



# Association of perceived discrimination with the risk of depression among US older adults: A prospective population-based cohort study

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## ARTICLE INFO

### Keywords:

Perceived discrimination  
Depression  
Older adults  
Dose-response relationship

## ABSTRACT

**Aims:** Association between perceived discrimination and depression has been demonstrated in some sources of discrimination, such as age, sex, and race. However, the effects of perceived discrimination both in any domain and each domain on development of depression are still unclear. We aimed to estimate the association of any and each domain of perceived discrimination with the risk of depression among US older adults.

**Methods:** We did a population-based cohort study using eight waves (from 2006 to 2020) of data from the Health and Retirement Study (HRS), a nationally representative study of US older adults aged 51 years and above. Perceived discrimination was measured by the shortened 5-item version of Williams' discrimination scale, including five domains (less courtesy, service setting, not smart, threatened or harassed, and medical setting). Depressive symptoms were assessed with shortened 8-item version of the Center for Epidemiological Depression scale (8-item CES-D). Cox proportional hazards models were used to estimate the crude and adjusted hazards ratio (HRs) and their 95 % confidence intervals (CIs) between perceived discrimination and risk of depression, after controlling for potential confounders.

**Results:** A total of 18502 participants were included in our final analyses. 42.8 % of them had any perceived discrimination at baseline, and the most prevalent perceived discrimination was feeling less courtesy, which was observed in 5893 people (31.6 %). During a median of 9.8 years follow-up, 44.7 % of participants developed depression. The risk of depression was 46 % (adjusted HR: 1.46, 95 % CI: 1.39–1.52) higher among people with perceived discrimination than those without. The associations between perceived discrimination in each domain and risk of depression were all prominent.

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<https://doi.org/10.1016/j.heliyon.2023.e23843>

Received 17 August 2023; Received in revised form 22 November 2023; Accepted 13 December 2023

Available online 21 December 2023

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**Conclusions:** Both any and each domain of perceived discrimination were associated with an increased risk of depression. Considering the high prevalence of perceived discrimination and the following poor health outcomes, our findings suggested the integrated measures of providing public education and diversified communication to reduce discrimination, as well as accessible emotional supports to prevent depression are urgently needed.

## 1. Introduction

Depression is a common illness that attributes to a substantial global burden of disease as the leading mental cause of mortality for all ages [1]. The lifetime risk of depression is nearly 15–18 %, meaning almost one in five people would experience one episode at some point in their lifetime [2]. Across the lifespan, the onset of depression could have a lasting and profound impact on people's health. Plenty of studies demonstrated that depression was directly associated with poor quality of life [3]. Moreover, as a negative factor, the appearance of depression can lead to a lot of chronic diseases, such as cognitive deficits, cardiovascular diseases, etc. [4,5] What's worse, in addition to the individual influence, depression can cause premature mortality to further impair social functioning and economic productivity [6]. However, the impacts of depression are neither well understood nor acknowledged, and the globe still takes an insufficient response to prevent and treat depression, though its importance is not distinct from other diseases that people face [6].

Discrimination is defined as treating one individual less favorably than another due to a protected characteristic, such as sex, age, race, religion, weight, physical ability, etc. [7] and is considered to be a lasting chronic stressor. Perceived discrimination reflects the direct subjective experience of discrimination, and has been shown to contribute to poor physical and mental health in individuals across different groups, which may be interpreted by increased proinflammatory cytokines linked to acute and chronic stress exposure [8]. For example, plenty of studies has demonstrated that perceived discrimination was associated with various chronic diseases including hypertension, cardiovascular diseases, cognitive impairment and so on [9], as well as mental diseases including anxiety, depression and loneliness [10–12]. The prevalence of perceived discrimination was reported highly in the United States (US), with 25.2%–43.5 % of US population experiencing discrimination [13,14]. This rate varied across different racial groups. It was estimated that as high as 69.45 % of Black individuals in US experienced discrimination from time to time or regularly in comparison to the 29.61 % of Whites [14]. In addition to the impacts on individuals' health, such a high prevalence of perceived discrimination could lead to a numerous disease burden for family and society because of its association with all-cause mortality [15]. Therefore, it is an urgent but pending issue to eliminate the discrimination in US.

A series of studies have presented a significant relationship between perceived discrimination and depression or depressive symptoms [7,12]. These studies were mostly conducted in England and US. Current researches about perceived discrimination and depression among US older adults were mainly about one specific type of perceived discrimination, including perceived age, weight, and healthcare discrimination [16–18]. For example, one study using data of the Health and Retirement Study (HRS) found that perceived weight discrimination was significantly associated with increased risk of depressive symptoms and mediated the prospective association between obesity and depressive symptoms [17]. Similar associations were also presented between perceived age or healthcare discrimination and depression [12,16]. Additionally, the majority of population concerned in current studies were vulnerable population, such as people living with HIV; Black minority; lesbian, gay, bisexual and transgender populations [12,19,20]. For instance, White et al. [12] found that Black older adults with persistently high and moderate general discrimination trajectories were more like to have higher rate of depressive symptoms than those in persistently low trajectory. Although the association between perceived discrimination and depression has been discussed a lot, diverse effects of any and each discrimination on depression and the relationship between changes of discrimination levels and risk of depression are still unknown.

Therefore, in this cohort study, we used 8 waves data of HRS including assessment of perceived discrimination from 2006 to 2020 to estimate the association of perceived discrimination with risk of depression among older US adults. We further explored the dose-response relationship between perceived discrimination and depression to evaluate the risk of depression by different levels of perceived discrimination.

## 2. Methods

### 2.1. Study design and participants

We used data from the Health and Retirement Study (HRS), a nationally representative population-based cohort of older community-dwelling adults [21]. The HRS is a longitudinal study supported by the National Institute on Aging that measures changes in the health of Americans as they age and is nationally representative of persons older than 50 years. The HRS was initiated in 1992 and survey data were collected every 2 years. It has recruited 15 waves of 11 000 to 23 000 participants each from 1992 to 2020 and continues to recruit. New participants have periodically been recruited to remain representative of the US population. HRS interviews are conducted by phone or face to face with the overall response rate >80 % [21]. All HRS respondents provided written informed consent for their participation, and data collection was approved by the by the University of Michigan Institutional Review Board. From 1992 to 2020, the total sample size was 42 406. Given that perceived discrimination was first investigated in wave 8 (2006), we used the waves 8–15 HRS data (2006–2020) in this study. Of the 31465 participants interviewed from 2006 to 2020, a total of 23295 participants did discrimination assessment at baseline. Participants aged above 50 years who did assessment on discrimination without

any depression or other diagnosed psychiatric diseases at baseline and were followed up at least one wave later were eligible to be included in this study. We excluded 8161 participants without assessment on discrimination at baseline, 4478 participants with depression or other psychiatric diseases at baseline, and 315 participants with missing data on depression, leaving a final sample of 18502 participants (Fig. 1).

## 2.2. Perceived discrimination

At the baseline interview on discrimination, HRS participants completed the shortened version of Williams' discrimination scale. The scale consisted of five items to assess the frequency of participants' experiences of discrimination on a scale ranging from one to six (one "almost every day", two "at least once a week", three "a few times a month", four "a few times a year", five "less than once a year", or six "never"), which had been validated among older adults with Cronbach's alpha 0.80 [22,23]. The five items included: (1) "You are treated with less courtesy or respect than other people"; (2) "You receive poorer service than other people at restaurants or stores"; (3) "People act as if they think you are not smart"; (4) "People act as if they are afraid of you"; and (5) "You are threatened or harassed." [23] The above 5 items measured 5 domains (less courtesy, service setting, not smart, threatened or harassed, and medical setting) of perceived discrimination, respectively [24]. In consistent with previous studies [23,24], we reverse-coded each discrimination scale's response item ranging from 0 (never) to 5 (almost every day), and we divided the answers of each item into two groups (a few times or more a year vs less than once a year or never) to indicate whether participants had experienced discrimination in the past year [24]. In this study, perceived discrimination was defined as experienced discrimination in any of the 5 domains. The exposure group was participants who experienced discrimination at baseline in the cohort. The control group was those who did not experience any discrimination at baseline.

## 2.3. Outcomes

The primary outcome of this study was the incidence of probable depression, which was defined as having a depression symptom score above established cut point during the follow-up waves [25]. Depressive symptoms were assessed with the revised shortened 8-item version of the Center for Epidemiological Depression scale (8-item CES-D), which was developed from the full 20-item CES-D for preferable use in older adults and had been extensively validated among US older adults with high correlation with the full version (Person  $r = 0.88$ ) and a Cronbach's alpha of 0.78 [26]. We used the recommended threshold derived from validation work among older adults, which classified probable depression among adults if they experienced 3 or more symptoms for the 8-item CES-D [25].

## 2.4. Covariates

This study included covariates (baseline sociodemographic characteristics, healthy lifestyle, health status) that theory and empirical evidence suggest are likely associated with discrimination and the risk of depression. Baseline sociodemographic characteristics included age groups ( $\leq 55$  years old, 56–64 years old, or  $\geq 65$  years old), gender (male or female), race (White/Caucasian, Black/African American, or other), marital status (married/partnered, divorced/separated, widowed, or unmarried), educational level (less than upper secondary, upper secondary and vocational training, or tertiary), and total wealth by quantiles. Healthy lifestyle included smoke (never, former smoker, or current smoker), drink (yes or no). Health status included self-reported health (good or poor), diagnosed chronic diseases (diabetes, hypertension, cancer, lung disease, heart disease, or stroke), and measured body mass index (BMI). BMI was divided into four groups, including underweight ( $\text{BMI} < 18.5 \text{ kg/m}^2$ ), normal weight ( $18.5\text{--}24.9 \text{ kg/m}^2$ ), overweight ( $25\text{--}29.9 \text{ kg/m}^2$ ), and obesity ( $\text{BMI} \geq 30 \text{ kg/m}^2$ ).

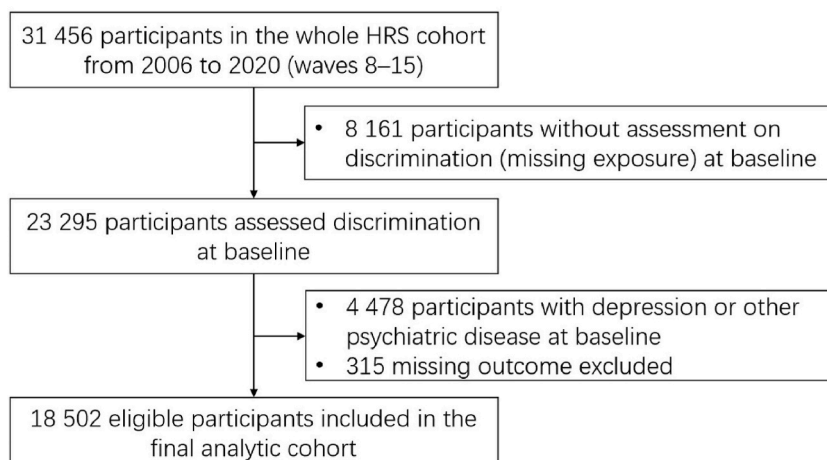


Fig. 1. Flowchart showing selection of the participants.

**Table 1**  
Prevalence of perceived discrimination by baseline characteristics.

Characteristics	N (%)	Perceived discrimination (%)	No perceived discrimination (%)	P value
Total	18502 (100.0)	7918 (42.8)	10584 (57.2)	
<b>Sociodemographic characteristics</b>				
Age group, years				<0.001*
≤55	9492 (51.3)	4425 (46.6)	5067 (53.4)	
56–64	5942 (32.1)	2462 (41.4)	3480 (58.6)	
≥65	3068 (16.6)	1031 (33.6)	2037 (66.4)	
Gender				<0.001*
Male	7947 (43.0)	3735 (47.0)	4212 (53.0)	
Female	10555 (57.0)	4183 (39.6)	6372 (60.4)	
Race				<0.001*
White/Caucasian	14141 (76.6)	5753 (40.7)	8388 (59.3)	
Black/African American	3038 (16.4)	1571 (51.7)	1467 (48.3)	
Other	1287 (7.0)	578 (44.9)	709 (55.1)	
Marital status				<0.001*
Married or partnered	14822 (80.1)	6218 (42.0)	8604 (58.0)	
Divorced or separated	1974 (10.7)	968 (49.0)	1006 (51.0)	
Widowed	954 (5.2)	342 (35.8)	612 (64.2)	
Unmarried	752 (4.0)	390 (51.9)	362 (48.1)	
Educational level				0.016*
Less than upper secondary	3042 (16.5)	1233 (40.5)	1809 (59.5)	
Upper secondary and vocational training	10850 (58.6)	4715 (43.5)	6135 (56.5)	
Tertiary	4609 (24.9)	1969 (42.7)	2640 (57.3)	
Total wealth by quantiles				<0.001*
Quartile 1 (the lowest)	3061 (16.6)	1450 (47.4)	1611 (52.6)	
Quartile 2	4412 (24.0)	1972 (44.7)	2440 (55.3)	
Quartile 3	5140 (28.0)	2160 (42.0)	2980 (58.0)	
Quartile 4 (the highest)	5775 (31.4)	2273 (39.4)	3502 (60.6)	
<b>Healthy lifestyle</b>				
Smoke				<0.001*
Never	8296 (45.1)	3336 (40.2)	4960 (59.8)	
Former smoker	6624 (36.0)	2882 (43.5)	3742 (56.5)	
Current smoker	3483 (18.9)	1661 (47.7)	1822 (52.3)	
Drink				0.218
No	6277 (33.9)	2647 (42.2)	3630 (57.8)	
Yes	12225 (66.1)	5271 (43.1)	6954 (56.9)	
<b>Health status</b>				
Self-reported health				<0.001*
Good	15630 (84.5)	6528 (41.8)	9102 (58.2)	
Poor	2872 (15.5)	1390 (48.4)	1482 (51.6)	
Number of chronic diseases				<0.001*
0	7675 (41.5)	3065 (39.9)	4610 (60.1)	
1	6235 (33.7)	2691 (43.2)	3544 (56.8)	
2	3113 (16.8)	1404 (45.1)	1709 (54.9)	
>2	1479 (8.0)	758 (51.3)	721 (48.7)	
Diabetes				<0.001*
No	16574 (89.6)	6953 (42.0)	9621 (58.0)	
Yes	1928 (10.4)	965 (50.1)	963 (49.9)	
Hypertension				<0.001*
No	11633 (62.9)	4817 (41.4)	6816 (58.6)	
Yes	6869 (37.1)	3101 (45.1)	3768 (54.9)	
Cancer				0.058
No	17389 (94.0)	7472 (43.0)	9917 (57.0)	
Yes	1113 (6.0)	446 (40.1)	667 (59.9)	
Lung disease				0.001*
No	17642 (95.4)	7501 (42.5)	10141 (57.5)	
Yes	860 (4.6)	417 (48.5)	443 (51.5)	
Heart disease				0.051
No	16524 (89.3)	7031 (42.6)	9493 (57.4)	
Yes	1978 (10.7)	887 (44.8)	1091 (55.2)	
Stroke				0.001*
No	18074 (97.7)	7702 (42.6)	10372 (57.4)	
Yes	428 (2.3)	216 (50.5)	212 (49.5)	
Body mass index, BMI (kg/m <sup>2</sup> )				<0.001*
Underweight (<18.5)	147 (0.8)	56 (38.1)	91 (61.9)	
Normal weight (18.5–24.9)	5715 (30.9)	2129 (37.3)	3586 (62.7)	
Overweight (25–29.9)	7389 (40.0)	3145 (42.6)	4244 (57.4)	
Obesity (≥30)	5221 (28.3)	2578 (49.4)	2643 (50.6)	

Missing data: race 36 (0.2 %), educational level 1 (0.0 %), smoke 99 (0.5 %), BMI 30 (0.2 %).

\*P < 0.05.

**Table 2**  
Associations between baseline characteristics and the incidence of depression.

	N	Incidence of depression (%)	P value
<b>Total</b>	18502	8275 (44.7)	
<b>Perceived discrimination in any domain</b>			<0.001*
No	10584	4296 (40.6)	
Yes	7918	3979 (50.3)	
<b>Five domains of perceived discrimination</b>			
<b>Less courtesy</b>			<0.001*
No	7947	5267 (41.6)	
Yes	10555	3008 (51.5)	
<b>Service setting</b>			<0.001*
No	15399	6671 (43.3)	
Yes	3103	1604 (51.7)	
<b>Not smart</b>			<0.001*
No	14478	6063 (41.9)	
Yes	4024	2212 (55.0)	
<b>Threatened or harassed</b>			<0.001*
No	16361	7238 (44.2)	
Yes	2141	1037 (48.4)	
<b>Medical setting</b>			<0.001*
No	17300	7578 (43.8)	
Yes	1202	697 (58.0)	
<b>Sociodemographic characteristics</b>			
<b>Age group, years</b>			<0.001*
≤55	9492	4052 (42.7)	
56–64	5942	2674 (45.0)	
≥65	3068	1549 (50.5)	
<b>Gender</b>			<0.001*
Male	7947	2911 (36.6)	
Female	10555	5364 (50.8)	
<b>Race</b>			<0.001*
White/Caucasian	14141	6286 (44.5)	
Black/African American	3038	1421 (46.8)	
Other	1287	555 (43.1)	
<b>Marital status</b>			<0.001*
Married or partnered	14822	6457 (43.6)	
Divorced or separated	1974	958 (48.5)	
Widowed	954	542 (56.8)	
Unmarried	752	318 (42.3)	
<b>Educational level</b>			0.016*
Less than upper secondary	3042	1842 (60.6)	
Upper secondary and vocational training	10850	4932 (45.5)	
Tertiary	4609	1501 (32.6)	
<b>Total wealth by quantiles</b>			<0.001*
Quartile 1 (the lowest)	3061	1746 (57.0)	
Quartile 2	4412	2130 (48.3)	
Quartile 3	5140	2209 (43.0)	
Quartile 4 (the highest)	5775	2148 (37.2)	
<b>Healthy lifestyle</b>			
<b>Smoke</b>			<0.001*
Never	8296	3465 (41.8)	
Former smoker	6624	2868 (43.3)	
Current smoker	3483	1893 (54.3)	
<b>Drink</b>			0.218
No	6277	3165 (50.4)	
Yes	12225	5110 (41.8)	
<b>Health status</b>			
<b>Self-reported health</b>			<0.001*
Good	15630	6478 (41.4)	
Poor	2872	1797 (62.6)	
<b>Number of chronic diseases</b>			<0.001*
0	7675	3005 (39.2)	
1	6235	2837 (45.5)	
2	3113	1579 (50.7)	
>2	1479	854 (57.7)	
<b>Diabetes</b>			<0.001*
No	16574	7320 (44.2)	
Yes	1928	955 (49.5)	
<b>Hypertension</b>			<0.001*
No	11633	4983 (42.8)	

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Table 2 (continued)

	N	Incidence of depression (%)	P value
Yes	6869	3292 (47.9)	
Cancer			0.058
No	17389	7744 (44.5)	
Yes	1113	531 (47.7)	
Lung disease			0.001*
No	17642	7751 (43.9)	
Yes	860	524 (60.9)	
Heart disease			0.051
No	16524	7278 (44.0)	
Yes	1978	997 (50.4)	
Stroke			0.001*
No	18074	8042 (44.5)	
Yes	428	233 (54.4)	
Body mass index, BMI (kg/m <sup>2</sup> )			<0.001*
Underweight (<18.5)	147	75 (51.0)	
Normal weight (18.5–24.9)	5715	2502 (43.8)	
Overweight (25–29.9)	7389	3229 (43.7)	
Obesity (≥30)	5221	2454 (47.0)	

Missing data: race 36 (0.2 %), educational level 1 (0.0 %), smoke 99 (0.5 %), BMI 30 (0.2 %).

\*P < 0.05.

## 2.5. Statistical analysis

We used the  $\chi^2$  test to compare the distributions of prevalence rates of perceived discrimination according to different baseline characteristics, which could reflect the difference of characteristics between exposure group (people with discrimination) and control group (people without discrimination), and also presented factors potentially associated with perceived discrimination. The incidence rates of depression among different discrimination groups and other baseline characteristics were also compared using the  $\chi^2$  test for primarily identifying which characteristics could influence the onset of depression. For each participant, we calculated person years of follow-up from the first investigate date on discrimination at baseline to the date of occurrence of study outcomes, last return of a valid follow-up questionnaire, or end of follow-up, whichever came first. Univariate and multivariate Cox proportional hazard models were used to estimate crude hazard ratios (CHRs) and adjusted hazard ratios (aHRs) with their 95 % confidence intervals (CIs) of depression. We analyzed perceived discrimination in any domain as well as each of the five domains (less courtesy, service setting, not smart, threatened or harassed, and medical setting). Cox proportional hazard models were tested for the proportion hazards assumption on the basis of Schoenfeld residuals, which was not found to be violated.

To examine the robustness of our findings, we performed sensitivity analyses by adjusting different confounders in the Cox proportional hazard models. In model 1, we used univariate Cox proportional hazard model and did not adjust for any confounders. In model 2, we used Cox proportional hazards model adjusted for baseline sociodemographic characteristics (age, gender, race, marital status, educational level, and total wealth) and healthy lifestyle variables (smoke, and drink). In model 3 (full model), we used Cox proportional hazards model adjusted for age, gender, race, marital status, educational level, total wealth, smoke, drink, self-reported health, chronic diseases, and BMI. To further consider the impact of death on the competitive risk for primary outcome (depression), we used competitive risk model in model 4, taking death as a competitive risk after adjustment of age, gender, race, marital status, educational level, total wealth, smoke, drink, self-reported health, chronic diseases, and BMI.

In the subgroup analysis, we divided participants into different subgroups on the basis of baseline characteristics. Among these baseline subgroups, we examined the associations between perceived discrimination and the incidence of depression after adjusting for other potential risk factors.

We further explore the dose-response relationship of scores on five perceived discrimination domains (all ranged from 0 to 5) with the incidence of depression in the Cox proportional hazards models. Dose-response analysis was widely used in various disciplines, such as Epidemiology, Environment and Pharmacology, to evaluate the relationship between changes in exposure levels and outcomes, and can reveal the difference for intensity of effects of diverse exposure on outcomes. Moreover, we calculated the perceived discrimination score in any domain using the median score of the five items to produce a discrimination scale ranging from 0 to 5, to analyze the dose-response relationship of score on total perceived discrimination in any domain with the risk of depression. Participants with score of perceived discrimination equal to 0 were defined as the reference group.

All analyses were done with Stata software, version 18. Two-sided p values of less than 0.05 were deemed to be statistically significant.

## 3. Results

### 3.1. Baseline characteristics of the study population

Of the included 18502 participants, the median age was 55 (IQR: 52, 60) years. 7947 (43.0 %) were male and 10555 (57.0 %) were female. 14141 (76.6 %) participants were White or Caucasian. 8296 (45.1 %) and 6277 (33.9 %) participants never smoke and never

drink, respectively. 15630 (84.5 %) participants had good self-reported health and 7675 (41.5 %) had no chronic diseases. Totally, 7918 (42.8 %) participants had any perceived discrimination at baseline. 5839 (31.6 %), 3103 (16.8 %), 4024 (21.7 %), 2141 (11.6 %) and 1202 (6.5 %) participants suffered from perceived discrimination in less courtesy, service setting, not smart, threatened or harassed, and medical setting, respectively (Table S1-S5). According to  $\chi^2$  tests' results, except drink, cancer, and heart disease, the distribution of prevalence rates of perceived discrimination was significantly different across baseline characteristics (all p-value <0.05; Table 1).

### 3.2. Perceived discrimination and risk of depression

During a median of 9.8 years follow-up, the incidence of depression was 44.7 % (8275/18502). As  $\chi^2$  tests' results showed (Table 2), except drink, cancer and heart disease, the incidence of depression was obviously diverse according to different characteristics of perceived discrimination in any domain, each domain of perceived discrimination, sociodemographic characteristics (age, gender, race, marital status, educational level, wealth), smoke, and health status (self-reported health, number of chronic diseases, diabetes, hypertension, cancer, lung disease, stroke, and BMI) with p-value <0.05.

In final adjusted model (model 3), participants with perceived discrimination in any domain at baseline had a 46 % (aHR: 1.46, 95 % CI: 1.39–1.52) higher risk of depression, compared to those without perceived discrimination in any domain (Table 3). Specifically, the risk of depression increased by 41 % (aHR: 1.41, 95 % CI: 1.35–1.48) among participants with perceived discrimination of less courtesy, 34 % (aHR: 1.34, 95 % CI: 1.27–1.42) among those with perceived discrimination of service setting, 49 % (aHR: 1.49, 95 % CI: 1.42–1.57) among those with perceived discrimination of not smart, 39 % (aHR: 1.39, 95 % CI: 1.30–1.49) among those with perceived discrimination of threatened or harassed and 76 % (aHR: 1.76, 95 % CI: 1.63–1.91) among those with perceived discrimination of medical setting, compared to those without relative type of perceived discrimination (Table 3).

In sensitivity analyses, similar results were observed after including different confounders in model 1 and model 2 as well as using competitive risk models in model 4.

### 3.3. Subgroup analyses

Across most subgroup characteristics, the association between perceived discrimination and risk of depression remained prominent (all p value < 0.01). An exception was BMI, for which we only found no increased risk of depression due to perceived discrimination in underweight participants (Fig. 2 and Table S6).

### 3.4. Dose-response relationships

The aHRs of depression for 1, 2, 3, 4, 5 score of perceived discrimination in any domain were 1.19 (95 % CI: 1.13–1.25), 1.53 (95 %

**Table 3**  
Associations of perceived discrimination with risk of depression in the multivariable models.

	Model 1		Model 2		Model 3		Model 4	
	cHR (95 % CI)	p value	aHR (95 % CI)	p value	aHR (95 % CI)	p value	aHR (95 % CI)	p value
Perceived discrimination in any domain								
No	1 (Ref)		1 (Ref)		1 (Ref)		1 (Ref)	
Yes	1.45 (1.39–1.51)	<0.001*	1.49 (1.42–1.55)	<0.001*	1.46 (1.39–1.52)	<0.001*	1.44 (1.38–1.51)	<0.001*
<b>Five domains of perceived discrimination</b>								
Less courtesy								
No	1 (Ref)		1 (Ref)		1 (Ref)		1 (Ref)	
Yes	1.42 (1.36–1.48)	<0.001*	1.44 (1.38–1.51)	<0.001*	1.41 (1.35–1.48)	<0.001*	1.41 (1.35–1.48)	<0.001*
Service setting								
No	1 (Ref)		1 (Ref)		1 (Ref)		1 (Ref)	
Yes	1.34 (1.27–1.42)	<0.001*	1.36 (1.29–1.44)	<0.001*	1.34 (1.27–1.42)	<0.001*	1.34 (1.26–1.41)	<0.001*
Not smart								
No	1 (Ref)		1 (Ref)		1 (Ref)		1 (Ref)	
Yes	1.61 (1.54–1.70)	<0.001*	1.53 (1.45–1.60)	<0.001*	1.49 (1.42–1.57)	<0.001*	1.60 (1.52–1.67)	<0.001*
Threatened or harassed								
No	1 (Ref)		1 (Ref)		1 (Ref)		1 (Ref)	
Yes	1.30 (1.22–1.39)	<0.001*	1.41 (1.32–1.51)	<0.001*	1.39 (1.30–1.49)	<0.001*	1.30 (1.21–1.38)	<0.001*
Medical setting								
No	1 (Ref)		1 (Ref)		1 (Ref)		1 (Ref)	
Yes	1.75 (1.62–1.89)	<0.001*	1.80 (1.67–1.95)	<0.001*	1.76 (1.63–1.91)	<0.001*	1.72 (1.59–1.86)	<0.001*

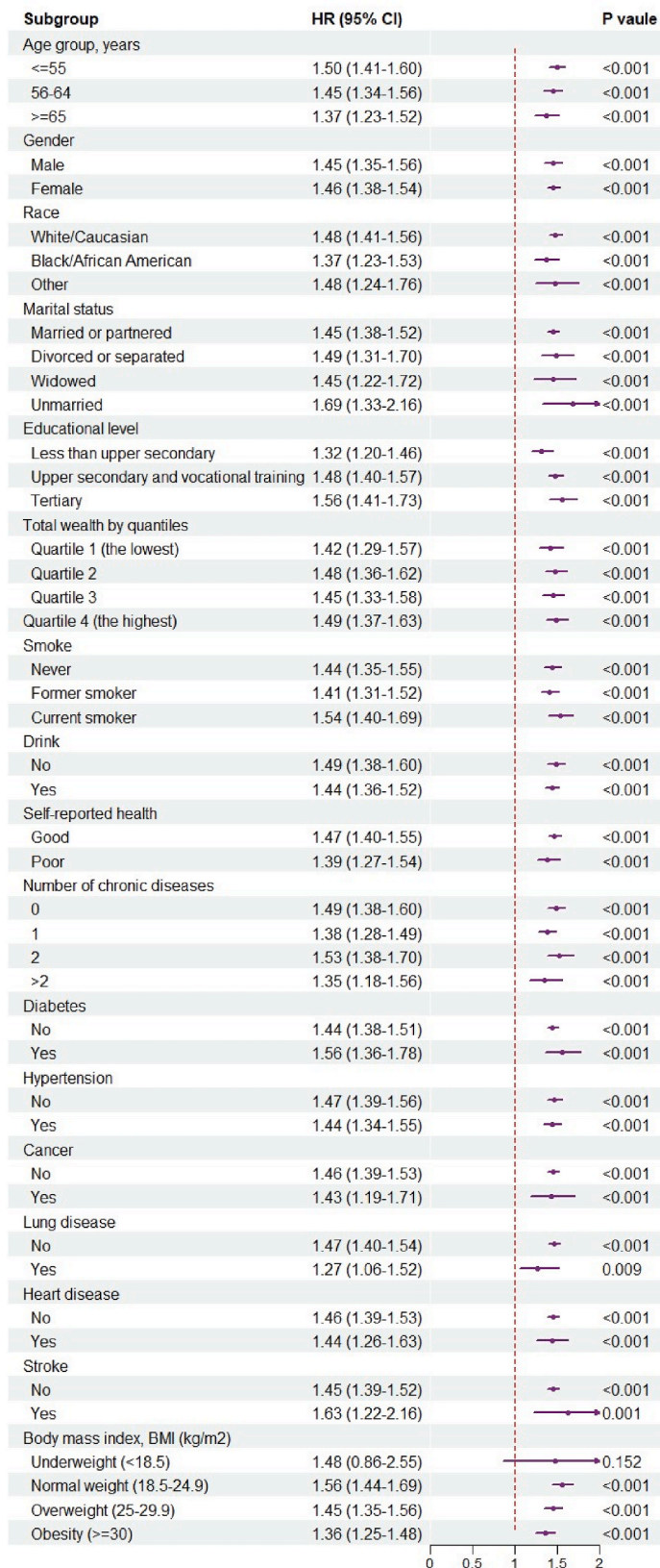
cHR, crude hazard ratio; aHR, adjusted hazard ratio. \*p < 0.05. Model 1: unadjusted Cox proportional hazards models.

Model 2: Cox proportional hazards models adjusted for age, gender, race, marital status, educational level, total wealth, smoke, and drink.

Model 3: Cox proportional hazards models adjusted for age, gender, race, marital status, educational level, total wealth, smoke, drink, self-reported health, chronic diseases, and BMI.

Model 4: Competitive risk models adjusted for age, gender, race, marital status, educational level, total wealth, smoke, drink, self-reported health, chronic diseases, and BMI.





(caption on next page)



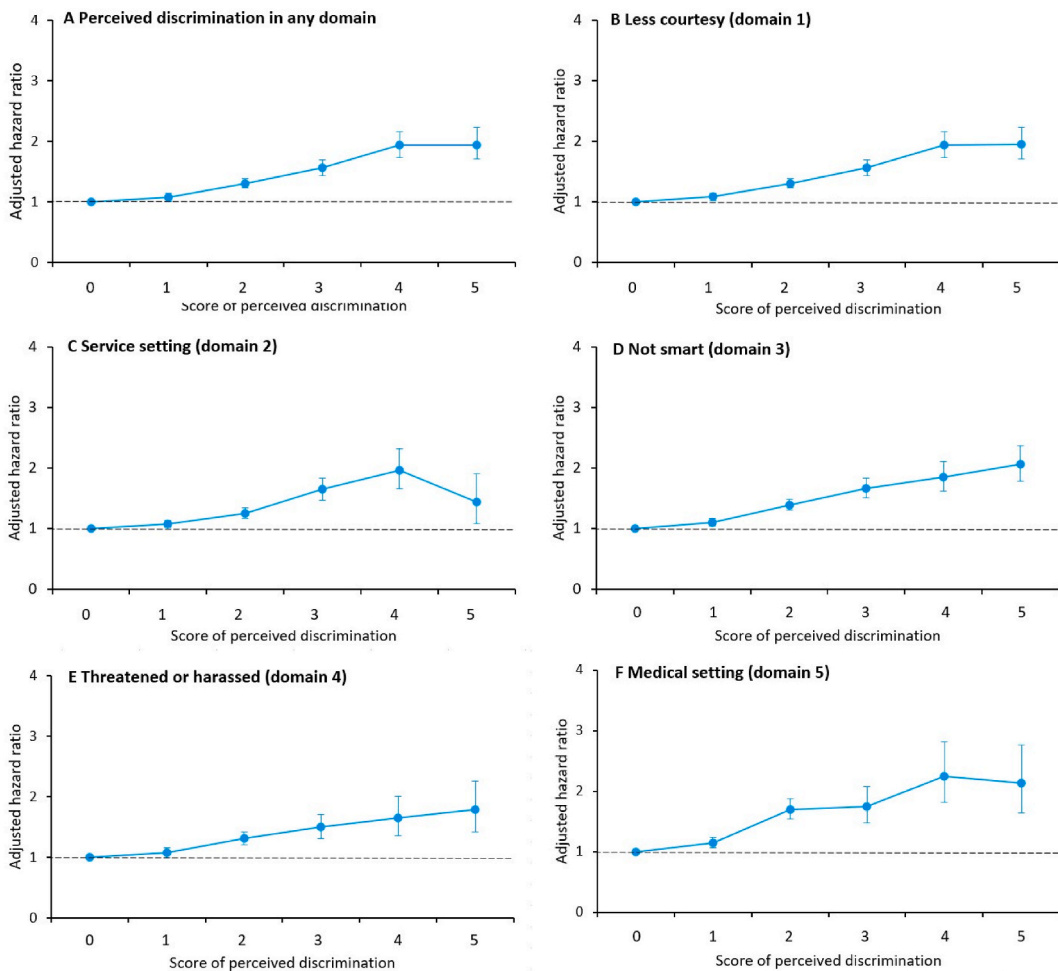
**Fig. 2.** Subgroup analysis on the associations of perceived discrimination with risk of depression in the multivariable Cox proportional hazards models by baseline characteristics.

CI: 1.44–1.64), 2.16 (95 % CI: 1.95–2.40), 2.28 (95 % CI: 1.88–2.76), and 2.57 (95 % CI: 1.80–3.67), respectively, presenting an obvious linear dose-response relationship (Fig. 3 (A) and Table S7). Additionally, this linear dose-response relationship was also shown in association between risk of depression and each domain of perceived discrimination except for service setting (Fig. 3 (B–F)). Noticeably, an inverse U-shape curve dose-response relationship was observed in association of perceived discrimination of service setting with risk of depression, with a highest aHR of incidence of depression in 4 score (Fig. 3 (C)).

**4. Discussion**

Compared to current studies, our study further assessed the longitudinal and dose-response relationship of perceived discrimination with risk of depression in a large-scale cohort from 2006 to 2020 among older adults in US. We noted that perceived discrimination was distinctly associated with the increased risk of depression, either in any domain or in specific domain including less courtesy, service setting, not smart, threatened or harassed, and medical setting. Considering the health-related impacts of depression, integrated interventions, such as promoting diversified exchanges and providing accessible psychological counseling, need be strengthened to restrain the progress from perceived discrimination to depression among older adults.

Our study indicated that 42.8 % of older adults in US experienced perceived discrimination in 2006, which was higher than other studies using the same data from HRS [12,18]. Reasons for this difference are that other studies mainly concentrated on one specific type of perceived discrimination not the whole, or focused on particular older population not the total older population [12,18]. Noticeably, shown in our study and other study [27], although aging was a kind of source to induce perceived age discrimination aside



**Fig. 3.** Dose-response relationship of perceived discrimination with risk of depression in the Cox proportional hazards models. Notes: Score of perceived discrimination equal to 0 as reference group.

from racism and sexism, the prevalence of perceived discrimination was higher in younger population. While some studies presented that the prevalence rate of perceived age discrimination grew with age [28,29]. Combining these findings, the source of discrimination for younger population might be mainly explained by other characteristics (e.g., sex, race, physical ability) not age. Therefore, the implementation of related interventions to combat discrimination from disparate sources should be different among specific-age population.

44.7 % of older participants in our study developed depression from 2006 to 2020, higher than the proportions of other studies also using data from HRS, with a range of 15.4 %–31.5 % from 1992 to 2016 [18,30,31], indicating that depression was increasingly prevalent among US older adults consistent with the global trend [32]. Noticeably, the prevalence of depression shown in our study was close to the results from studies on late-life depression because of similar age [33,34]. These findings remind us that the ascending prevalence of depression is linked to time as age and year. Given the adverse health outcomes consequent on depression and the complex factors related to depression occurrence, effective actions at individual-, economy-, and society-level are needed to prevent or mitigate the effects of depression, especially needed to be strengthened among older adults.

Results of our study represented that the associations of perceived discrimination in both any domain and each domain with risk of depression among older US adults were prominent, indicating an over-2-year effect of perceived discrimination on development of depression. Similar to our results, plenty of studies have showed that perceived discrimination was related to an increased risk of depression with an OR of 1.47 (95 % CI: 1.16–1.86) for perceived age discrimination among English older adults [9], a RR of 1.60 (standard error: 0.07) for perceived healthcare discrimination among Brazil older adults [18], and an OR of 3.80 (95 % CI: 2.89–4.98) for perceived ethnic discrimination among South Korea adolescents [35]. Based on these results as well as subgroup analyses in our study, the association between perceived discrimination and depression was robust across different countries, and among population with various sociodemographic and health-related characteristics, and diverse sources of perceived discrimination. In addition, we found a dose-response relationship between perceived discrimination and risk of depression, indicating that eradicating discrimination, even one type of discrimination, can reduce the probability of depression episode.

To cut off the linkage between perceived discrimination and depression, we should first figure out the potential mechanisms by which perceived discrimination could induce depression episode. There are several plausible interpretations for this association. One probable pathway might be the physiological and psychological response to discrimination events as stressors. The model set up by Pascoe and Smart Richman et al. [36] illustrated that perceived discrimination could directly trigger a decreased positive emotion and increased negative emotion. If an individual perceives discrimination on a regular basis, these stress responses should be activated more often, potentially resulting in a consistently negative emotional state. Moreover, some studies found that perceived discrimination was connected to active systemic inflammation as stress responses including higher concentrations of interleukin-6 (IL-6) and C-reactive protein (CRP), which might enhance the risk of depression [37,38]. In addition to directly creating a psychological burden, some inflammatory cytokines (e.g., CRP) attributable to perceived discrimination can also instigate a physiological burden or allostatic load, amplifying the likelihood of chronic diseases and further eliciting depression episode [36,39,40]. Thus, the experience of discrimination could trigger depression mainly through emotion dysregulation and allostatic load as a stress response.

Another possible pathway by which perceived discrimination could result in depression is through impacts on health-related behaviors, including smoking, alcohol, substance use, medication adherence, exercise, etc. [36] To cope with unfair treatment and seek for relief, people suffering from discrimination were prone to develop unhealthy behaviors, such as substance use, smoking, and alcohol use [36]. One study mentioned that experience of discrimination could impair the ability of self-control, promoting individuals to be more difficult to refuse high-risk activities [41]. Although these unhealthy behaviors could generate short-term release as an avoidance mechanism to discrimination events, they played a more essential and direct role in depression episode [42], besides physical health problems.

It should be highlighted that depression could affect the emergence of perceived discrimination in return, the other direction of the causal association of perceived discrimination with depression apart from our results. As the stigma of depression and other psychological illnesses still persists, people with mental disorders might be more likely to perceive discrimination [43]. Due to the manifestations of illnesses and the public insufficient acknowledge or afraid about diseases, people with mental disorders are usually classified as divergent group from ordinary people. Individuals with mental disorders can be discriminated by family, friends, employers, medical services and so on. Moreover, stigma can also emerge from individuals themselves in the form of self-stigmatization. This direction of the causal association not only intensified the linkage between discrimination and depression, but also increase the risk of other health problems associated with perceived discrimination. Although the bidirectional causality between perceived discrimination and depression still needs more studies to be clear in future, it is urgent and evident that we should take actions now to restrain the progress from perceived discrimination to depression.

With the increasing number of older people in US, and the adverse effects on wellbeing according to depression, timely and early interventions to cut off the linkage between perceived discrimination and depression are urgently needed. There are two main aspects to be considered. First, effective and comprehensive measures need to be made to eliminate discrimination from various sources fundamentally. Unfortunately, this is an ambitious prospect not likely to be realized easily. Because stereotypes of discrimination from different sources, such as age, sex, race etc., are pervasive and deep-rooted in society and culture. Both personal (friends, family and dating) and public (neighbors, education and physical healthcare) relationships of people with mental illness did not understand the disease thoroughly and might misunderstand them through subjective opinions and negative information [44]. So, improving education of the public and advocating contact with population with diverse characteristics can have positive effects on reducing discrimination [45]. The second feasible approach to prevent depression due to perceived discrimination is providing adequate beneficial moderators to help people coping with stress. These moderators include social support, coping style, ethnic identity, and personality variables [36]. For example, the communications with friends or family after experiences of discrimination can help people

release bad emotion and rebuild a feeling of self-worth, further avoiding the development of depression. Additionally, with the rapid innovation of technology, these emotional supports can be provided not only by real humans but also products of artificial intelligence. Anyway, an integrated and systematic strategy for people experiencing perceived discrimination to be away from depression episode is required because of the vacant fact.

This study had several limitations. First, in this study, we referred to people with depressive symptoms above cut points of experiencing 3 or more symptoms for the 8-item CES-D as having depression. We acknowledged that CES-D were not designed to estimate clinically ascertained depression or depression that meets conventional diagnostic criteria such as DSM-IV or ICD-10. However, CES-D was one of the most widely used tools to evaluate depression in the population-based epidemiological studies. Second, the assessment of perceived discrimination was based on the self-statement, in which the recall bias cannot be ignored. Third, we excluded people with depression at baseline, which could affect the effect size of our estimates as those people might suffer more severe perceived discrimination.

In conclusion, both any and each domain of perceived discrimination was significant associated with depression events. A dose-response relationship was shown between perceived discrimination and risk of depression. Considering the aging society and the numerous disease burden of perceived discrimination and depression, we suggested providing more multicultural education and contacts in public to reduce discrimination and supplying accessible emotional supports among older people to help them cope with discrimination.

### Ethical approval

This study was approved by the Ethical Committee of Peking University Third Hospital (ethical approval number: LM2023324) and was exempt from the need of informed consent because of a secondary analysis using de-identified data from HRS. All HRS respondents provided written informed consent for their participation, and data collection was approved by the University of Michigan Institutional Review Board.

### Funding

This study was only funded by the National Natural Science Foundation of China (grant number 72122001), which was shown in Funding section. The data used in this study were from open dataset and were downed from the HRS official website.

### Data availability statement

The data that support the findings of this study are openly available at the NRS official website (<https://hrs.isr.umich.edu/>).

### CRedit authorship contribution statement

**Yaping Wang:** Writing – review & editing, Writing – original draft, Formal analysis. **Jiaojiao Liao:** Writing – review & editing, Software. **Hongguang Chen:** Writing – review & editing. **Liyuan Tao:** Writing – review & editing, Data curation, Conceptualization. **Jue Liu:** Writing – review & editing, Formal analysis, Data curation, Conceptualization.

### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

### Acknowledgements

We appreciated all participants and investigators in HRS.

### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.heliyon.2023.e23843>.

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