



Discrimination hurts: The effect of discrimination on the development of chronic pain

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ABSTRACT

We examine the hypothesis that psychological distress due to perceived discrimination can result in chronic pain, where perceived discrimination is based on age, gender, race, ethnicity, disability, sexual orientation, height/weight, religion, and other characteristics. Using a sample of 1908 individuals from the two most recent waves (2004–2006 and 2013–2014) of panel data from the National Survey of Midlife Development in the United States, we apply instrumental variables regression where measures of daily and lifetime perceived discrimination are instruments whose effects on chronic pain are mediated by psychological distress. We find statistically significant dose-response relationships between daily perceived discrimination and psychological distress, between lifetime perceived discrimination and psychological distress, and between psychological distress and chronic pain. Based on our instrumental variables regression model, we estimate that 4.1 million people in the US in 2016, aged 40 and older, experience chronic pain that is caused by increased psychological distress, where psychological stress has increased due to perceived discrimination.

Chronic pain is a major health concern in the US. Chronic pain affects over 30% of the population. Of this group, approximately one-fifth experience mild pain (nagging and annoying but does not interfere with activities of daily living), almost half experience moderate pain (significantly interferes with activities of daily living), and approximately one-third experience severe pain (rendering a person unable to perform activities of daily living) (Johannes et al., 2010; National Institutes of Health, 2003). Chronic pain places a burden not only on individuals, but also on society, costing the US economy \$261–\$300 billion annually in health care expenditures, and another \$299–\$335 billion annually due to decreased productivity (Gaskin and Richard, 2012).

There is significant evidence that perceived discrimination is correlated with chronic pain. Among African-Americans the relationship between perceived discrimination and chronic pain and low-back pain persists even after controlling for socioeconomic and health-related characteristics, and the relationship between chronic pain and perceived discrimination is significantly different between African-Americans and non-Hispanic whites (Burgess et al., 2009; Goodin et al., 2013; Edwards, 2008).

A related study of African-Americans with sickle-cell disease found a positive association between perceived discrimination from healthcare providers (based on disease status) and daily chronic pain and the burden of pain (Haywood et al., 2014). However, others have found

that, with regard to this group, such perceived discrimination only had an impact on laboratory-induced pain (Mathur et al., 2016).

Positive associations between perceived discrimination and chronic pain also occur among Asians. In particular, associations have been found for Vietnamese-Americans, Filipino-Americans, Chinese-Americans, and South Koreans (Gee et al., 2007; Lee et al., 2017)

A likely mechanism explaining the correlation between perceived discrimination and chronic pain is psychological distress or diminished psychological well-being. As we explain below, this mechanism has two parts. In the first part, perceived discrimination initiates psychological distress. In the second part, psychological distress both potentiates the experience of pain and even initiates pain. Both of these occur in a dose-response fashion. Neurobiological processes underlie these linkages.

A large literature finds an association between perceived discrimination and psychological distress or diminished psychological well-being (Schmitt et al., 2014; Torres and Taknint, 2015; Ikram et al., 2014; Schaafsma, 2011; Pascoe and Richman, 2009; Williams et al., 2003; Kessler et al., 1999). Causal evidence of this association comes from human experimental evidence that the level of pervasiveness of perceived discrimination, defined as the frequency of discrimination and the number of contexts in which it occurs, is fundamental to perceived discrimination having harmful psychological effects (Schmitt et al., 2014). In other words, perceived discrimination causes

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psychological harm when it is more pervasive, suggesting a dose-response relationship.

The next step in the causal chain is between psychological distress and pain. The biopsychosocial review of the literature on pain and emotion by Lumley et al. (2011) shows that psychological distress plays a large role in the experience of pain (Lumley et al., 2011). In fact, while tissue damage from injury or disease often precedes pain, a large literature finds that pain is also often preceded by psychological distress (Currie and Wang, 2005; Mykletun et al., 2011; Knaster et al., 2012; Afari et al., 2014; PhyoMaung et al., 2014; Aro et al., 2015; Tegethoff et al., 2015).

The process by which psychological distress may result in pain is no longer a black box. Consider anxiety, a type of psychological distress, that consists of negative affect based on apprehension about anticipated future threats that have uncertain outcomes (Olango and Finn, 2014). The resulting hypervigilance from such anxiety can result in neurobiological changes that can result in hyperalgesia (increased sensitivity to pain) (Olango and Finn, 2014). This appears to be an adaptive response, since heightened pain sensitivity allows potential threats to be detected more readily (Olango and Finn, 2014).

Human studies have found that experimentally-induced anxiety, in the form of pain-relevant information, can cause hyperalgesia (Schumacher and Velden, 1984; Weisenberg et al., 1984; Dougher, 1979; Cornwall and Donderi, 1988; Rhudy and Meagher, 2000; Williams and Rhudy, 2007; Thompson et al., 2008). Human studies have even found that not only increased sensitivity to pain, but actual pain itself can be induced in subjects by experimentally inducing anxiety (Schweiger and Parducci, 1981; Bayer et al., 1991; Leistad et al., 2006; Colloca and Benedetti, 2007).

Since there is significant overlap between anxiety and depression (another form of psychological distress) (Eysenck and Fajkowska, 2017), hyperalgesia and the initiation of pain may also occur as part of at least some types of depression (Trivedi, 2004; Thompson et al., 2016; Tikasz et al., 2016). Taken together, the above studies suggest that psychological distress can both heighten sensitivity to existing pain and also induce pain where there was previously no pain.

A key finding from the literature on hyperalgesia is that hyperalgesia can occur when stressors are repetitive and moderately intense (Olango and Finn, 2014). This mirrors the key finding in the literature on perceived discrimination and diminished psychological well-being: that the pervasiveness of perceived discrimination is fundamental to whether psychological harm occurs.

We thus have ample evidence to hypothesize that more pervasive perceived discrimination will result in higher psychological distress, and that higher psychological distress will increase the probability of experiencing chronic pain. To our knowledge, no empirical study to date has shown that psychological distress due to perceived discrimination can cause chronic pain. The significance of this hypothesis is that if perceived discrimination can induce psychological distress that results in chronic pain, then this makes the issue of discrimination a public health issue.

This hypothesis cannot be tested in vivo within laboratory settings, primarily due to ethical constraints. We therefore evaluate this hypothesis using observational data to which we apply econometric methods, specifically the instrumental variable method. The instrumental variable method is a step beyond a retrospective case-control approach in that the use of the instrumental variables allows us to estimate causal effects (Wooldridge, 2010).

Discrimination may be based on a variety of characteristics (race, ethnicity, gender, age, religion, sexual orientation, physical appearance, obesity, etc.). We focus not on these characteristics, but on the influence of discriminatory experiences in inducing chronic pain via psychological distress. We use measures of perceived discrimination that capture a wide variety of ways in which people may experience discrimination (Kessler et al., 1999). Our results will thus be applicable to perceived discrimination that occurs for any reason, if it results in the

psychological distress that we measure in this study.

1. Methods

1.1. Data

We use data from the National Survey of Midlife Development in the United States (MIDUS) obtained from the Inter-University Consortium for Political and Social Research. MIDUS is a longitudinal panel of US adults that began in 1995. There have been three waves of data: MIDUS I (1995–1996), MIDUS II (2004–2006) and MIDUS III (2013–2014). The original MIDUS I random digit dialing sample included a nationally representative sample of US adults, an oversampling of five metropolitan areas, a sample of the national sample respondents' siblings, and a national sample of twins. The data were collected by phone interviews and self-administered questionnaires. All racial/ethnic groups were included in the sample. Retention rates in subsequent waves were higher among women, whites, married people, and people with more education and better health (Radler and Ryff, 2010). Since there is no measure of chronic pain in MIDUS I, we only use data from MIDUS II and MIDUS III, which both contain measures of chronic pain (Ryff et al., 2017a, 2017b).

1.2. Measures

The primary outcome is chronic pain. The primary independent variables of interest are measures of lifetime perceived discrimination, daily perceived discrimination, and psychological distress. All other variables discussed are control variables. All variables come from the MIDUS.

Chronic pain includes pain occurring anywhere in the body. To construct an indicator of chronic pain, we first considered the MIDUS screening question, "Do you have chronic pain, that is do you have pain that persists beyond the time of normal healing and has lasted anywhere from a few months to many years?" For those answering "yes", we examined their score on the Brief Pain Inventory (BPI) interference scale, a valid and reliable instrument for assessing the extent to which pain has interfered with seven daily activities: sleep, mood, enjoyment, relationships with others, general activity, walking, and work, using a zero (did not interfere) to 10 (completely interfered) scale (Raichle et al., 2006; Williams et al., 2006). Shortened interference scales are often used in research as some items may not be appropriate for all classes of patients (Bjornnes et al., 2016; Cowan et al., 2006; Harding et al., 2010). Cronbach's alpha for the shortened scale used here (the questions on walking and work are not available in the MIDUS data) is 0.95. No other questions on chronic pain are available in MIDUS I, II, or III. We constructed a binary variable and coded as one those with both a positive screen and a positive BPI as having chronic pain that was sufficient to result in at least some interference with ordinary life activities. All else was coded as zero.

MIDUS contains scales of lifetime perceived discrimination and daily perceived discrimination that are based on previous qualitative studies. Each scale has been validated (Williams et al., 1997; Kessler et al., 1999).

The lifetime perceived discrimination scale is based on 11 questions evaluating how often a person has experienced major discriminatory events. See Table 1. The scale is constructed by summing the number of discriminatory event categories experienced and ranges from zero to 11. Cronbach's alpha is 0.92.

In contrast, the daily perceived discrimination scale is based on nine questions evaluating how often (never, rarely, sometimes, often) each respondent experienced various types of everyday discrimination. See Table 1. The responses are coded as zero through three and the values are then summed, ranging from zero to 27. Cronbach's alpha is 0.70.

Psychological distress was measured using the valid and reliable K6 (Kessler et al., 2002). Cronbach's alpha is 0.84. The K6 is based on six

Table 1

Discrimination questions.
Source: MIDUS II, 2004–2006.

<p>Lifetime discrimination questions: In each of the following, indicate how many times in your life you have been discriminated against because of race, ethnicity, gender, age, religion, physical appearance, sexual orientation, or other characteristics.</p> <p>You were discouraged by a teacher or advisor from seeking higher education. You were denied a scholarship. You were not hired for a job. You were not given a job promotion. You were fired. You were prevented from renting or buying a home in the neighborhood you wanted. You were prevented from remaining in a neighborhood because neighbors made life so uncomfortable. You were hassled by the police. You were denied a bank loan. You were denied or provided inferior medical care. You were denied or provided inferior service by a plumber, car mechanic, or other service provider.</p>
<p>Daily discrimination questions: How often on a day-to-day basis do you experience each of the following types of discrimination? Answers: never, rarely, sometimes, often.</p> <p>You are threatened or harassed? You are called names or insulted? People act as if they think you are not as good as they are? People act as if they think you are dishonest? People act as if they are afraid of you? People act as if they think you are not smart? You receive poorer service than other people at restaurants or stores? You are treated with less respect than other people? You are treated with less courtesy than other people?</p>

questions: “During the past 30 days, how much of the time did you feel: nervous, hopeless, worthless, restless or fidgety, so sad nothing could cheer you up, that everything was an effort?” The answers to each of the questions (none of the time, a little of the time, some of the time, most of the time, all of the time) are coded zero to four and then summed yielding a range from zero to 24. Scores of 13 or higher indicate severe psychological distress that is indicative of serious mental illness, whereas scores of five to 12 indicate moderate psychological distress (Prochaska et al., 2012). We use the K6 in its continuous form following Kessler et al. (1999), Andrés (2004), Flint et al. (2013), McKenzie et al. (2014), Oshio (2014), and Foster et al. (2016).

While current chronic pain and current psychological distress come from MIDUS III, the other variables of interest, the daily perceived discrimination scale and lifetime perceived discrimination scale, as well as all control variables, come from MIDUS II. The daily and lifetime perceived discrimination scales come from MIDUS II, while current psychological distress comes from MIDUS III, in order to avoid reverse causation running from psychological distress to perceived discrimination. Similarly, all control variables come from MIDUS II in order to avoid reverse causation that may run from chronic pain to the set of control variables.

Control variables include age and its square, sex (male, female), race/ethnicity (white, black, Hispanic, Asian/Pacific Islander, other race), marital status (single, married, divorced, separated, widowed), education (less than high school, high school, some college, bachelors, graduate school), relevant personality traits (neuroticism, conscientiousness, and agreeableness), religion (none, Protestant, Catholic/Orthodox, Jewish, other), sexual preference (heterosexual, homosexual/bisexual), disability status, activities of daily living, height, obesity/overweight status, past pain status (no pain, chronic pain, non-chronic pain), past moderate-to-severe psychological distress (yes/no), employment, health insurance status, occupation category (9 categories), industry category (12 categories), and household income equivalized by accounting for household size (Hagenaars et al., 1994).

1.3. Conceptual and statistical models

We adapt the conceptual model of Pascoe and Richman (2009) and posit that discrimination may result in chronic pain through two possible pathways: psychological distress or poor health care/habits, each of which can result in reduced health status. Our analysis seeks to estimate the average probability of developing chronic pain due to increases in psychological distress, where increases in psychological distress are *only* due to increases in the pervasiveness of daily and lifetime perceived discrimination.

To obtain a consistent estimate of the relationship between psychological distress and chronic pain, we must correct for biases that may arise due to reverse causality, omitted variables, and/or random measurement error (Wooldridge, 2010). The presence of reverse causality, the effect of chronic pain on psychological distress, may bias the estimate of the effect of psychological distress on chronic pain. In addition, there may be variables that we are unable to control for that may correlate with both psychological distress and chronic pain. This can result in omitted variable bias. Finally, there may be random measurement error in our measure of psychological distress. This can also result in bias. Each type of bias must be removed in order to obtain consistent estimates.

Each of the above problems are different manifestations of the situation in which psychological distress may be correlated with the error term, such that the parameter for psychological distress, indicating the effect of psychological distress on chronic pain, may be biased. We correct each of these problems by removing the correlation between psychological distress and the error term by the use of instrumental variables.

Specifically, we employ a two-stage least squares (2SLS) linear probability model to determine the local average treatment effect (LATE) of psychological distress on the probability of experiencing chronic pain, where psychological distress is only due to perceived discrimination. This model is appropriate when the mean of the dependent variable is in the range of [0.2, 0.8] (Cox, 1970). We do not use control function methods to apply instrumental variables to nonlinear models such as probit or logit (e.g., two-stage residual inclusion models (2SRI)) since this approach can result in substantially biased estimates of the LATE in contexts where the marginal group of people who suffer psychological distress and subsequent chronic pain due to perceived discrimination are unique in the sense that they react differently to perceived discrimination than the general population (Chapman and Brooks, 2016).

In order to remove the correlation between psychological distress and the error term, we use both the lifetime and daily perceived discrimination scales from MIDUS II as instruments for current psychological distress from MIDUS III. The first and second stages of 2SLS are represented by equations (1) and (2), where *PsychologicalDistress* is the K6, *PastDiscrimination* is a vector of scales measuring past perceived discrimination, *Controls* is a vector of the control variables previously discussed, and η and ε are error terms. In equation (2), the predicted value of current psychological distress from equation (1) is substituted for current psychological distress in equation (2), and the standard errors are appropriately adjusted.

$$\text{PsychologicalDistress} = \alpha_0 + \alpha_1 \text{PastDiscrimination} + \alpha_2 \text{Controls} + \eta \quad (1)$$

$$\text{Pr}(\text{Chronic Pain}) = \beta_0 + \beta_1 \widehat{\text{PsychologicalDistress}} + \beta_2 \text{Controls} + \varepsilon \quad (2)$$

Our instruments, the lifetime and daily perceived discrimination scales from MIDUS II, must satisfy standard validity criteria. They must (1) correlate strongly with current psychological distress, but (2) not correlate with the error term in the second stage (Wooldridge, 2010). The first criterion can be tested using an Olea and Pflueger (2013) weak instrument test that is robust to heteroscedasticity and serial

correlation. The second criterion can be divided into two sub-criteria, (2a) independence from the chronic pain outcome, conditional on the covariates; and (2b) having no effect on the chronic pain outcome other than through the first-stage pathway of psychological distress (Angrist and Pischke, 2009). These sub-criteria can be tested using a standard overidentification test that assumes at least one of the instruments is valid. We add an additional instrument that is necessarily valid for purposes of this test.

Including the correct set of covariates allows us to achieve statistical independence with regard to the perceived discrimination scales, such that these scales will have no effect on chronic pain other than through psychological distress. Both scales relate to perceived discriminatory acts that are based on a defined list of characteristics. To the extent that any of these characteristics are risk factors for chronic pain and are also associated with psychological distress, they must be included in the regression equation in order to establish the validity of the perceived discrimination scales as instruments. In addition, including variables that capture the effect of perceived discrimination on health habits and ultimately health status is also essential in order to control for this alternative pathway between perceived discrimination and chronic pain.

Age, gender, race/ethnicity, religion, height and weight (obesity), physical disability, sexual orientation, occupation, financial status, and education, have all been found to be risk factors for chronic pain (Yu et al., 2006; McBeth and Jones, 2007; Croft, van der Windt, Boardman, and Blyth, 2010; Cimmino et al., 2011; Roberts et al., 2013; VanDenKerkhof et al., 2013; Taylor et al., 2014; Younger, 2015). These factors are also likely to affect psychological distress. We thus include controls for each. To account for the “other” category, we include the personality trait neuroticism, since those with higher trait neuroticism may be more sensitive in their perception of discriminatory behavior than others (Huebner et al., 2005). Trait neuroticism is also a risk factor for chronic pain and will obviously be correlated with psychological distress (Charles et al., 1999; VanDenKerkhof et al., 2013; Boggero et al., 2014).

Finally, we control for the pathway from the perceived discrimination scales through poor health habits to chronic pain by including the personality traits conscientiousness and agreeableness, which are related to self-control (Jensen-Campbell et al., 2007). The stress of perceived discrimination may have a larger impact on those with lower trait conscientiousness (via reduced participation in positive health behaviors), and higher trait agreeableness plays a role among those with low conscientiousness in that such individuals are more prone to participate in negative health behaviors in the sense that they have a stronger tendency to “go along with the crowd” (Jensen-Campbell et al., 2007; Inzlicht et al., 2006). Finally, we also include past measures of chronic pain, non-chronic pain, activities of daily living, disability, and psychological distress (from MIDUS II) in order to account for problems that may have already been present. Once all of the above are included, the only pathway through which perceived discrimination may impact chronic pain is through psychological distress.

All analyses were conducted using Stata 15.0. Equations (1) and (2) are estimated using 2SLS with standard errors clustered by family to take into account the presence of siblings (Baum et al., 2010).

2. Results

The reasons individuals give as the basis of the discrimination they experience are presented in Table 2. The categories are not mutually exclusive. Apart from the category “other”, the top four perceived reasons for discrimination are gender, age, height/weight, and race. Since the categories are not mutually exclusive, we cannot easily disentangle the effects of discrimination based on specific characteristics, but instead focus on the overall experience of discrimination.

Table 2

Perceived reasons for discrimination – MIDUS II.

^aSource: MIDUS II, 2004–2006; ^bSource: MIDUS II Milwaukee African American Sample, 2005–2006.

Variable	Overall Sample ^a	African-American Sample ^b
	Mean	Mean
Gender	0.171	0.271
Age	0.137	0.311
Other reason	0.098	0.172
Height/weight	0.089	0.181
Race	0.070	0.745
Other aspect of appearance	0.055	0.184
Religion	0.044	0.130
Ethnicity	0.033	0.533
Sexual orientation	0.015	0.092
Physical disability	0.014	0.119

It may be surprising that race ranks relatively low in the overall sample column of Table 2. However, this is largely a statistical artifact that is a function of racial minorities being a relatively small percentage of the population. To put these rankings into perspective, we also present the same information in the adjacent column from a sample of African-Americans from Milwaukee, Wisconsin, a sample that was collected as a refinement to MIDUS II to examine health issues in minority populations. This sample cannot be linked to individuals in MIDUS III, so it was not included as part of the main analysis. This column shows that, for African-Americans, race and ethnicity are far and above the primary reasons given for perceived discrimination.

Table 3 presents additional descriptive statistics. As of MIDUS II, the average age is approximately 54, ranges from 30 to 84, and approximately 19% of individuals in the sample suffer from moderate-to-severe psychological distress. As of MIDUS III, approximately 33% of individuals suffered from chronic pain.

The mean value of the daily perceived discrimination scale is approximately 3.6. Approximately 10% of the sample has a daily discrimination scale score of 9 or higher, and approximately 2% of the sample has a score of 14 or higher. Approximately 41% of individuals experienced no daily discrimination.

The mean value of the lifetime perceived discrimination scale is slightly less than one. Approximately 62% of individuals experienced no lifetime discrimination, approximately 16% of individuals experienced one category of major discrimination, approximately 22% of individuals experienced two or more categories of major discrimination, and approximately 2% of individuals experienced five or more categories of major discrimination.

Table 4 presents the final results. We used both the untransformed and natural logarithm of the K6 and found potential bias was minimized using the natural logarithm of the K6. Columns 1 through 3 present a model with a limited set of controls, while columns 4 through 6 present a model with a comprehensive set of controls. We focus on columns 4 through 6. The two scales of discrimination used as instruments each have a strong correlation with psychological distress, rejecting the hypothesis of weak instruments (effective *F*-statistic of the joint strength of the instruments = 7.094 > 7.092 critical value for 5% of worst case bias) and each show a clear dose-response relationship. For every unit increase in the daily perceived discrimination scale, psychological distress increases by 0.01 ($p = 0.03$) or 1.0% ($1.0\% = 100 \times [\exp(.010) - 1]$). The daily perceived discrimination scale varies in the sample from zero to 27, so the largest measurable increase in psychological distress due to daily perceived discrimination is 27.0% ($27.0\% = 27 \times 1.0\%$).

In contrast, for every one unit increase in the lifetime perceived discrimination scale, the psychological distress scale increases by 0.026

Table 3

Descriptive statistics.
Source: MIDUS II (2004–2006) and MIDUS II (2013–2014). SD: Standard deviation.

Variables	Mean	SD
MIDUS III		
Any chronic pain with a positive BPI	0.334	–
Non-specific psychological distress (range: 0–3)	2.528	3.178
MIDUS II		
Neuroticism (range: 1–4)	2.023	0.625
Conscientiousness (range: 1.8–4)	3.440	0.434
Agreeableness (range: 1.2–4)	3.435	0.498
Female	0.539	–
Age (range: 30 to 84).	54.398	10.844
Black	0.026	–
Other race	0.034	–
Hispanic	0.027	–
High school	0.229	–
Some college/associates degree	0.272	–
Bachelor degree	0.274	–
Graduate	0.191	–
Married	0.743	–
Divorced	0.123	–
Separated	0.014	–
Widow(er)	0.045	–
Household income (equivalized)	88,337	70,224
Catholic/Orthodox	0.275	–
Protestant	0.541	–
Jewish	0.028	–
Other religion	0.022	–
Homosexual/bisexual	0.026	–
Chronic pain	0.333	–
Non-chronic pain	0.591	–
Moderate-to-severe psychological distress	0.187	–
Activities of daily living (range: 1–4)	1.166	0.458
Overweight or obese	0.678	–
Height (inches)	67.171	3.913
Disabled	0.009	–
Health insurance	0.945	–
Employed	0.704	–
Daily discrimination scale (range: 0–27)	3.599	4.301
Lifetime discrimination scale (range: 0–9)	0.844	1.432

Occupational category (9 categories) and industry category (12 categories) are included but not reported.

($p = 0.05$) or 2.6% ($2.6\% = 100 \times [\exp(.026) - 1]$). The lifetime perceived discrimination scale varies in the sample from zero to nine, so the largest measurable increase in psychological distress due to daily discrimination is 23.4% ($23.4\% = 9 \times 2.6\%$). The maximum measurable increase in psychological distress due to all forms of discrimination is thus 50.4%.

Column 5 of Table 4 shows that the probability of experiencing chronic pain increases by 0.469 percentage points ($0.469, p = 0.01$) with every 1% increase in the psychological distress scale. The corrected estimate is over four times as large as the OLS estimate, shown in Column 6, and is statistically different from the OLS estimate ($\chi^2: 5.15, p = 0.02$).

We also conducted overidentification tests, which evaluate the hypothesis that the overidentified instrument is valid (e.g., uncorrelated with the error term and correctly excluded from the second-stage equation) assuming that at least one other instrument is valid. Since our two instruments measure different aspects of discrimination, we use an additional instrument to obtain valid overidentification tests: death of a family member within approximately the last five years, a dummy variable that is equal to one if one's father, mother, sibling, and/or child died during that period. The death of a family member is a random event that can cause psychological distress but is exogenous. We test each perceived discrimination instrument separately against the death of a family member using Hansen's J test. We were unable to reject the null hypothesis of exogeneity for either daily perceived discrimination ($\chi^2: 0.65, p = 0.42$) or lifetime perceived discrimination ($\chi^2: 0.61, p = 0.43$). Thus, there is no evidence that perceived discrimination is correlated with the error term.

The overall relationship between each measure of perceived discrimination and chronic pain is illustrated in Fig. 1. Each relationship is calculated by multiplying the estimated coefficients for each measure of perceived discrimination in column 4 by the coefficient for psychological distress in column 5 and then varying the scales measuring each form of perceived discrimination.

To compute the percentage of the population, as represented by this cohort, that experiences chronic pain due to perceived discrimination, we take the average level of each type of discrimination from Table 2 and multiply these levels by their respective parameters in column 4 of Table 4 [$0.06 = (0.01 \times 3.6) + (0.026 \times 0.84)$]. We then multiply the result by the average effect of psychological distress on the probability of experiencing chronic pain, 0.469, in column 5 of Table 4 to obtain 0.028 ($0.028 = 0.469 \times 0.06, p = 0.01$). If we reasonably posit that our sample is largely representative of the population aged 40 and older (as of MIDUS III), which represents 147 million people in 2016 (US Census, 2017), then our estimates imply that approximately 4.1 million people (0.028×147 million) suffer chronic pain due to their experience of discrimination.

3. Discussion

This is the first study to estimate the causal effect of psychological distress on chronic pain, where variation in psychological distress is only due to variation in perceived discrimination. We used instrumental variable models to correct for bias in the estimated parameter of psychological distress, bias that may be due to reverse causality, measurement error, and/or omitted variables (Wooldridge, 2010). A dose-response relationship is clearly evident, with lifetime perceived discrimination having a stronger impact on the development of pain than daily perceived discrimination as shown in Fig. 1. These findings are consistent with a human experimental literature that demonstrates the negative effects of perceived discrimination on psychological well-being and the effects of psychologically distressing experiences on the development of pain (Schmitt et al., 2014; Olanga and Finn, 2014; Jennings et al., 2014; Schweiger and Parducci, 1981).

The differences in the dose-response effects found between the lifetime and daily perceived discrimination scales give rise to considerations about the order in which this public health problem should be addressed, given scarce resources. The larger impact of the lifetime perceived discrimination scale suggests that prevention activities should start with a focus on preventing these types of interactions, and only subsequently move to addressing the more diffuse experiences described in the daily perceived discrimination scale.

3.1. Limitations

This study has limitations. There is evidence of attrition bias in the MIDUS, with retention rates in subsequent waves being higher among women, whites, married people, and people with more education and better health (Radler and Ryff, 2010). This does not impact the internal validity of our study, but to the extent that our study cohort reflects a population that experiences less discrimination than the general US population, our findings may be understated.

4. Conclusions

Much has been written about racism, gender inequality and other discriminatory elements embedded within societal structures, and their impacts on health (Williams and Mohammed, 2013a; Hudson et al., 2013; Geronimus, 2013; Gilbert et al., 2016). Our findings focus on one of many pathways posited between discrimination and health (Williams and Mohammed, 2013a), in particular, the pathway where psychological responses (Adler and Snibbe, 2003) affect health outcomes via neurobiological mechanisms (Geronimus, 2013). Numerous approaches to reducing racial discrimination have been put forth, many of which

Table 4
The effect of psychological distress on chronic pain.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	First stage	Second stage	OLS	First stage	Second stage	OLS
Ln(K6) (range: 0–23) _{M3}	–	0.473** (0.095)	0.143** (0.014)	–	0.469** (0.181)	0.107** (0.015)
Neuroticism (range: 1–4) _{M2}	0.512** (0.026)	–0.160** (0.055)	0.019 (0.019)	0.363** (0.029)	–0.131 (0.071)	0.004 (0.020)
Conscientiousness (range: 1.8–4) _{M2}	–0.155** (0.038)	0.032 (0.032)	–0.027 (0.025)	–0.114** (0.038)	0.020 (0.036)	–0.024 (0.025)
Agreeableness (range: 1.2–4) _{M2}	0.005 (0.034)	–0.000 (0.025)	0.004 (0.022)	–0.002 (0.034)	0.003 (0.026)	0.004 (0.022)
Female _{M2}	–0.020 (0.033)	0.025 (0.024)	0.021 (0.022)	–0.067 (0.054)	0.076* (0.039)	0.055 (0.032)
Age (range: 30–84) _{M2}	–0.025 (0.013)	0.017 (0.010)	0.010 (0.008)	–0.028* (0.014)	0.013 (0.011)	0.003 (0.009)
Square of age _{M2}	0.000 (0.000)	–0.000 (0.000)	–0.000 (0.000)	0.000 (0.000)	–0.000 (0.000)	–0.000 (0.000)
Black _{M2}	–0.398** (0.108)	0.036 (0.062)	–0.039 (0.052)	–0.331** (0.110)	–0.017 (0.070)	–0.101* (0.046)
Other race _{M2}	–0.113 (0.096)	0.026 (0.064)	–0.011 (0.055)	–0.024 (0.092)	0.042 (0.068)	0.034 (0.059)
Hispanic _{M2}	0.040 (0.126)	–0.027 (0.075)	0.006 (0.062)	0.036 (0.132)	–0.086 (0.075)	–0.060 (0.058)
High school _{M2}	–0.082 (0.100)	–0.058 (0.060)	–0.092 (0.056)	–0.086 (0.098)	–0.009 (0.066)	–0.043 (0.059)
Some college/AA/AS _{M2}	–0.087 (0.099)	–0.026 (0.059)	–0.061 (0.056)	–0.037 (0.097)	–0.020 (0.065)	–0.035 (0.059)
Bachelor degree _{M2}	–0.096 (0.100)	–0.051 (0.061)	–0.089 (0.057)	–0.013 (0.099)	–0.033 (0.065)	–0.039 (0.062)
Graduate _{M2}	–0.082 (0.102)	–0.075 (0.063)	–0.110 (0.059)	–0.017 (0.103)	–0.064 (0.071)	–0.073 (0.064)
Married _{M2}	–0.129* (0.058)	0.150** (0.045)	0.094* (0.037)	–0.124* (0.061)	0.123* (0.052)	0.071 (0.040)
Divorced _{M2}	–0.074 (0.073)	0.117* (0.053)	0.091* (0.045)	–0.078 (0.075)	0.080 (0.056)	0.050 (0.046)
Separated _{M2}	–0.052 (0.148)	0.178 (0.107)	0.145 (0.093)	–0.177 (0.136)	0.119 (0.107)	0.045 (0.086)
Widow(er) _{M2}	–0.018 (0.088)	0.113 (0.065)	0.093 (0.059)	–0.033 (0.090)	0.088 (0.070)	0.065 (0.063)
Household income (equivalized) _{M2}	–0.000** (0.000)	0.000 (0.000)	–0.000 (0.000)	–0.000* (0.000)	0.000 (0.000)	0.000 (0.000)
Catholic/Orthodox _{M2}	–	–	–	0.002 (0.056)	–0.032 (0.040)	–0.034 (0.034)
Protestant _{M2}	–	–	–	–0.035 (0.051)	–0.014 (0.037)	–0.029 (0.031)
Jewish _{M2}	–	–	–	0.045 (0.099)	0.094 (0.081)	0.107 (0.072)
Other religion _{M2}	–	–	–	0.009 (0.119)	0.019 (0.077)	0.023 (0.070)
Homosexual/bisexual _{M2}	–	–	–	0.081 (0.097)	0.034 (0.079)	0.070 (0.067)
Past Chronic pain _{M2}	–	–	–	0.123** (0.038)	0.250** (0.039)	0.300** (0.026)
Past Non-chronic pain _{M2}	–	–	–	0.166** (0.039)	–0.023 (0.044)	0.040 (0.025)
Past Moderate-to-severe K6 _{M2}	–	–	–	0.546** (0.047)	–0.197 (0.109)	0.008 (0.032)
ADLs (range: 1–4) _{M2}	–	–	–	0.115** (0.041)	0.023 (0.038)	0.068** (0.025)
Overweight or obese _{M2}	–	–	–	–0.020 (0.034)	0.031 (0.025)	0.028 (0.022)
Height _{M2}	–	–	–	–0.003 (0.007)	0.005 (0.004)	0.004 (0.004)
Disabled _{M2}	–	–	–	–0.116 (0.197)	0.157 (0.120)	0.114 (0.103)
Health insurance _{M2}	–	–	–	–0.073 (0.078)	–0.018 (0.058)	–0.048 (0.047)
Employed _{M2}	–	–	–	0.082 (0.066)	–0.191** (0.056)	–0.160** (0.049)
INSTRUMENTS						
Daily discrimination scale (range: 0–27) _{M2}	0.019** (0.005)	–	–	0.010* (0.004)	–	–
Lifetime discrimination scale (range: 0–9) _{M2}	0.044** (0.013)	–	–	0.026* (0.013)	–	–

(continued on next page)

Table 4 (continued)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	First stage	Second stage	OLS	First stage	Second stage	OLS
Constant	1.301** (0.406)	−0.524 (0.315)	−0.048 (0.254)	1.715** (0.637)	−0.841 (0.549)	−0.204 (0.398)
Observations	2119	2119	2119	1908	1908	1908
F-stat	40.87	4.437	9.370	6.522	10.22	6.522

M2: MIDUS II (2004–2006), M3: MIDUS III (2012–2013). ** $p \leq 0.01$, * $p \leq 0.05$ Robust standard errors in parentheses. First and second stages of two-stage least squares are presented in columns 1, 2 and 4, 5. Ordinary least squares results are presented in columns 3 and 6. Equations 4 through 6 also include, but do not report, occupational categories and industry categories.

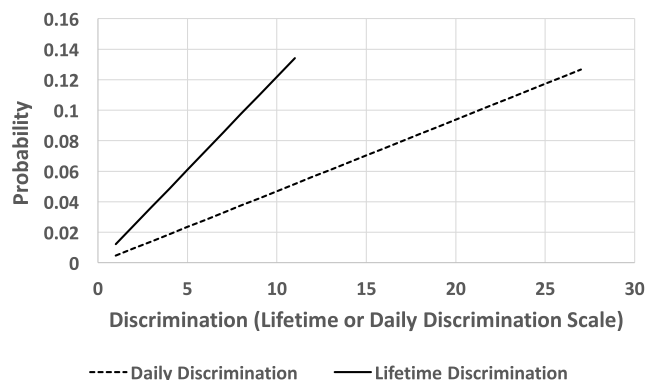


Fig. 1. Probability of developing chronic pain due to experiencing varying amounts of discrimination.

may also be adaptable to other forms of discrimination (Williams and Mohammed, 2013b). Our finding that approximately 4.1 million people likely suffer from chronic pain, chronic pain that is caused by psychological distress due to discrimination, is an important motivator to find effective and lasting solutions.

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Conflicts of interest

None.

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