Published in final edited form as:
Popul Environ. 2008 ; 30(1-2): 3–25. doi:10.1007/s11111-008-0075-8.

Proximate industrial activity and psychological distress

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Abstract

This paper examines the role that gender, occupational status, and family status play in moderating the effect of industrial activity on the psychological well-being of nearby residents. Using a unique spatial assessment of industrial activity and an environmental risk/social stressor framework in conjunction with individual-level data from the Detroit Area Study (DAS) and demographic data from the U.S. census, we find that residents of neighborhoods in close proximity to industrial activity report elevated levels of psychological distress compared to residents of neighborhoods removed from this type of activity. These influences are more pronounced among women but gender differences are also contingent upon occupational and family statuses. We show that specific combinations of work and family statuses make persons particularly vulnerable to the influence of this environmental stressor and women are two and a half times more likely than men to have these vulnerable statuses. This study makes an important contribution to the environmental health literature because it reminds researchers of the fundamental influence of social roles when examining the link between environmental risks and mental health.

Keywords

Neighborhood; Psychological distress; Stress; Pollution

Introduction

Sociologists have long understood neighborhood characteristics to be important determinants of well-being (Wilson 1987; Park et al. 1925) and work on “neighborhood effects” has grown considerably in the past 10 years (Clampet-Lundquist and Massey 2008; Kawachi and Berkman 2003; Sampson et al. 2002; Robert 1999). Most of this work has focused on the social and economic aspects of neighborhoods (Kawachi and Berkman 2003) and only a limited body of

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A previous version of this article was presented at the 2005 meetings of the American Sociological Association in Philadelphia, PA.

This article presents the perspectives of the authors and does not necessarily reflect the views of any organization.

work has examined environmental risk factors due to manufacturing activity (Downey and Van Willigen 2005; Marshall 2004; Evans and Kantrowitz 2002). In fact, in a recent review of the demographic literature on contextual and neighborhood effects, Entwisle (2007) shows that less than 5% of the 503 articles she identified deal with environmental hazards. She states (Entwisle 2007, pp. 692–693):

> For instance, exposure to hazardous waste; environmental toxins related to manufacturing, mining, or agricultural activities; air pollution; water pollution; and ambient noise … is the least examined neighborhood attribute. Given that toxins and hazards tend to be concentrated in poorer neighborhoods … they may be quite important to consider in a study of poverty and health outcomes. What appear to be the consequences of poverty may in reality be the consequences of air pollution or some other hazard.

As such, exploration of the health implications of both poverty and pollution can shed additional light on the mechanisms leading to negative health outcomes. Moreover, among the limited research examining health impacts of environmental stressors such as air and noise pollution, most of the work has focused on main effects despite strong theoretical reasons to expect members of different social groups to interpret or respond to the same environmental stressor very differently—to vary in their subjective interpretations of environmental stressors. To date, however, very little work has examined the ways in which stressful environmental factors differentially influence mental health across social groups.

The distinction between objective and subjective measures of environmental risk is important because they may diverge and therefore differ in their impacts. Exploration of this possible divergence can thus inform theoretical development in this area. This possible divergence by social position is also important because it suggests that relationships between physical environments and well-being cannot be explained solely in terms of objective characteristics —the influence of subjective perceptions of these characteristics must also be considered.

In this paper, we aim to determine the relationship between proximate environmental risk, social stressors, and psychological well-being by testing whether gender, occupational status, and family status moderate the association between neighborhood industrial activity and psychological distress. In doing this, we expand upon a recent study by Sampson and Raudenbush (2004) who show that perceptions of disorder are partly the result of individual interpretations which are, in turn, shaped by the social statuses of neighborhood residents such as gender and occupational status. They conclude that “social structure proved a more powerful predictor of perceived disorder” than did physical cues of disorder (2004, p. 336). As Entwisle (2007) highlights, most of the literature on neighborhood effects emphasizes things that happen *to* people (Glass and McAtee 2006) rather than the ways in which individuals interpret and interact with their physical environments. Our work contributes to these understudied topics by elaborating on the ways in which social position shapes psychological responses to neighborhood conditions—thereby considering interpretation and interaction as related to social statuses.

Framing environmental risk in this manner requires the integration of work from environmental sociology, social psychology, and the social stress literature. This paper helps to bridge these related fields by providing a coherent framework with which to examine these very complex processes and by providing an empirical test of the various hypotheses derived from this framework. In order to test specific hypotheses regarding these relationships, we use a multi-level model that links individual-level data from the DAS, neighborhood-level demographic data from the U.S. census, and a unique measure of proximate industrial activity.

Social location, ambient stressors, distressful interpretations

Ambient stressors are "chronic, global conditions of the environment—pollution, noise, residential crowding, traffic congestion—which, in a general sense, represent noxious stimulation, and which, as stressors, place demands upon us to adapt or cope" (Campbell 1983, p. 360). Borrowing from both the environmental risk and stress literature, we characterize industrial activity as a hazardous condition and ambient stressor (Vandermoere 2008; Edelstein 2004; Matthies et al. 2000; Elliott et al. 1997; Baum et al. 1992; Pearlin et al. 1981). Further, we argue that the psychological distress associated with living near industrial activity is socially patterned because social roles will influence the exposure to this stressor (Downey 2003) and access to stress-coping resources (Thoits 1995; Lin and Ensel 1989; Pearlin et al. 1981). We also argue that different social roles will influence how this potential stressor is interpreted. That is, the presence of industrial activity may evoke very different responses for people in different social locations because of the different meaning(s) that people attach to this activity (Kroll-Smith et al. 2000; Kroll-Smith and Couch 1991). As such, industrial activity may be an ambient stressor for some, may not evoke any distressful response for others, and for some it may actually improve psychological well-being. We focus on three interrelated social characteristics that we hypothesize moderate the association between proximate industrial activity and adult mental health: gender, occupational experience, and family status.

First, we anticipate that industrial activity will more strongly affect the mental health of women because of gender differences in the way in which health risks are perceived. Researchers have shown that although men and women express similar levels of concern about broad environmental issues, women are more likely than men to express concern about *local* environmental issues, especially those that involve potential health and safety risks (Blocker and Eckberg 1997; Bord and O'Connor 1997; Mohai 1997; Davidson and Freudenburg 1996). For example, Marshall (2004) examines the risk perceptions of adults living in communities with and without nearly industrial plants and finds that 29% of women and 25% of men who lived in communities without plants reported illness from industry to be a serious risk (RR = 1.13, n.s.). However, among those living in communities with plants, 49% of women but only 35% of men (RR = 1.4, $P < .01$) reported illness from industry to be a serious concern. This finding is important because perceptions of health status—in particular perceptions of ill-health—have long been understood to be an important source of stress for adults (Lin and Ensel 1989). Therefore, proximate industrial activity may be more stressful for women than for men simply because women are more likely than men to perceive industrial activity to be detrimental to their physical health or the health of their families.

Men and women may also be differentially affected by industrial activity surrounding their neighborhoods because of gender differences in interpretation of residential environments. For example, research has shown that while men tend to describe their neighborhoods using physical criteria—e.g., the layout of the area or the availability of services—women tend to describe their neighborhoods in social terms and to stress the importance of interactions with others (Davidson and Freudenburg 1996). Compared to men, women also tend to have a larger share of their social resources invested in their neighborhoods, resulting in high rates of informal interactions with neighbors, increased levels of trust, and a reliance on neighborhood social ties as a source of social capital and good health (Schulz and Lempert 2004; Ross and Jang 2000; Campbell and Lee 1992; Campbell and Lee 1990). Therefore, neighborhood influences, in general, should be more pronounced among women.

Second, occupation denotes another important social mechanism that shapes interpretations of the environment (Sampson et al. 2002). Researchers have shown that among residents of communities near airports, the distressing and annoying effects of commercial airplane activity are less pronounced for individuals who work in airline industries than for other individuals

(Cohen and Spacapan 1984, Cohen and Weinstein 1981). This suggests that individuals engaged in industrial occupations may perceive proximate industrial activity differently than do individuals engaged in other occupations. That is, individuals engaged in industrial occupations may perceive proximate industrial activity positively in that it represents a source of potential income and, therefore, a benefit rather than an environmental risk factor (Kazis and Grossman 1982). Alternatively, rather than promoting psychological well-being, industrial employment may simply mute the negative effects of residential proximity to industrial activity. Industrial activity might have this moderating effect for those employed in manufacturing because regular activity in and around industrial facilities may increase the predictability of this particular stressor. In other words, the routine activity of working in or near industrial facilities might make this type of stressor less problematic or non-problematic —even if not psychologically beneficial (Lazarus 1966).

Finally, family and parental statuses are also likely to shape interpretations of industrial activity (Mohai 1997), and may interact with the gender and occupational status differences hypothesized above. Davidson and Freudenburg (1996) note, for example, that due to gender socialization, men in families may be more likely than women in families to be concerned about economic issues such as municipal tax revenues and providing an income, while women may be more likely than men to be concerned about the safety and well-being of their families. Therefore, among those with families, men may view industrial activity positively as a potential source of revenue while women may view industrial activity negatively as a threat to their families. In addition, having had children may increase the salience of traditional gender roles, resulting in a decline in men's concerns about industrial environmental risks *and* an increase in women's concerns about industrial environmental risks (Bevc et al. 2007; Blocker and Eckberg 1989; George and Southwell 1986). However, it is also possible that the presence of children in the home may increase both mothers' *and* fathers' concerns about industrial environmental risks (Davidson and Freudenburg 1996; Hamilton 1985).

Summary of literature

In sum, we anticipate that adults who reside within close proximity to large-scale industrial activity will interpret this activity as an ambient stressor and display elevated levels of psychological distress compared to adults whose homes are more distant from such activity. We also expect that interpretations of industrial activity will vary by social position and that the deleterious effect of residential proximity to industrial activity will be more pronounced among women than men. We further expect that residential proximity to industrial activity will be psychologically advantageous to men and women who are employed in manufacturing jobs, but that this relationship will be moderated by family status. Specifically, we believe that proximate industrial activity will be the most psychologically damaging to women in non-manufacturing jobs who have mothered children in their lifetime and the least psychologically damaging to men in manufacturing-oriented work positions who have not had children in their lives. Moreover, men in manufacturing-oriented work positions who have not had children in their lives may actually derive psychological benefits from living near industrial activity.

Data and methods

Industrial activity data

Industrial activity data are obtained from the Environmental Protection Agency's (EPA) 1995 Toxic Release Inventory (TRI). The TRI records the number of pounds of specified chemicals[1] that are released into the environment each year by manufacturing facilities that

[1]Currently there are 581 chemicals in 30 different categories.

employ 10 or more full-time workers and manufacture, process, or otherwise use these chemicals in specified quantities.[2] We use the TRI data to create our indicator of industrial activity for several reasons. First, the TRI is the most comprehensive, address-specific record of U.S. industrial activity currently publicly available. Second, we can use emissions data for each facility as a proxy for facility size and visibility. This is important because (a) our conceptualization of industrial activity as an ambient stressor suggests that industrial facilities are not likely to impact residents' mental health if residents are unaware of them (Slovic et al. 1994), (b) residential proximity to large industrial facilities is more likely than residential proximity to small industrial facilities to produce psychological distress (Downey and Van Willigen 2005), and (c) other measures of facility size and visibility—such as the number of employees, square footage, or economic output of the facilities in the database—are unavailable, either in the TRI or in any other publicly available database. Third, the TRI only includes manufacturing facilities that have the equivalent of 10 or more employees. Thus, the TRI does not include the nation's smallest facilities (assuming that fewer employees mean a smaller facility). Therefore, by removing the smallest and least visible manufacturing facilities from the database, the TRI allows us to create more valid indicators of 'visible industrial activity' than we could create if we included all the manufacturing facilities existing in the study area.

Industrial activity indicators

Using methods similar to previous work (Downey 2003), we use a sequential four step process to calculate each census block's residents' potential visual exposure to industrial activity. We first locate the TRI facilities on a census block map and then calculate, for each facility, three rectangular grids composed of 105.6-foot resolution square cells (105.6 feet is 1/50th of a mile).

The first grid is the distance from the center of each cell in the metropolitan area to the center of the cell containing that grid's TRI facility. Second, a *weighting grid* provides a weight (w, where $0 \leq w \leq 1$) that allows the impact of each facility to decline as distance increases for each metropolitan area grid cell. The weight is calculated by inserting the distance values, d, from the first grid into the following distance decay function:

$$F(w)=1-(2.0*10^{-5})(d)-(1.34*10^{-8})(d^2), \quad (1a)$$

where $0 \leq d \leq 7920$, and

$$F(w)=0, \quad (1b)$$

where $d > 7920$.

In these equations, d equals distance in feet from each TRI facility and each facility's impact is assumed to decline relatively slow at first and more quickly as distance increases. The function takes on a value of zero at distances greater than 1.5 miles (i.e., 7,920 feet).

The third grid, the *relative effects grid*, is calculated by multiplying each cell in the weighting grid by the total pounds of TRI air pollutants emitted by that grid's TRI facility. The *relative effects grids* for all the facilities in the database are then summed together to create a new grid

[2]In 1995, the specified quantities were 25,000 pounds for facilities that manufacture or process TRI chemicals and 10,000 pounds for facilities that otherwise use TRI chemicals.

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in which each cell value represented the *summed relative effect* of all Detroit metropolitan area TRI facilities on that cell. For example, if there had been five facilities in the study area, and the *relative effect* of these facilities on grid cell A had been 0, 300, 10, 500, and 0 respectively, then their *summed relative effect* on grid cell A would have equaled 0 + 300 + 10 + 500 + 0, or 810.

The cell values in the *summed relative effects grid* are then aggregated to the census block level by placing an electronic census block map over the *summed relative effects grid* and calculating the average cell value in each census block. This provides the *mean relative effect* of all study area facilities on each study area census block. Finally, because we are concerned with the psychological consequences of living near *heavy* industrial activity, we use a dichotomous variable that differentiates between census blocks found in the highest quartile of the *mean relative effect* distribution (above the 75th percentile) and census blocks found in the other three quartiles of the *mean relative effect* distribution. Thus, our *industrial activity* variable allows differentiation between respondents who live in close proximity to heavy industrial activity and those who do not (for more detail, see Appendix A). We also experimented with different thresholds (between 60 and 80 percentiles) and these changes did not change our empirical results or substantive conclusions.

Neighborhood poverty

We control for the poverty status of each respondent's neighborhood due to the strong relationship between neighborhood disadvantage, industrial activity, and increased levels of psychological distress (Ross 2000). The neighborhood poverty measure uses block group data drawn from the 1990 U.S. census and, following previous work on neighborhood effects (Kasarda 1993), we create a dummy variable (coded 1) if block group poverty levels exceed 20% and 0 if otherwise. As with our industrial activity measure, neighborhoods in which at least one-fifth of the neighbors are poor tend to be visibly distinct from neighborhoods with lower rates of poverty (Anderson 1990). We use block group data rather than block-level data because 1990 poverty rate data are unavailable at the block level, however it is very common for researchers to use block-group data when examining more proximate neighborhood activity (Sampson and Raudenbush 2004).

Individual-level data

Individual-level data come from the 1995 DAS. One of a series of yearly studies conducted by the Survey Research Center and the Department of Sociology at the University of Michigan, the 1995 DAS is unique in its ability to explicitly identify detailed social influences on physical and mental health of adults. These data come from a multistage area probability sample of 1,139 adult respondents, 18 years of age and older, residing in Wayne, Oakland, and Macomb counties in Michigan, which include the city of Detroit. Face-to-face interviews were completed between April and October 1995 by University of Michigan graduate students in a survey research training practicum as well as professional interviewers from the Survey Research Center. The overall response rate was 70% which is comparable to other studies in the survey series (Clemens et al. 2002). Hispanic ($n = 11$), Asian American ($n = 15$), and Native American ($n = 4$) respondents, and respondents who reported another race/ethnicity ($n = 3$), were dropped from the study because of small sample sizes. These deletions result in a final sample size of 1,106. Although relatively small, the DAS has been used extensively by sociologists because of the multilevel study design and the rich information on acute and chronic stressors (Boardman et al. 2001; Schulz et al. 2000). All multivariate analyses use weighted data that adjusts for the sampling design and non-response as a function of the primary sampling unit (census tracts).

Individual-level measures

Dependent variable—The dependent variable, *psychological distress*, is measured via an unweighted six-item index, commonly referred to as the K-6. The K-6 scale was originally developed for use in the National Health Interview Survey to assess nonspecific distress[3] and to discriminate between cases and non-cases of serious mental illness (Kessler et al. 2003). DAS respondents were asked to indicate how often, in the past 30 days, they felt: (a) “so sad that nothing could cheer you up”; (b) “nervous”; (c) “restless or fidgety”; (d) “hopeless”; (e) “that everything was an effort”; and (f) “worthless.” Responses for each item range from (1) “never” to (5) “very often.” Items were coded to ensure that higher scores reflect greater levels of distress ($\alpha = .85$). The DAS measure of psychological distress has been identified as a valid measure of mental health in several studies (Furukawa et al. 2003) and the 6 item scale (used here) has been validated in a multi-stage study in which telephone screening interviews (n = 1000) were followed up with face-to-face assessments in a clinical setting (n = 153) (Kessler et al. 2002).[4] Moreover, the K-6 scale has been widely used in population health surveys, is highly related to other measures of distress, has high internal reliability, and has been demonstrated to have consistent reliability across major socio-demographic subsamples including those by gender, SES, and race/ethnicity (Cairney et al. 2007;Baillie 2005;Kessler et al. 2003;Kessler et al. 2002). As final evidence for the psychometric properties of this scale, the 6 item version of distress has been included in the U.S. National Health Interview Survey (n ~30,000) at different times—the NHIS is widely considered the standard source for population health statistics among demographers and epidemiologists.

Statistical controls—Because individuals may also be exposed to other sources of chronic and acute stress (beside the focus of our study—proximate industrial activity), we include controls for stress exposure across five important areas: crime, work, finance, family, and health. *Crime-related stress* is assessed by response to three questions. First, respondents were asked to report the frequency of “problems with muggings, burglaries, assaults, or anything else like that around here.” Those who responded “often” or “very often” were coded 1 and those who responded “not too often”, “hardly ever”, or “never” were coded 0. Respondents were also asked to report if, in the past year, they had: (a) “been the victim of a serious physical attack or assault”; (b) been “robbed” or (c) had their “home burglarized.” Affirmative responses were coded 1 and negative responses were coded 0. These four values were summed and *crime-related stress* was coded 1 for respondents with a score greater than or equal to 1 (had experienced any of these events). *Work-related stress* assesses if, in the past year, anyone in the household had been “unemployed for longer than 3 months” or had had any “hassles at work?” This variable is coded 1 for respondents who indicated “yes” to at least one question and 0 for those who responded “no” to both items. *Financial stress* is measured by responses to two items. First, respondents were asked “how difficult is it for you to meet the monthly payments on your bills?” Responses ranged from (1) “not difficult at all” to (5) “extremely difficult.” They were also asked if, in the past 12 months, they had had “serious financial problems or difficulties.” Those who responded “yes” to this question or who responded either “very difficult” or “extremely difficult” to the first question were coded 1. All other respondents were coded 0. *Family-related stress* is measured by responses to three questions about family-related stressors that occurred in the past month. Respondents were asked about “problems with aging parents”, “problems with your children”, and “trouble balancing work and family demands.” This variable is coded 1 if respondents indicated “yes” to any of these questions and 0 if they responded “no” to all three items. *Health-related stress* is measured with self-

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[3]Kessler et al. (2002, p. 961) define non-specific distress as a “heterogeneous set of cognitive, behavioral, emotional and psychophysiological symptoms that are elevated among people with a wide range of different mental disorders.”

[4]A 10 item scale (the K10) for psychological distress is also commonly used (Kessler et al. 2002) but the six item scale is more common in larger samples such as ours.

rated health. All respondents were asked to rate their health from 1 (“poor”) to 5 (“excellent”). This single item is one of the most widely used measures of overall health status because it is consistently found to be a valid measure of current health status among adults (Benyamini and Idler 1999; Idler and Benyamini 1997). Because ill-health is conceptualized as an important stressor, we reverse this item and code self-rated health such that higher levels indicate perception of worse health. This measure is particularly important because of the consistent evidence that links neighborhood-level stressors to adverse physical health outcomes (Kawachi and Berkman 2003). It is important to control for health status to properly assess the impact of industrial activity on adults’ mental health because poor physical health status is routinely considered to be among the leading chronic stressors (Ellison et al. 2001).

Finally, seven socio-demographic control variables are used in all the multivariate models: (1) *age* is a continuous variable measured in years; (2) *sex* is reflected with a binary variable, male as referent; (3) *race* is measured by respondent self-identification and is coded 1 if respondents indicated they were African-American and 0 if they indicated they were non-Hispanic and white; (4) *marital status* is measured dichotomously, coded 1 if the respondent was married at the time of the interview and 0 otherwise; (5) *yearly income* is the income the respondent’s family earned the previous year (in $1,000s); (6) *no children* is coded 1 if respondents have not had any children in their lifetime and 0 otherwise; and (7) *manufacturing* is coded 1 if a respondent’s current or most recent job is/was in a manufacturing-oriented industry. Of the 1,106 respondents in this survey, only 20 reported that they had never “held a regular job for pay”. Those that had held a regular job for pay were then asked “what kind of business or industry (is/was) that in? What (do/did) they make or do where you (work/worked)?” Responses were then coded using the 3 digit 1980 census industry code, and respondents with codes between 100 (manufacturing; nondurable goods; food and kindred products; meat products) and 392 (manufacturing; durable goods; non specified manufacturing industries) were coded as manufacturing oriented (US Bureau of the Census 1981).

Statistical analyses

In this paper, we estimate the relationship between psychological distress, proximate industrial activity, and the individual and neighborhood-level controls using a multilevel model that specifies error at the individual and neighborhood levels. We control for a full range of social stressors so that we can identify proximity to industrial activity as uniquely contributing to an individual’s stress profile. We first estimate a model with individual-level characteristics only. We then sequentially enter controls for neighborhood poverty and industrial activity. This sequence is important because it allows examination of the possibility that some of the observed association between neighborhood disadvantage and psychological distress reported earlier (Boardman 2004) may be due to proximate industrial activities. We then estimate these same models separately for men and women and extend these gender specific models to include interactions with work and family statuses (see description below). Our primary reason for using the multilevel model is to adjust the parameter estimates for the similarity of observations within neighborhoods. Because the number of observations within blocks and block groups is quite small, we adjust for census tract clustering of observations using a multilevel model with a random intercept (Raudenbush and Bryk 2002). The multilevel models are estimated using PROC MIXED in SAS 8.2 (Littell et al. 1996).

Findings

Table 1 lists the mean psychological distress levels of respondents by industrial activity proximity. When men and women are considered together, the average level of psychological distress is higher among individuals who reside near heavy industrial activity than it is among those who do not. When they are considered separately, however, the relationship between proximity and psychological distress is more pronounced among women than men. For men, the difference in psychological distress levels across residential types is only marginally significant ($P < .08$). For women, the difference is highly significant ($P < .001$) and nearly twice as large as for men (1.70 vs. .93).

Although these findings support the hypothesis that residential proximity to industrial activity is psychologically distressing and that the negative psychological effect of residential proximity is more pronounced for women than men, it is possible that residents of industrial neighborhoods differ from residents of other communities in terms of their socio-demographic characteristics and their exposure to social stressors. Likewise, industrial neighborhoods may have higher poverty rates than other neighborhoods. Accordingly, Table 2 examines the relationship between industrial activity and psychological distress using three successive multivariate models in which individual and neighborhood-level characteristics are controlled and important confounding and mediating relationships are elaborated.

Model 1 includes the individual-level controls only. With the exception of crime-related stress, all of the social stress variables are strongly and positively associated with psychological distress. Those who reported experiencing work-related stress, financial stress, familial stress, or health-related stress[5] reported elevated levels of psychological distress compared to those who did not face these stressors. In addition, women experienced higher levels of psychological distress than did men—even when controlling for these other specific stressors. Finally, the residual variance estimates suggest that roughly 8% of the variance in psychological distress is due to unmeasured characteristics of respondents' neighborhoods.

Model 2 enters a dummy variable indicating whether a respondent resides in a poor neighborhood. According to the parameter estimate for this variable, regardless of their socio-demographic characteristics or stress profiles, residents of poor neighborhoods have significantly higher levels of psychological distress than do residents of non-poor neighborhoods. In addition, roughly 11% of the unexplained level-2 variance in Model 1 is accounted for by differences in poverty rates across communities.

Model 3 enters the industrial proximity variable into the regression equation, providing us with a similar estimate to the one presented in Table 1, albeit one that is adjusted for differences across individuals and neighborhoods. These adjustments attenuate the effect of industrial activity on psychological distress by nearly one-half (from 1.31 to .73; see Table 1), but also suggest that the effect of industrial activity on adult psychological distress is independent of the individual- and neighborhood-level effects commonly found in the literature. Thus, Model 3 supports the hypothesis that residential proximity to industrial activity is psychologically distressing. In addition, the estimated effect of neighborhood poverty status is slightly reduced in this model, suggesting that one reason residents of poor communities have elevated levels of psychological distress compared to residents of non-poor communities (Schulz et al. 2000) may be that poor neighborhoods have higher levels of industrial activity than do non-poor neighborhoods (Downey 2003).

Full model estimates for men and women are presented separately in Table 3. As with the estimates in Table 1, these estimates support the hypothesis that the association between residential proximity to industrial activity and poor mental health is more pronounced for women compared to men. Indeed, once individual and neighborhood-level factors are considered, our results suggest that industrial activity is no longer significantly associated with

[5]Although these items are strongly associated with one another, the correlations are not high enough to introduce problematic multicolinearity. As evidence, a number of different studies have used these measures as independent predictors in multivariate models (see Ellison et al. 2001 for an example).

psychological distress among men (*b* = .35, n.s.) but that it continues to be positively and significantly linked to women's psychological distress (*b* = .89, $P < .05$).

In order to determine whether occupational status and parental status moderate the relationship between residential proximity and psychological distress among men and women, we estimate a model similar to the full model presented in Model 3 of Table 2 with two important changes. We combined information on respondent's gender, occupational status, and parental status to create eight categories for the three binary variables. We then estimated the full model with these categories (with female respondents who have ever had children and who were not employed in manufacturing as the reference category) and interacted the seven dummy variables with the proximity dummy variable. Standard error estimates for the linear combination of the main effect of industrial activity (*b* = 1.41, $P < .05$; results not shown) and the interaction between industrial activity and the seven categories of the three binary variables (gender, occupation, and family) were calculated using the LINCOM function in STATA 9.0. The standard errors were then used to calculate 95% confidence intervals for each group-specific slope.

Because of the large number of categories and interactions in this model we do not present the results in tabular form. Instead, we present point estimates and confidence intervals graphically in Fig. 1. The point estimates describe the estimated effect of industrial activity on psychological distress for each group. The left-hand panel in Fig. 1 presents results for women and the right-hand panel presents results for men. As before, positive values indicate that proximity to industrial activity is associated with greater psychological distress and negative values indicate that proximity to industrial activity is associated with lesser psychological distress.

The results presented in Fig. 1 are surprising in three respects. First, we did not expect women who have had children and are not employed in manufacturing (the reference group) to be the only group of female respondents to experience elevated psychological distress levels as a result of living near industrial activity. Second, we did not expect any group of men to experience elevated distress levels as high as those experienced by women in the reference category. Nevertheless, male respondents who have had children, are employed in manufacturing, and reside near heavy industrial activity experienced high levels of psychological distress, levels that are comparable to those experienced by women in the reference category. Third, we did not expect either group of men employed in manufacturing to experience elevated levels of psychological distress relative to men not employed in manufacturing as a result of living near heavy industrial activity. However, male respondents who have had children and are employed in manufacturing were the only group of men to experience elevated levels of psychological distress as a result of residing near industrial activity. Another interesting finding to emerge from these analyses is that men and women who have never been parents respond very similarly to proximate industrial activity, regardless of their occupation. Said differently, the interaction between gender and occupation only manifests among those who have been parents. This fits with our theoretical model and it, again, stresses the importance of considering various social roles when considering the mental health consequences of environmental stressors.

Discussion

Neighborhood effects research tends to overlook the role that social location plays in structuring perceptions of local environments and, therefore, the psychological responses individuals have to neighborhood conditions (Sampson and Raudenbush 2004; Blumer 1969; Mead 1934). Although much is made of the way in which individuals interpret different socio-environmental characteristics as stressful or benign, the relevance of social position in the interpretation of environmental risk is often overlooked in current studies of neighborhood effects, which tend to focus on objective as opposed to subjective neighborhood characteristics (Downey and Van Willigen 2005). Future research would benefit from the inclusion of a more ecological-symbolic approach that stresses both objective and subjective interpretations of environmental risk (Kroll-Smith et al. 2000; Kroll-Smith and Couch 1991).

Although our data do not allow us to directly examine respondents’ subjective interpretations of industrial activity, they do suggest that the relationship between neighborhood conditions and psychological well-being is moderated in complex ways by the social statuses of neighborhood residents. For instance, the data support the hypothesis that living near industrial activity is psychologically distressing and that the negative effects of residential proximity are more pronounced for women than for men. However, the fact that only one of the four groups of women and one of the four groups of men in the sample are negatively affected by residential proximity to industrial activity (Fig. 1) suggests that the psychological effect of residential proximity on men and women is strongly conditioned by occupational and parental status.

This complexity makes it difficult to make any general statements regarding the role of industrial activity as an ambient stressor or the role that gender plays in moderating the effect of proximate industrial activity on psychological distress. This, however, denotes the primary contribution of this paper. Rather than criticizing the environmental stress perspective, our findings suggest that more efforts should be made to characterize the social and demographic composition of studies and to clarify the mechanisms through which environmental stressors may influence mental health. As shown here, gender plays a vital role in structuring psychological responses to proximate industrial activity, in part, because it shapes the distribution of occupational and parental status group categories: two-thirds of all female respondents belong to the single female group that appears to be negatively affected by proximate industrial activity but only one-quarter of male respondents belong to the single male group that appears to experience the same psychological reaction. As a result, in this study, female respondents are more than two-and-a-half times as likely as male respondents to belong to a group that appears to experience elevated levels of psychological distress due to residing near heavy industrial activity.

Conclusion

As with any study, there are several important limitations that should be considered when evaluating the results presented here. First, because this is a study of a single metropolitan area, the findings may not be generalizable beyond Detroit. Therefore, similar studies of other metropolitan areas should be developed to replicate our research. Second, although most of the results were in line with the hypothesized associations, the sample sizes for several of the status groups examined in this paper were quite small and may have decreased the precision of some of our parameter estimates (as indicated by the fairly large confidence intervals). Third, the variables used to create the occupational and parental status categories do not tell us respondents’ current employment and parental status, the age of respondents’ children, or whether respondents’ children still live at home (such variables were unavailable to us). Thus, we were unable to determine whether current occupational and parental status play a more important role in moderating the effect of proximity on distress than do occupational and parental status. Also, we do not have precise measures of the social interpretive meanings of gender and gender roles beyond a simple sex dichotomy.

Fourth, our findings highlight the need for future qualitative inquiry into the process of meaning construction associated with industrial activity. Although our work suggests that individual’s social statuses are important points of departure for understanding how potentially stressful aspects of the built environment are translated into subjective “stressors”, we were unable to measure or describe the ways in which individual respondents interpreted industrial activity or the ways in which community members share collective understandings of industrial activity. This suggests the need for ground-level research on how individuals occupying particular social positions interpret characteristics of their neighborhoods and how neighborhood social structures potentially facilitate or dissuade similar assessments among neighbors.

Despite these limitations, this study makes several important contributions to sociological studies of neighborhood effects, particularly to studies that examine the relationship between neighborhood context and mental health. First, this study confirms previous findings that proximate industrial activity is negatively associated with mental health (Downey and Van Willigen 2005). Second, it extends this work by considering the role that social statuses play in shaping psychological responses to neighborhood conditions. In doing this, this study contributes to the broader neighborhood effects literature which (a) rarely asks whether factors other than race and socioeconomic status moderate the impact of neighborhood context on individual well-being and (b) rarely considers the ways in which perceptions of and reactions to 'objective' stressors may be socially structured. The interactive perspective in this paper is important because it stresses the "fundamental causes" (Link and Phelan 1995) explanation for health disparities from a relatively new perspective. According to this argument, new health risks emerge over time (e.g., evidence regarding the effects of smoking) and those in relatively advantageous social positions are the first to make changes in their behaviors to adjust to this information. Over time there are changes in the modifiable health risks (e.g., obesity) but more affluent persons are always the first to make health promotive changes. Therefore, while the proximate determinants of health may change, social status remains a fundamental cause of health because it consistently shapes exposure to each successive risk factor. Borrowing from this perspective, the same can be said for contextual studies focusing on ambient environmental stressors. Social roles have consistently been linked to environmental exposures (Robert 1999) which follows the fundamental cause perspective but these social roles may also moderate the associations in predictable ways. That is, if the psychological consequences of proximate industrial activity differ systematically because of social roles such as gender, work, and family, then these factors should be considered fundamental to our understanding of environmental health risks.

Third, similar to other research we highlight the importance of incorporating indicators of social position in studies related to environmental risk (Hunter 2000). Importantly, this study demonstrates that categories such as gender, parental status, and occupational status can at times obfuscate as much as they reveal. For example, if we had limited our analysis to the results found in Tables 1, 2, and 3, we would have concluded that proximate industrial activity is psychologically damaging to women but not men. However, Fig. 1 clearly shows that among our sample of survey respondents, only one group of women experienced higher levels of psychological distress as a result of living near heavy industrial activity. Moreover, one group of men, representing almost 25% of our male respondents, also experienced higher levels of psychological distress when living near heavy industrial activity. Thus, taking gender into account without also accounting for respondents' occupational and parental status would have been quite misleading.

Finally, this study highlights the advantages of taking a combined social stress and environmental risk approach to understanding neighborhood effects. As noted above, previous neighborhood effects research is somewhat limited because it does not adequately address the ways in which objective neighborhood characteristics are subjectively grasped or how these subjective interpretations may be socially structured. While, a number of previous studies have focused on the relationship between perceived contextual disorder and mental health (e.g. Sampson et al. 2002; Ross 2000; Ross et al. 2000; Geis and Ross 1998; Aneshensel and Sucoff

1996), few studies have examined the role that social status plays in structuring these perceptions. Although our study does not examine this mismatch empirically, our indirect assessment of this process is consistent with the theoretical model that we describe. While our paper emphasizes gender as a mechanism through which risky social roles are allocated (women are placed in family and work roles that make them more susceptible to this particular form of stress compared to men) we make a more important (and general) contribution by highlighting the role that multiple social roles play in structuring individual's psychological reactions to ambient environmental stressors.

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Appendix 1

Figure 2 illustrates the *industrial activity* variable construction process for two fictitious census blocks. Each census block contains a single facility (F1 and F2) and each block is divided into 16 grid cells. Objects 1, 3, and 5 illustrate the first three steps in the process for facility 1, and objects 2, 4, and 6 illustrate the first three steps in the process for facility 2. Object 1 (in the top left-hand corner of Fig. 2) lists the distance from the center of each cell to the center of the cell in which facility 1 is located and object 2 (in the top right-hand corner of Fig. 2) lists the distance from the center of each cell to the center of the cell in which facility 2 is located (distance equals zero in the facility 1 cell in object 1 and the facility 2 cell in object 2).

Objects 3 and 4 display the weights grids that were created, respectively, for facilities 1 and 2. To simplify the presentation, the mathematical function used to create these weights grids, F (*w*), is linear rather than curvilinear. Thus, each cell value in object 3 was calculated by inserting the distance value from the corresponding cell in object 1 into the distance decay function listed below object 3; and each cell value in object 4 was calculated by inserting the distance value from the corresponding cell in object 2 into the distance decay function listed below object 4. For example, the weight for the grid cell in the top left-hand corner of block A in object 3 equals ($1-(7.\overline{57}*10^{-4}*141.4)$), or 0.893, and the weight for the grid cell in the top left-hand corner of block A in object 4 equals ($1-(7.\overline{57}*10^{-4}*608.3)$), or 0.539 (141.4 is the distance in feet from facility 1 to the center of the cell in the top left-hand corner of tract A and 608.3 is the distance in feet from facility 2 to the center of the cell in the top left-hand corner of tract A).

Objects 5 and 6 are the *relative effects grids* created, respectively, for facilities 1 and 2. In this example, facility 1 emits 100 pounds of TRI air pollutants and facility 2 emits 1,000 pounds of TRI air pollutants. Thus, the cell values in object 5 were calculated by multiplying the cell values in object 3 by 100, and the cell values in object 6 were calculated by multiplying the cell values in object 4 by 1,000. The cell values in objects 5 and 6 were then summed together to create object 7, the *summed relative effects grid* for facilities 1 and 2. Thus, the value of each cell in object 7 was calculated by summing together the values of its corresponding cell in object 5 and its corresponding cell in object 6. For example, the cell value in the top left-hand corner of block A in object 7 equals the cell value in the top left-hand corner of block A in object 5 plus the cell value in the top left-hand corner of block A in object 6 (89.3 + 539 = 628.3).

Finally, object 8 lists the average cell value for each block in object 7. These values, which represent the *mean relative effect* of all study area facilities on each study area analysis unit, are calculated by summing together the cell values in each analysis unit and then dividing each analysis unit total by the number of cells in that analysis unit.

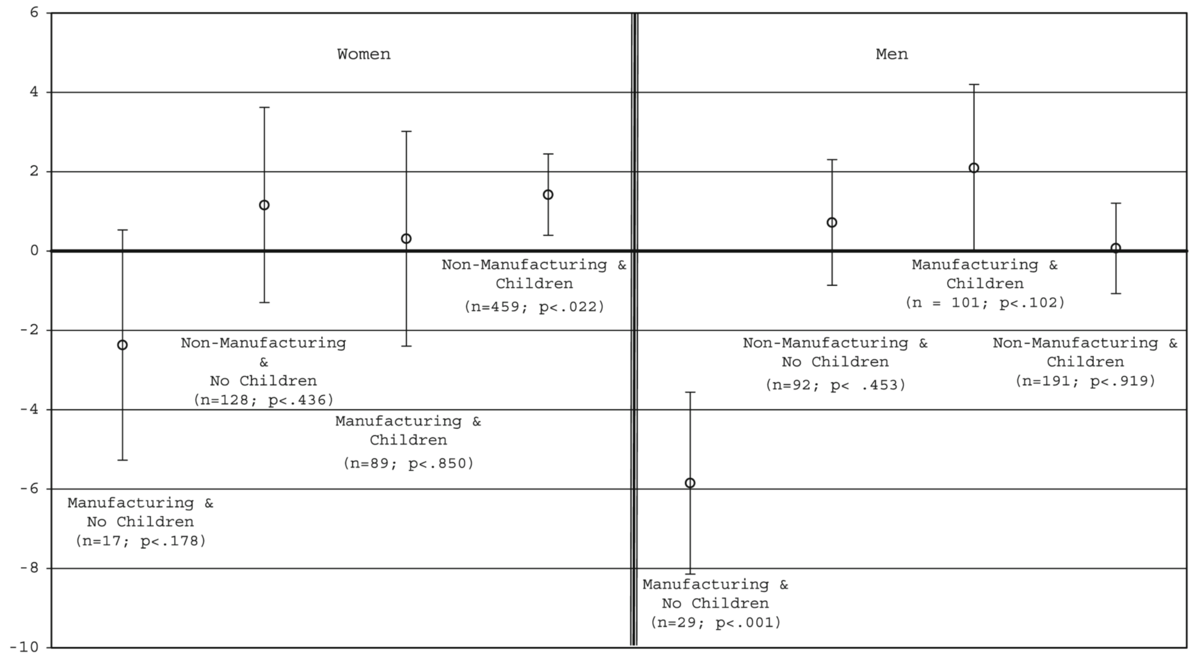

Fig. 1.
The estimated effect of local industrial activity on the psychological distress of men and women: the role of work and family. *Note*: The values describe the estimated effect (and 95% confidence interval) of industrial activity on the psychological well-being for each group. *Source*: 1995 Detroit Area Study (n = 1,106)

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(1) Distance Grid For Facility 1

Block A / Block B

141.4	100	141.4	223.6	316.2	412.3	509.9	608.3
100	**F1**	100	200	300	400	500	600
141.4	100	141.4	223.6	316.2	412.3	509.9	608.3
223.6	200	223.6	282.8	360.6	447.2	538.5	632.4

(2) Distance Grid For Facility 2

Block A / Block B

608.3	509.9	412.3	316.2	223.6	141.4	100	141.4
600	500	400	300	200	100	**F2**	100
608.3	509.9	412.3	316.2	223.6	141.4	100	141.1
632.4	538.5	447.2	360.6	282.8	223.6	200	223.6

(3) Weights Grid for Facility 1

Block A / Block B

0.893	0.924	0.893	0.831	0.760	0.688	0.614	0.539
0.924	**1.000**	0.924	0.848	0.773	0.697	0.621	0.545
0.893	0.924	0.893	0.831	0.760	0.688	0.614	0.539
0.831	0.848	0.831	0.786	0.727	0.661	0.592	0.521

F(x) = 1 - (.000757575757 * d), for 0 <= x < 1320
F(x) = 0, for 0 >= 1320

(4) Weights Grid for Facility 2

Block A / Block B

0.539	0.614	0.688	0.760	0.831	0.893	0.924	0.893
0.545	0.621	0.697	0.773	0.848	0.924	**1.000**	0.924
0.539	0.614	0.688	0.760	0.831	0.893	0.924	0.893
0.521	0.592	0.661	0.727	0.786	0.831	0.848	0.831

F(x) = 1 - (.000757575757 * d), for 0 <= x < 1320
F(x) = 0, for 0 >= 1320

(5) Relative Effects Grid for Facility 1

Block A / Block B

89.3	92.4	89.3	83.1	76.0	68.8	61.4	53.9
92.4	**100.0**	92.4	84.8	77.3	69.7	62.1	54.5
89.3	92.4	89.3	83.1	76.0	68.8	61.4	53.9
83.1	84.8	83.1	78.6	72.7	66.1	59.2	52.1

Air Emissions = 100 pounds

(6) Relative Effects Grid for Facility 2

Block A / Block B

539	614	688	760	831	893	924	893
545	621	697	773	848	924	**1000**	924
539	614	688	760	831	893	924	893
521	592	661	727	786	831	848	831

Air Emissions = 1000 pounds

(7) Summed Relative Effects Grid for Facilities 1 and 2

Block A / Block B

628.3	706.4	777.3	843.1	907.0	961.8	985.4	946.9
637.4	**721.0**	789.4	857.8	925.3	993.7	**1062.1**	978.5
628.3	706.4	777.3	843.1	907.0	961.8	985.4	946.9
604.1	676.8	744.1	805.6	858.7	897.1	907.2	883.1

(8) Tract Level Relative Effects Average

Block A	Block B
734.15	**944.24**

Fig. 2.

Determining proximity to industrial activity: the variable construction process

Table 1

The relationship between industrial activity and psychological distress: mean distress levels for men and women by residential status

	Proximate industrial activity			
	Yes	**No**	$\mu_{yes}-\mu_{no}$	**Pr**$\|\mu_{yes}-\mu_{no}\| = 0$
Men	11.99 (5.03) *100*	11.06 (4.90) *313*	0.93	<.0717
Women	13.45 (5.58) *152*	11.75 (4.39) *541*	1.70	<.0002
Total	12.74 (5.40) *252*	11.43 (4.59) *854*	1.31	<.0004

Note: Cell entries represent means, standard deviations (in parentheses), and sample size (in italics)

Source: 1995 Detroit Area Study (n = 1,106)

Table 2

Neighborhood-level socioeconomic characteristics, industrial activity, and psychological distress: multilevel model estimates

	Model 1	Model 2	Model 3
Intercept	17.23*** (1.14)	17.04*** (1.14)	16.70*** (1.15)
Gender (Men)			
Women	0.66* (0.27)	0.64* (0.27)	0.66* (0.27)
Marital status (Unmarried)			
Married	0.27 (0.31)	0.32 (0.31)	0.29 (0.31)
Children (Yes)			
No	0.58 (0.36)	0.62 (0.36)	0.61 (0.36)
Race/Ethnicity (NH White)			
NH Black	−0.27 (0.41)	−0.86 (0.48)	−0.83 (0.48)
Age (years)	−0.01 (0.01)	−0.01 (0.01)	−0.01 (0.01)
Education (years)	−0.22*** (0.06)	−0.21*** (0.06)	−0.20*** (0.06)
Income ($1000s/yr)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Primary occupation (Non-manufacturing)			
Manufacturing	−0.12 (0.33)	−0.13 (0.33)	−0.11 (0.33)
Social stressors			
Crime related stress	0.34 (0.38)	0.22 (0.38)	0.24 (0.38)
Work-related stress	1.02*** (0.29)	0.98** (0.29)	0.97*** (0.29)
Financial stress	2.30*** (0.40)	2.28*** (0.40)	2.25*** (0.40)
Familial stress	1.41*** (0.29)	1.43***	1.44*** (0.29)
Perceived health	1.13*** (0.14)	1.13*** (0.14)	1.12*** (0.14)
Neighborhood characteristics			
Poverty rate (< 20%)			
Greater than 20%	–	1.15* (0.51)	1.07 * (0.51)
Industrial Activity [0–74th percentile]			
75th–99th percentile	–	–	0.73* (0.36)
Residual variance estimates			
Level 2	1.62 *** (0.49)	1.44 ** (0.47)	1.39 ** (0.46)
Level 1	17.47*** (0.79)	17.49*** (0.79)	17.48*** (0.79)

Note: Cell entries represent unstandardized parameter estimates and standard errors (in parentheses) from a series of hierarchical linear models

*** *P* < .001

** *P* < .01

* *P* < .05 (two-tailed)

Source: 1995 Detroit Area Study (*n* = 1,106)

Table 3

The differential impact of industrial activity on psychological distress for men and women

	Women	**Men**
Intercept	16.99*** (1.55)	16.89*** (1.67)
Marital Status (Unmarried)		
Married	0.29 (0.40)	0.01 (0.52)
Children (Yes)		
No	0.61 (0.48)	0.72 (0.55)
Race/Ethnicity (NH White)		
NH Black	−1.41* (0.62)	0.07 (0.69)
Age (years)	−0.01 (0.01)	−0.01 (0.01)
Education (years)	−0.31*** (0.09)	−0.10 (0.09)
Income ($1000s/yr)	0.01 (0.01)	−0.01* (0.01)
Primary occupation (Non-manufacturing)		
Manufacturing	−0.62 (0.50)	0.34 (0.46)
Social stressors		
Crime related stress	0.47 (0.50)	0.29 (0.59)
Work-related stress	0.44 (0.41)	1.29** (0.44)
Financial stress	2.97*** (0.55)	1.79** (0.58)
Familial stress	2.25*** (0.37)	0.43 (0.44)
Perceived health	0.87*** (0.18)	1.28*** (0.22)
Neighborhood characteristics		
Poverty rate [< 20%]		
Greater than 20%	1.98** (0.65)	−0.30 (0.76)
Industrial Activity [0–74th percentile]		
75th–99th percentile	0.89* (0.44)	0.35 (0.52)
Level 2	2.93 (0.85)	0.77 (0.75)
Level 1	17.69 (1.04)	15.48 (1.25)

Note: Cell entries represent unstandardized parameter estimates and standard errors (in parentheses) hierarchical linear models for men (n = 413) and women (n = 693) separately.

*** $P < .001$

** $P < .01$

* $P < .05$ (two-tailed)

Source: 1995 Detroit Area Study (n = 1,106)