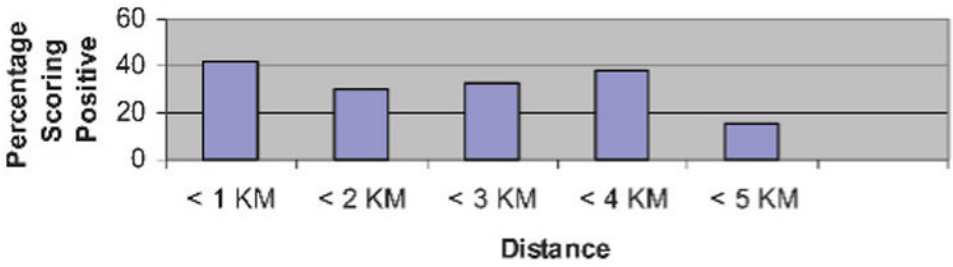

Figure 3.
Percentage of respondents scoring positive on one or more of HSV-1, EBV-EA or EBV-VCA by distance from the fence line of the petrochemical companies.

Table 1

Selected demographic, physiological and health variables from the Texas City Stress and Health Study

A. Sociodemographics, health behaviours and perceived stress and health measures from the Texas City Stress and Health Study (n = 2604)

	Mean (SD) or %
Demographics:	
Age (years)	49.0 (16.1)
% Female	58.6
Education	11.5 (3.2)
Ethnicity	
% Non-Hispanic white	35.5
% Non-Hispanic black	12.5
% Mexican–American	52.0
% Income <25 K	35.6
% Income ≥25 K <50 K	32.4
% Income ≥50 K	21.8
% Missing on income	11.0
Health behaviours:	
% Has insurance	60.1
% Sedentary	27.5
% Former smoker	20.7
% Current smoker	29.7
% Never smoked	49.4
BMI	30.4 (7.1)
Environmental stressors:	
Distance from plant line in km	1.8 (1.0), range 0.02–4.7
Petrochemical concern	10.1 (5.4), range 0–16
Perceived stress:	
Perceived Stress Scale	13.2 (7.2), range 0–39
Perceived health:	
SF-36: Physical	48.8 (10.7), range 7.3–70.9
SF-36: Mental	50.5 (11.4), range 5.0–76.4
Depressive symptoms	9.5 (12.7), range 0–77

B. Selected physiological markers from the Texas City Stress and Health Study (n = 1410)

	Mean (SD) or %	% Positive
Inflammatory markers:		
IL-1	166.5 (386.7), range 0.01–2500	
IL-6	1.9 (4.8), range 0.01–84.1	
CRP	13.6 (16.5), range 0.02–187.9	
TNF-receptor 1	1829.2 (1479.8), range 89.7–31865	

B. Selected physiological markers from the Texas City Stress and Health Study (n = 1410)

	Mean (SD) or %	% Positive
Viral reactivation markers:		
EBV-EA	23.0 (24.8), range 5–160	2.3
EBV-VCA	809.9 (932.9), range 5–5120	15.7
HSV-1	909.8 (815.0), range 10–5120	24.2
% with at least one positive on EBV-EA, EBV-VCA and HSV-1		34.1

IL-1, interleukin-1; IL-6, interleukin-6; CRP, C-reactive protein; EBV-EA, Epstein–Barr virus-early antigen; EBV-VCA, Epstein–Barr virus-viral capsid antigen; HSV-1, herpes simplex virus-1.

Table 2

Results from regression analyses of physiological and psychological markers and outcomes of stress on distance from petrochemical activity and concern about petrochemical health risk from the Texas City Stress and Health Study (n = 1410 for biological markers; n = 2604 for perceived stress and health)

	Logged inflammatory markers†				Logged viral reactivation markers†			Positive on at least one of EA,VCA or HSV§	Perceived stress†	Perceived health/depressive symptoms†		
Environmental variables	**IL-1**	**IL-6**	**CRP**	**TNF-Ri**	**EA‡**	**VCA**	**HSV**		**PSS**	**PCS**	**MCS**	**CESD-R**
Residential distance from plants' fence line in km	0.02	−0.09**	0.00	0.01	−0.04	−0.01	−0.04	0.79 (0.65 to 0.96)	−0.03	−0.08*	−0.03	0.03
Petrochemical concern	−0.02	−0.01	−0.02	−0.01	0.01	−0.00	−0.04	0.96 (0.94 to 0.98)	0.06	−0.11*	−0.06	0.13**
N	1410								2604			

Note: Models adjusted for age, gender, race/ethnicity, education, income, insurance, smoking, physical activity and BMI. Each outcome (column) represents one model (total = 12 models).

*p<0.05

**p<0.01

†Ordinary least squares regression, standardised coefficients presented.

‡EA is not logged.

§Logistic regression, odds ratios presented, 95% CI.

IL-1, interleukin-1; IL-6, interleukin-6; CESD-R, Center for Epidemiologic Studies Depression scale; CRP, C-reactive protein; EA, Epstein–Barr virus-early antigen; VCA, Epstein–Barr virus-viral capsid antigen; HSV-1, herpes simplex virus-1; MCS, mental component of the Medical Outcomes Study; PCS, physical component of the Medical Outcomes Study; PSS, Perceived Stress Scale; TNF-Ri, tumour necrosis factor receptor 1.