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Discrimination Hurts: The Effect of Discrimination on the Development of Chronic Pain

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1 Discrimination Hurts: The Effect of Discrimination on the Development of Chronic Pain**4 ABSTRACT**

5 We examine the hypothesis that psychological distress due to perceived discrimination can result
6 in chronic pain, where perceived discrimination is based on age, gender, race, ethnicity,
7 disability, sexual orientation, height/weight, religion, and other characteristics. Using a sample of
8 1,908 individuals from the two most recent waves (2004-2006 and 2013-2014) of panel data
9 from the National Survey of Midlife Development in the United States, we apply instrumental
10 variables regression where measures of daily and lifetime perceived discrimination are
11 instruments whose effects on chronic pain are mediated by psychological distress. We find
12 statistically significant dose-response relationships between daily perceived discrimination and
13 psychological distress, between lifetime perceived discrimination and psychological distress, and
14 between psychological distress and chronic pain. Based on our instrumental variables regression
15 model, we estimate that 4.1 million people in the US in 2016, aged 40 and older, experience
16 chronic pain that is caused by increased psychological distress, where psychological stress has
17 increased due to perceived discrimination.

18
19 **Keywords:** Discrimination; psychological distress; chronic pain; instrumental variables

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26

27 Chronic pain is a major health concern in the US. Chronic pain affects over 30% of the
28 population. Of this group, approximately one-fifth experience mild pain (nagging and annoying
29 but does not interfere with activities of daily living), almost half experience moderate pain
30 (significantly interferes with activities of daily living), and approximately one-third experience
31 severe pain (rendering a person unable to perform activities of daily living) (Johannes et al.,
32 2010; National Institutes of Health, 2003). Chronic pain places a burden not only on individuals,
33 but also on society, costing the US economy \$261-\$300 billion annually in health care
34 expenditures, and another \$299-\$335 billion due to decreased productivity (Gaskin and Richard,
35 2012).

36 There is significant evidence that perceived discrimination is correlated with chronic pain.
37 Among African-Americans the relationship between perceived discrimination and chronic pain
38 and low-back pain persists even after controlling for socioeconomic and health-related
39 characteristics, and the relationship between chronic pain and perceived discrimination is
40 significantly different between African-Americans and non-Hispanic whites (Burgess et al.,
41 2009; Goodin et al., 2013; Edwards, 2008).

42 A related study of African-Americans with sickle-cell disease found a positive association
43 between perceived discrimination from healthcare providers (based on disease status) and daily
44 chronic pain and the burden of pain (Haywood et al., 2014). However, others have found that,
45 with regard to this group, such perceived discrimination only had an impact on laboratory-
46 induced pain (Mathur et al., 2016).

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

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

56 A large literature finds an association between perceived discrimination and psychological
57 distress or diminished psychological well-being (Schmitt et al., 2014; Torres, 2015; Ikram et al.,
58 2014; Schaafsma, 2011; Pascoe and Richman 2009; Williams, Neighbors, and Jackson, 2003;
59 Kessler, Mickelson, and Williams, 1999). Causal evidence of this association comes from human
60 experimental evidence that the level of pervasiveness of perceived discrimination, defined as the
61 frequency of discrimination and the number of contexts in which it occurs, is fundamental to
62 perceived discrimination having harmful psychological effects (Schmitt et al., 2014). In other
63 words, perceived discrimination causes psychological harm when it is more pervasive,
64 suggesting a dose-response relationship.

65 The next step in the causal chain is between psychological distress and pain. Lumley's
66 (2011) review of the biopsychosocial literature on pain and emotion shows that psychological
67 distress plays a large role in the experience of pain (Lumley et al., 2011). In fact, while tissue
68 damage from injury or disease often precedes pain, a large literature finds that pain is also often

69 preceded by psychological distress (Currie and Wang, 2005; Mykletun et al. 2011; Knaster et al.
70 2012; Afari et al. 2014, Phyomaung et al., 2014; Aro et al. 2015; Tegethoff et al., 2017).

71 The process by which psychological distress may result in pain is no longer a black box.
72 Consider anxiety, a type of psychological distress, that consists of negative affect based on
73 apprehension about anticipated future threats that have uncertain outcomes (Olango and Finn,
74 2013). The resulting hypervigilance from such anxiety can result in neurobiological changes that
75 can result in hyperalgesia (increased sensitivity to pain) (Olango and Finn, 2013). This appears to
76 be an adaptive response, since heightened pain sensitivity allows potential threats to be detected
77 more readily (Olang and Finn, 2013).

78 Human studies have found that experimentally-induced anxiety, in the form of pain-relevant
79 information, can cause hyperalgesia (Schumacher and Velden 1984; Weisenberg et al., 1984;
80 Dougher 1979; Cornwall and Donderi 1988; Rhudy and Meagher 2000; Williams and Rhudy
81 2007; Thompson et al. 2008). Human studies have even found that not only increased sensitivity
82 to pain, but actual pain itself can be induced in subjects by experimentally inducing anxiety
83 (Schweiger and Parducci 1981; Bayer, Baer, and Early 1991; Leistad et al. 2005; Collaca and
84 Benedetti, 2007).

85 Since there is significant overlap between anxiety and depression (another form of
86 psychological distress) (Eysenck and Fajkowska, 2017), hyperalgesia and the initiation of pain
87 may also occur as part of at least some types of depression (Trivedi, 2004; Thompson et al.,
88 2016; Tikasz et al., 2016). Taken together, the above studies suggest that psychological distress
89 can both heighten sensitivity to existing pain and also induce pain where there was previously no
90 pain.

91 A key finding from the literature on hyperalgesia is that hyperalgesia can occur when
92 stressors are repetitive and moderately intense (Olango and Finn, 2013). This mirrors the key
93 finding in the literature on perceived discrimination and diminished psychological well-being:
94 that the pervasiveness of perceived discrimination is fundamental to whether psychological harm
95 occurs.

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

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

108 Discrimination may be based on a variety of characteristics (race, ethnicity, gender, age,
109 religion, sexual orientation, physical appearance, obesity, etc.). We focus not on these
110 characteristics, but on the influence of discriminatory experiences in inducing chronic pain via
111 psychological distress. We use measures of perceived discrimination that capture a wide variety
112 of ways in which people may experience discrimination (Kessler, Mickelson, and Williams,

113 1999). Our results will thus be applicable to perceived discrimination that occurs for any reason,
114 if it results in the psychological distress that we measure in this study.

115

116 **METHODS**

117 Data

118 We use data from the National Survey of Midlife Development (MIDUS) obtained from the
119 Inter-University Consortium for Political and Social Research. MIDUS is a longitudinal panel of
120 US adults that began in 1995. There have been three waves of data: MIDUS I (1995-1996),
121 MIDUS II (2004-2006) and MIDUS III (2013-2014). The original MIDUS I random digit dialing
122 sample included a nationally representative sample of US adults, an oversampling of five
123 metropolitan areas, a sample of the national sample respondents' siblings, and a national sample
124 of twins. The data were collected by phone interviews and self-administered questionnaires. All
125 racial/ethnic groups were included in the sample. Retention rates in subsequent waves were
126 higher among women, whites, married people, and people with more education and better health
127 (Radler and Ryff, 2010). Since there is no measure of chronic pain in MIDUS I, we only use data
128 from MIDUS II and MIDUS III, which both contain measures of chronic pain (Ryff et al., 2017a,
129 2017b).

130

131 Measures

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

136 Chronic pain includes pain occurring anywhere in the body. To construct an indicator of
137 chronic pain, we first considered the MIDUS screening question, “Do you have chronic pain,
138 that is do you have pain that persists beyond the time of normal healing and has lasted anywhere
139 from a few months to many years?” For those answering “yes”, we examined their score on the
140 Brief Pain Inventory (BPI) interference scale, a valid and reliable instrument for assessing the
141 extent to which pain has interfered with seven daily activities: sleep, mood, enjoyment,
142 relationships with others, general activity, walking, and work, using a zero (did not interfere) to
143 10 (completely interfered) scale (Raichle et al. 2006; Williams et al. 2006). Shortened
144 interference scales are often used as some items may not be appropriate for all classes of patients
145 (Bjornnes et al., 2014; Cowan et al., 2006; Harding et al., 2010). Cronbach’s alpha for the
146 shortened scale used here (the questions on walking and work are not available in the MIDUS
147 data) is 0.95. No other questions on chronic pain are available in MIDUS I, II, or III. We
148 constructed a binary variable and coded as one those with both a positive screen and a positive
149 BPI as having chronic pain that was sufficient to result in at least some interference with
150 ordinary life activities. All else was coded as zero.

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

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

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

162 Psychological distress was measured using the valid and reliable K6 (Kessler et al., 2002).
163 Cronbach's alpha is 0.84. The K6 is based on six questions: "During the past 30 days, how much
164 of the time did you feel: nervous, hopeless, worthless, restless or fidgety, so sad that nothing
165 could cheer you up, that everything was an effort?" The answers to each of the questions (never,
166 a little of the time, some of the time, most of the time, all of the time) are coded zero to four and
167 then summed yielding a range from zero to 24. Scores of 13 or higher indicate severe
168 psychological distress that is indicative of serious mental illness, whereas scores of five to 12
169 indicate moderate psychological distress (Prochaska et al., 2012). We use the K6 in its
170 continuous form following Kessler, Mickelson, and Williams (1999), Andrés (2004), Flint et al.
171 (2013), McKenzie et al. (2014), Oshio (2014), and Foster et al. (2016).

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

179 Control variables include age and its square, sex (male, female), race/ethnicity (white, black,
180 Hispanic, Asian/Pacific Islander, other race), marital status (single, married, divorced, separated,

181 widowed), education (less than high school, high school, some college, bachelors, graduate
182 school), relevant personality traits (neuroticism, conscientiousness, and agreeableness), religion
183 (none, Protestant, Catholic/Orthodox, Jewish, other), sexual preference (heterosexual,
184 homosexual/bisexual), disability status, activities of daily living, height, obesity/overweight
185 status, past pain status (no pain, chronic pain, non-chronic pain), past moderate-to-severe
186 psychological distress (yes/no), employment, health insurance status, occupation category (9
187 categories), industry category (12 categories), and household income (equivalized by accounting
188 for household size (Hagenaars, de Vos, and Zaidi, 1994).

189

190 Conceptual and Statistical Models

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

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

204 distress. This can also result in bias. Each type of bias must be removed in order to obtain
205 consistent estimates.

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

211 Specifically, we employ both a two-stage least squares (2SLS) linear probability model to
212 determine the local average treatment effect (LATE) of psychological distress on the probability
213 of experiencing chronic pain, where psychological distress is only due to perceived
214 discrimination. This model is appropriate when the mean of the dependent variable is in the
215 range of [0.2, 0.8] (Cox, 1970). We do not use control function methods to apply instrumental
216 variables to nonlinear models such as probit or logit (e.g., two-stage residual inclusion models
217 (2SRI)) since this approach can result in substantially biased estimates of the LATE in contexts
218 where the marginal group of people who suffer psychological distress and subsequent chronic
219 pain due to perceived discrimination are unique in the sense that they react differently to
220 perceived discrimination than the general population (Chapman and Brooks, 2016).

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

227 current psychological distress from equation 1 is substituted for current psychological distress in
 228 equation 2, and the standard errors are appropriately adjusted.

229
 230
$$\text{PsychologicalDistress} = \alpha_0 + \alpha_1 \text{PastDiscrimination} + \alpha_2 \text{Controls} + \eta \quad (1)$$

231
 232
$$\text{Pr}(\text{Chronic Pain}) = \beta_0 + \beta_1 \widehat{\text{PsychologicalDistress}} + \beta_2 \text{Controls} + \varepsilon \quad (2)$$

233
 234 Our instruments, the lifetime and daily perceived discrimination scales from MIDUS II, must
 235 satisfy standard validity criteria. They must (1) correlate strongly with current psychological
 236 distress, but (2) not correlate with the error term in the second stage (Wooldridge, 2010). The
 237 first criterion can be tested using an Olea and Pflueger (2013) weak instrument test that is robust
 238 to heteroscedasticity and serial correlation. The second criterion can be divided into two sub-
 239 criteria, (2a) independence from the chronic pain outcome, conditional on the covariates; and
 240 (2b) having no effect on the chronic pain outcome other than through the first-stage pathway of
 241 psychological distress (Angrist and Pischke, 2009). These sub-criteria can be tested using a
 242 standard overidentification test that assumes at least one of the instruments is valid. We add an
 243 additional instrument that is necessarily valid for purposes of this test.

244 Including the correct set of covariates allows us to achieve statistical independence with
 245 regard to the perceived discrimination scales, such that these scales will have no effect on
 246 chronic pain other than through psychological distress. Both scales relate to perceived
 247 discriminatory acts that are based on a defined list of characteristics. To the extent that any of
 248 these characteristics are risk factors for chronic pain and are also associated with psychological
 249 distress, they must be included in the regression equation in order to establish the validity of the
 250 perceived discrimination scales as instruments. In addition, including variables that capture the

251 effect of perceived discrimination on health habits and ultimately health status is also essential in
252 order to control for this alternative pathway between perceived discrimination and chronic pain.

253 Age, gender, race/ethnicity, religion, height and weight (obesity), physical disability, sexual
254 orientation, occupation, financial status, and education, have all been found to be risk factors for
255 chronic pain (Yu et al., 2006; McBeth and Jones, 2007; Croft, van der Windt, Boardman, and
256 Blyth, 2010; Cimmino, Ferrone, and Cutolo, 2011; Roberts et al., 2013; VanDenKerkhof et al.,
257 2013; Taylor et al., 2014; Younger, 2015). These factors are also likely to affect psychological
258 distress. We thus include controls for each. To account for the “other” category, we include the
259 personality trait neuroticism, since those with higher trait neuroticism may be more sensitive in
260 their perception of discriminatory behavior than others (Huebner, Nemeroff, and Davis, 2005).
261 Trait neuroticism is also a risk factor for chronic pain and will obviously be correlated with
262 psychological distress (Charles et al., 1999; VanDenKerkhof et al., 2013; Boggero et al., 2014).

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

274 through which perceived discrimination may impact chronic pain is through psychological
275 distress.

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

279

280 **RESULTS**

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

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

295 Table 3 presents additional descriptive statistics. As of MIDUS II, the average age is
296 approximately 54, ranges from 30 to 84, and approximately 19% of individuals in the sample

297 suffer from moderate-to-severe psychological distress. As of MIDUS III, approximately 33% of
298 individuals suffered from chronic pain.

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

303 The mean value of the lifetime perceived discrimination scale is slightly less than one.
304 Approximately 62% of individuals experienced no lifetime discrimination, approximately 16%
305 of individuals experienced one category of major discrimination, approximately 11% of
306 individuals experienced two or more categories of major discrimination, and approximately 2%
307 of individuals experienced five or more categories of major discrimination.

308 Table 4 presents the final results. We used both the untransformed and natural logarithm of
309 the K6 and found potential bias was minimized using the natural logarithm of the K6. Columns 1
310 through 3 present a model with a limited set of controls, while columns 4 through 6 present a
311 model with a comprehensive set of controls. We focus on columns 4 through 6. The two scales
312 of discrimination used as instruments each have a strong correlation with psychological distress,
313 rejecting the hypothesis of weak instruments (effective F -statistic of the joint strength of the
314 instruments = 7.094 > 7.092 critical value for 5% of worst case bias) and showing a clear dose-
315 response relationship. For every unit increase in the daily perceived discrimination scale,
316 psychological distress increases by 0.01 ($p = 0.03$) or 1.0% ($1.0\% = 100 \times [\exp(.010) - 1]$). The
317 daily perceived discrimination scale varies in the sample from zero to 27, so the largest
318 measurable increase in psychological distress due to daily perceived discrimination is 27.0%
319 ($27.0\% = 27 \times 1.0\%$)

320 In contrast, for every one unit increase in the lifetime perceived discrimination scale, the
321 psychological distress scale increases by 0.026 ($p = 0.05$) or 2.6% ($2.6\% = 100 \times [\exp(.026) -$
322 $1]$). The lifetime perceived discrimination scale varies in the sample from zero to nine, so the
323 largest measurable increase in psychological distress due to daily discrimination is 23.4% (23.4%
324 $= 9 \times 2.6\%$). The maximum measurable increase in psychological distress due to all forms of
325 discrimination is thus 50.4%.

326 Column 5 of Table 4 shows that the probability of experiencing chronic pain increases by
327 0.469 percentage points ($0.469, p = 0.01$) with every 1% increase in the psychological distress
328 scale. The corrected estimate is almost five times as large as the OLS estimate, shown in Column
329 6, and is statistically different from the OLS estimate ($\chi^2: 5.15, p = 0.02$).

330 We also conducted overidentification tests, which evaluate the hypothesis that the
331 overidentified instrument is valid (e.g., uncorrelated with the error term and correctly excluded
332 from the second-stage equation) assuming that at least one other instrument is valid. Since our
333 two instruments measure different aspects of discrimination, we use an additional instrument to
334 obtain valid overidentification tests: death of a family member within approximately the last five
335 years, a dummy variable that is equal to one if one's father, mother, sibling, and/or child died
336 during that period. The death of a family member is a random event that can cause psychological
337 distress but is exogenous. We test each perceived discrimination instrument separately against
338 the death of a family member using Hansen's J test. We were unable to reject the null hypothesis
339 of exogeneity for either daily perceived discrimination ($\chi^2: 0.65, p = 0.42$) or lifetime perceived
340 discrimination ($\chi^2: 0.60, p = 0.44$). Thus, there is no evidence that perceived discrimination is
341 correlated with the error term.

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

347 To compute the percentage of the population, as represented by this cohort, that experiences
348 chronic pain due to perceived discrimination, we take the average level of each type of
349 discrimination from Table 2 and multiply these levels by their respective parameters in column 4
350 of Table 4 [$0.06 = (0.01 \times 3.6) + (0.026 \times 0.84)$]. We then multiply the result by the average
351 effect of psychological distress on the probability of experiencing chronic pain, 0.469, in column
352 5 of Table 4 to obtain 0.028 ($0.028 = 0.469 \times 0.06$, $p = 0.01$). If we reasonably posit that our
353 sample is largely representative of the population aged 40 and older (as of MIDUS III), which
354 represents 147 million people in 2016 (US Census, 2017), then our estimates imply that
355 approximately 4.1 million people (0.028×147 million) suffer chronic pain due to their
356 experience of discrimination.

357

358 **DISCUSSION**

359 This is the first study to estimate the causal effect of psychological distress on chronic pain,
360 where variation in psychological distress is only due to variation in perceived discrimination. We
361 used instrumental variable models to correct for bias in the estimated parameter of psychological
362 distress, bias that may be due to reverse causality, measurement error, and/or omitted variables
363 (Wooldridge, 2010). A dose-response relationship is clearly evident, with lifetime perceived
364 discrimination having a stronger impact on the development of pain than daily perceived

365 discrimination as shown in Figure 1. These findings are consistent with a broad human
366 experimental literature that demonstrates the negative effects of perceived discrimination on
367 psychological well-being and the effects of psychologically distressing experiences on the
368 development of pain (Schmitt et al. 2014; Olanga and Finn, 2013; Jennings, 2013; Schweiger
369 and Parducci, 1981).

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

376

377 Limitations

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

383

384 Conclusions

385 Much has been written about racism, gender inequality and other discriminatory elements
386 embedded within societal structures, and their impacts on health (Williams and Mohammed,
387 2013a; Hudson et al., 2013; Geronimus, 2013; Gilbert et al., 2016). Our findings focus on one of

388 many pathways posited between discrimination and health (Williams and Mohammed, 2013a), in
389 particular, the pathway where psychological responses (Adler and Snibbe, 2003) affect health
390 outcomes via neurobiological mechanisms (Geronimus, 2013). Numerous approaches to
391 reducing and even eliminating racial discrimination have been put forth, many of which may also
392 be adaptable to other forms of discrimination (Williams and Mohammed, 2013b). Our finding
393 that approximately 4.1 million people likely suffer from chronic pain, chronic pain that is caused
394 by psychological distress due to discrimination, is an important motivator to find effective and
395 lasting solutions.

396

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707 **TABLE 1. Discrimination Questions**

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.

You were discouraged by a teacher or advisor from seeking high 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.

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.

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?

708 Source: MIDUS II, 2004-2006.

709

710 **TABLE 2. Perceived Reasons for Discrimination – MIDUS II (Overall Sample)**

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

711 ^aSource: MIDUS II, 2004-2006. ^bSource: MIDUS II Milwaukee African American Sample, 2005-2006.

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TABLE 3. Descriptive Statistics

VARIABLES	Mean	SD
MIDUS III		
Any chronic pain with a positive BPI	0.334	-
Non-specific psychological distress (range: 0-24)	2.528	3.178
MIDUS II		
Neuroticism (Big 5) (range:	2.023	0.625
Conscientiousness (Big 5) (range:	3.440	0.434
Agreeableness (Big 5) (range:	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)	88,337.14	70,224.23
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: 0-11)	0.844	1.432

Source: MIDUS II (2004-2006) and MIDUS II (2013-2014). SD: Standard deviation. Occupational category (9 categories) and industry category (12 categories) are included but not reported.

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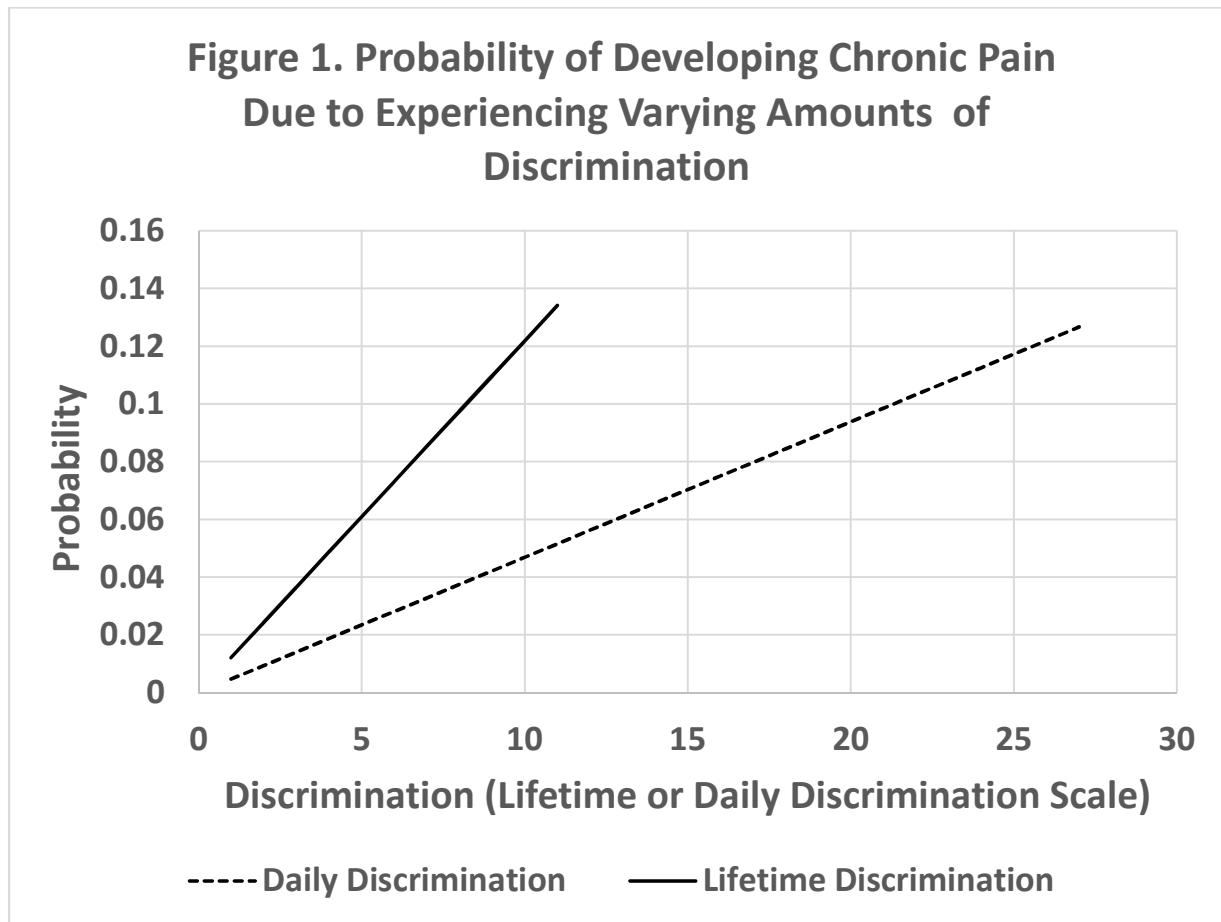
731

732 **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: 0-24) _{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: 1-4) _{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: 1-4) _{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 (0.067)	-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 (range: 0-27) _{M2}	0.019** (0.005)	-	-	0.010* (0.004)	-	-
Lifetime discrimination scale (range: 0-11) _{M2}	0.044** (0.013)	-	-	0.026* (0.013)	-	-
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	2,119	2,119	2,119	1,908	1,908	1,908
F-stat	40.87	4.437	9.370	6.522	10.22	6.522

733 M2: MIDUS II (2004-2006), M3: MIDUS III (2012-2013). ** p<0.01, * p<0.05 Robust standard errors in
734 parentheses. First and second stages of two-stage least squares are presented in columns 1, 2 and 3,4. Ordinary least
735 squares results are presented in columns 3 and 6. All equations also include, but do not report occupational category
736 and industry categories.
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ACCEPTED

Research Highlights

- Discrimination, mediated by psychological distress, causes chronic physical pain.
- There is a dose-response relationship between discrimination and chronic pain.
- 4.1 million people in the US experience chronic physical pain due to discrimination.