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| **Supplementary Table 1. ICD-9-CM and ICD-10-CM Mental and Behavioral Health Codes** |
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| **Disorder** | **Codes** |
| Major depression | ICD-9-CM codes: 296.2X, 296.3X, 300.4, 311 |
|  | ICD-10-CM codes: F32.XX (excluding F32.81 and F32.89), F33.XX |
|  |  |
| Suicide attempt  | ICD-9-CM codes: E950.X, E951.X, E952.X, E953.X, E954, E955.X, E956, E957.X  |
|  | ICD-10-CM codes: T14.91, T36.XX2, T37.XX2, T38.XX2, T39.XX2, T40.XX2, T41.XX2, T42.XX2, T43.XX2, T44.XX2, T45.XX, T46.XX2, T47.XX2, T48.XX2, T49.XX2, T50.XX2, T51.XX2, T52.XX2, T53.XX2, T54.XX2, T55.XX2, T56.XX2, T57.XX2, T58.XX2, T59.XX2, T60.XX2, T61.XX2, T62.XX2, T63.XX2, T64.XX2, T65.XX2, T71.1X2, T71.2X2 |
|  |  |
| Bipolar disorder  | ICD-9-CM codes: 296.0X, 296.1X, 296.4X, 296.5X, 296.6X, 296.7, 296.80, 296.81, 296.89, 301.13 |
|  | ICD-10-CM codes: F30.X, F31.X, F34.0 |
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| Nonaffective psychosis  | ICD-9-CM codes: 293.81, 293.82, 293.89, 295.XX, 297.X, 298.X, 301.22 |
|  | ICD-10-CM codes: F06.0, F06.1, F20.XX, F21, F22, F23, F24, F25.X, F28, F29, F53 |
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| Dementia  | ICD-9-CM codes: 290.XX, 294.1X, 294.8 |
|  | ICD-10-CM codes: F01.XX, F01.XX, F03.XX |
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| Intellectual disabilities  | ICD-9-CM codes: 317, 318, 319 |
|  | ICD-10-CM codes: F70, F71, F72, F73, F78, F79 |
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| Autism  | ICD-9-CM code: 299.XX |
|  | ICD-10-CM code: F84.0 |
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| Tourette’s disorder  | ICD-9-CM code: 307.23 |
|  | ICD-10-CM code: F95.2 |
|  |  |
| Stereotyped movement disorders  | ICD-9-CM code: 307.3 |
|  | ICD-10-CM code: F98.4 |
|  |  |
| Borderline intellectual functioning  | ICD-10-CM code: R41.83 |
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Abbreviations. ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification; ICD-10-CM, International Classification of Diseases, Tenth Revision, Clinical Modification.

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| **Supplementary Table 2. Survey predictorsa included in the full machine learning model predicting psychotherapy response** |
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| **Risk factor domain** |
|  |
| **1. Symptom profile** (Vrieze et al., 2014) |
| 1. 2-week depression symptoms (Akiskal et al., 2005; American Psychiatric Association, DSM-5 Task Force, 2013; Kessler & Ustün, 2004; Llerena et al., 2013; Rizvi et al., 2015; Rush, Gullion, Basco, Jarrett & Trivedi, 1996; Rush et al., 2003; Saffer, Lanting, Koehle, Klonsky & Iverson, 2015; Treynor, Gonzalez & Nolen-Hoeksema, 2003; Zimmerman et al., 2013): Anhedonia/loss of pleasure, Cognitive difficulties, Decrease in appetite, Decrease in weight, Dissociation, Increase in appetite, Increase in weight, Decrease/increase in appetite/weight (max score on 4 items), Early morning insomnia, Hypersomnia, Mid-nocturnal insomnia, Mixed episodes, Other related symptoms, Positive mental health, Rumination, Sleep onset insomnia, 2-week sleep problems scale, Count of sleep problems in the past 2 weeks, Worst sleep problem experiences in the past 2 weeksb
 |
| 1. Suicidality (Posner et al., 2009; Posner et al., 2011): How often tempted fate in the past 2 weeks, n=Number of lifetime attempts, Ever injured from suicide attempt, Most serious injuries from suicide attempt were moderate/severe, 2-week suicidal ideation prevalence, 2-week suicidal ideation frequency, Suicidal thoughts controllability, Suicidal thoughts duration, Suicidal ideation onset (1 year ago, 5 years ago, more than 5 years ago), Suicidality in the past 2 weeksc
 |
|  |
| **2. Clinical subtypes** (Dew et al., 1997; Feske, Frank, Kupfer, Shear & Weaver, 1998; Sotsky et al., 2006; Sotsky et al., 1991) |
| 1. Endogenous depression (Kessler & Ustün, 2004; Sotsky et al., 1991; Ursano et al., 2014): Very first depressive episode was caused by stressful experiences, Number of depressive episodes caused by stressful experiences (all/almost all, most, half, less than half/none), Cause of current depressive episode (happened out of the blue, caused by recent stressful experiences only, caused by long-term stressful events only, both recent and long-term stresses), Count of types of stresses that caused current depressive episode, Change in stresses since current depressive episode began (somewhat better or gone, staying the same, getting worse with no end in sight)
 |
|  |
| **3. Severity** (Bernecker, Constantino, Pazzaglia, Ravitz & McBride, 2014; Frank et al., 2011; Frank et al., 2002; Hamilton & Dobson, 2002; Jarrett et al., 1998; Jarrett, Eaves, Grannemann & Rush, 1991; Moggia, Lutz, Arndt & Feixas, 2020; Saunders et al., 2019; Szádóczky, Rózsa, Zámbori & Füredi, 2004; Vittengl et al., 2016) |
| 1. 2-week depression symptom severity (Aish, Wasserman & Renberg, 2001; American Psychiatric Association, DSM-5 Task Force, 2013; Inventory of Depressive Symptomatology (IDS) and Quick Inventory of Depressive Symptomatology (QIDS), 2020; Kessler & Ustün, 2004; Llerena et al., 2013; Rizvi et al., 2015; Rush et al., 1996; Rush et al., 2003; Saffer et al., 2015; Zimmerman et al., 2013): Sum of 43 standardized items, Hamilton Rating Scale for Depression severity levels (mild, moderate, severe, very severe), Quick Inventory of Depressive Symptomatology Self-Report Scale Score
 |
|  |
| **4. Clinical staging** (Carter et al., 2011; Carter et al., 2018; Dew et al., 1997; Driscoll et al., 2005; Feske et al., 1998; Fournier et al., 2009; Jarrett et al., 2013; Kavanagh & Wilson, 1989; Sotsky et al., 1991) |
| 1. Depression persistence (Kessler & Ustün, 2004; Sotsky et al., 1991; Ursano et al., 2014): Duration (months) of longest depressive episode, Number of years with severe depressive episodes, Percent of life with depression, Depression persistence-severityd, Ever free of depression for at least 6 months between first and current episode
 |
| 1. History of depression (Kessler & Ustün, 2004; Sotsky et al., 1991; Ursano et al., 2014): First depressive episode in life is current episode, Age of onset of first depressive episode, Number of years since onset of first depressive episode, Duration (months) of first depressive episode, Number of months in current depressive episode before seeking treatment
 |
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| **5. Early environmental exposures** (Harkness, Bagby & Kennedy, 2012; Nanni, Uher & Danese, 2012) |
| 1. Adverse childhood events (Weissman et al., 2000): Close loved one died, Close loved one attempted/committed suicide, lived in a foster home, Sent to a juvenile detention center, Sent to a juvenile detention center or lived in a foster home, Parent/caregiver was in prison for 6+ months, parent/caregiver had a mental illness, Parents/caregivers separated/divorced
 |
| 1. Childhood emotional abuse (Bernstein et al., 2003) - Sum of 2 items
 |
| 1. Childhood physical abuse (Bernstein et al., 2003) - Sum of 2 items
 |
| 1. Childhood physical neglect (Bernstein et al., 2003) - Sum of 3 items
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| **Supplementary Table 2 (continued). Survey predictorsa included in the full machine learning model predicting psychotherapy response** |
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| **Risk factor domain** |
|  |
| 1. Childhood sexual abuse (Bernstein et al., 2003) - Sum of 2 items
 |
| 1. Childhood emotional neglect (Bernstein et al., 2003; Parker, Tupling & Brown, 1979) - Sum of 3 items
 |
| 1. Childhood harsh parenting (Parker et al., 1979) - Score on 1 item
 |
| 1. Caregiver experienced emotional problems (depression, depression and suicidality, panic/anxiety, mania/bipolar disorder, problems with anger control, problems with alcohol/drugs, any other serious emotional problem, total frequency of all problems) (Weissman et al., 2000)
 |
| 1. Caregiver experienced psychological distresse (Weissman et al., 2000)
 |
| 1. Caregiver had a serious mental illnessf (Weissman et al., 2000)
 |
| 1. Other adverse childhood experiences (Stein et al., 2018): How often family was on welfare or homeless during childhood - Max score of 2 items
 |
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| **6. Recent environmental stressors** (Dew et al., 1997) |
| 1. 30-day chronic stress (Campbell-Sills et al., 2018b): Stress related to finances/career on 0-10 scale (Max of 2 items, score of 7 or more on subscale), Stress related to personal health on 0-10 scale (Score of 1 item , score of 7 or more on subscale), Stress in love life on 0-10 scale (Score of 1 item, score of 7 or more on subscale), Stress related to loved ones on 0-10 scale (Max of 2 items, score of 7 or more on subscale), Stress in relationships with family/others on 0-10 scale (Max of 2 items, score of 7 or more on subscale), Stress in life overall on 0-10 scale - (Score of 1 item, score of 7 or more on subscale), Total number of mild or no chronic stress (scores of 0-3 finances/career, personal health, love life, loved ones, relationships), Total number of severe or very severe chronic stress (scores of 7 or more in finances/career, personal health, love life, loved ones, relationships), Total number of very severe chronic stress (scores of 10 in finances/career, personal health, love life, loved ones, relationships), bullying (How often per month currently experience physical bullying, relational bullying, verbal bullying, any type of bullying)
 |
| 1. 12-month stressful life events (Ursano et al., 2014): Experienced any stressful life events, experienced 2 or more, total number experienced
 |
| 1. 12-month accidents/injuries (Ursano et al., 2014): Experienced life-threatening illness/injury, Mugged/victim of armed robbery, Break-in/burglary
 |
| 1. 12-month interpersonal violence (Ursano et al., 2014): Physically assaulted, Sexually assaulted or raped, total number
 |
| 1. 12-month interpersonal stressors (Ursano et al., 2014): Betrayal by someone close to you, Separation/divorce/serious romantic break-up, Break-up/falling out with close friend/relative, total number
 |
| 1. 12-month interpersonal loss/other stressors experienced by loved ones (Ursano et al., 2014): Close friend/relative experienced some other serious life crisis, Death of close friend/relative, Life-threatening illness/injury of close friend/relative, total number
 |
| 1. 12-month financial/legal stressors (Ursano et al., 2014): Experienced a major financial crisis, Arrested/serious trouble with police, Serious legal trouble, Lost a job, Lost a job or experienced a major financial crisis, Serious legal trouble or was arrested/serious trouble with police, total number
 |
| 1. 12-month other stressors (Ursano et al., 2014): Any other stressful life event
 |
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| **7. Family history** (Sotsky et al., 1991) |
| 1. Family depression history (Weissman et al., 2000): Number of parents/relatives with a history of depression
 |
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| **8. Functioning and quality of life** (Feske et al., 1998; Frank et al., 2011; Jarrett et al., 2013; Moggia et al., 2020; Sotsky et al., 1991) |
| 1. 2-week role impairment (Leon, Olfson, Portera, Farber & Sheehan, 1997): Full days out of role due to depression (any, number of days, percent of days), Partial days out of role due to depression (any, number of days, percent of days), Full and partial days out of role due to depression (any, total number of days, total percent of days), severe work impairment (score of 7 or more on 0-10 scale), severe family life/home responsibilities impairment (score of 7 or more on 0-10 scale), severe social life impairment (score of 7 or more on 0-10 scale), severe impairment in any area of life (score of 7 or more on 0-10 scale)
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| **Supplementary Table 2 (continued). Survey predictorsa included in the full machine learning model predicting psychotherapy response** |
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| **Risk factor domain** |
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| **9. Physical comorbidities** (Dew et al., 1997; Frank et al., 2011; Kroenke, Shen, Oxman, Williams & Dietrich, 2008; Troxel et al., 2012) |
| 1. Medications: Number of medications taken per day for ongoing physical problems
 |
| 1. Health care visits: Number of health care visits for physical problems in the past 12 months
 |
| 1. Health indicators: BMI (underweight, normal weight, normal or more, overweight, overweight or more, obese, obese or more, morbidly obese), Rating of overall physical health (excellent, very good, good, fair, poor)
 |
| 1. Continuity of care (Safran et al., 1998): Provider of routine physical health care (regular provider, regular place, neither), number of years going to a regular doctor/place for routine physical health care
 |
| 1. Traumatic brain injuries (Ursano et al., 2014): Lifetime prevalence, number of lifetime TBIs (1, 2 or more, total), age of first TBI, 12-month prevalence
 |
| 1. Somatic symptoms (Axelsson, Andersson, Ljótsson, Wallhed Finn & Hedman, 2016; Toussaint et al., 2016): Distressing/bothersome somatic symptoms - Frequency of symptoms per week x length per day x severity of symptoms, Duration of somatic symptoms (none, 1-3 months, 4-6 months, 7-12 months, 1-2 years, more than 2 years), Excessive/disruptive behaviors related to somatic symptoms, Somatic symptom disorder scale - Sum of 15 items, Somatic symptom related anxiety - Sum of 4 itemsg
 |
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| **10. Personality** (Bagby et al., 2008; Constantino et al., 2013; Huibers et al., 2015; JGL, Morina, Boendermaker, Topper & Emmelkamp, 2020; Joyce et al., 2007; Kuyken, Kurzer, DeRubeis, Beck & Brown, 2001; Marquett et al., 2013; Saatsi, Hardy & Cahill, 2007) |
| 1. Personality traits (Anderson, Sellbom & Salekin, 2018; Cyders, Littlefield, Coffey & Karyadi, 2014; Gosling, Rentfrow & Swann, 2003; Zimmermann, Rossier, Meyer de Stadelhofen & Gaillard, 2005): Agreeableness, Alexithymia, Antagonism/antisocial personality traits, Detachment, Emotionality, Externally oriented thinking, Extraversion/openness, impulsive/sensation-seeking, Negative Urgency, Psychoticism personality traits
 |
| 1. Temperament (Akiskal et al., 2005; Anderson et al., 2018; Costa & McCrae, 1992; Gosling et al., 2003; Spielberger, Gorsuch, Lushene, Vagg & Jacobs, 1983): Anxious, Cyclothymic, Depressive, Hyperthymic, Irritable
 |
| 1. Attachment style (Bartholomew & Horowitz, 1991): Dismissing-avoidant, Fearful-avoidant, Preoccupied/anxious-resistant, Secure
 |
|  |
| **11. Antecedent and concomitant psychiatric conditions** (Dew et al., 1997; Feske et al., 1998; Frank et al., 2011; Huibers et al., 2015; Kuyken & Tsivrikos, 2009) |
| 1. Presenting problem (Akiskal et al., 2005; American Psychiatric Association, DSM-5 Task Force, 2013; Anderson et al., 2018; Blevins, Weathers, Davis, Witte & Domino, 2015; Gibbons et al., 2016; Kessler & Ustün, 2004; Rush et al., 1996; Spielberger et al., 1983; Weissman et al., 2000; Zimmerman et al., 2013; Zuromski et al., 2019): Anger (Anger was only presenting problem, Anger was primary presenting problem, Anger was primary/secondary presenting problem, Anger was primary/secondary/unreported by met criteria)h, GAD (GAD was only presenting problem, GAD was primary presenting problem, GAD was primary/secondary presenting problem, GAD was primary/secondary/unreported by met criteria)I, OCD (OCD was only presenting problem, OCD was primary presenting problem, OCD was primary/secondary presenting problem, OCD was primary/secondary/unreported by met criteria)j, Panic/phobia (Panic/phobia was only presenting problem, Panic/phobia was primary presenting problem, Panic/phobia was primary/secondary presenting problem, Panic/phobia was primary/secondary/unreported by met criteria)k, PTSD was primary/secondary/unreported by met criteria)l, Alcohol/substance use disorder (Alcohol/substance use disorder was only presenting problem, Alcohol/substance use disorder was primary presenting problem, Alcohol/substance use disorder was primary/secondary presenting problem, Alcohol/substance use disorder was primary/secondary/unreported by met criteria)m, Any other serious emotional problem (Any other serious emotional problem was only presenting problem, Any other serious emotional problem was primary presenting problem, Any other serious emotional problem was primary/secondary presenting problem, Any other serious emotional problem was primary/secondary/unreported by met criteria)n, Depression was only presenting problemo, Number of anxiety presenting problems (total sum, any, exactly 2, exactly 3)p, Number of externalizing presenting problems (total, exactly 2, exactly 3)q, Number of other presenting problems (total, exactly 2, exactly 3), Number of presenting problems and depression (1, 2, 2 or more, 3 or more), Comorbid presenting problems (Anxiety and any externalizing problem, At least 1 anxiety and 1 externalizing and PTSD, Anxiety and PTSD, Any externalizing and PTSD)r,s, Primary/secondary comorbid presenting problems (1 or more comorbid presenting problems, 1 or more comorbidities at least 1 is primary, 1 or more primary comorbidities), Primary/secondary comorbid presenting problems (2 or more comorbid presenting problems, 2 or more comorbidities at least 1 is primary, 2 or more primary comorbidities), Primary/secondary comorbid presenting problems (3 or more comorbid presenting problems, 3 or more comorbidities at least 1 is primary, 3 or more primary comorbidities), Primary/secondary comorbid presenting problems (4 or more comorbid presenting problems, 4 or more comorbidities at least 1 is primary, 4 or more primary comorbidities), Number of any type of presenting problems (total, exactly 2, exactly 3, exactly 4, exactly 5, exactly 6), Number of "not a problem" presenting problems (total, exactly 2, exactly 3, exactly 4, exactly 5, exactly 6), Number of "primary" presenting problems (total, exactly 2, exactly 3, exactly 4, exactly 5), Above the median of the sum of standardized Panic/phobia, PTSD, and GAD comorbid presenting problem variables, where the raw scale of the variables went from 0-3, with 3 = primary, 2 = secondary, 1 = not reported but met criteria, and 0 = none, Number of "secondary" presenting problems (total, exactly 2, exactly 3, exactly 4, exactly 5)
 |
| 1. 30-day substance use (Gibbons et al., 2016; Hamilton et al., 2011): Marijuana used every or nearly every day, No drugs used, Total frequency of all drugs used, Quantity of nicotine products used per day, Count of alcohol/drug related problems experienced at least once a month, Alcohol quantity\*frequency (amount of drinks per day x frequency of drinking per month), Count of alcohol/drug related problems experienced at least once a week, Heavy drug usert, Heavy smokeru, Heavy drinkerv
 |
| 1. 12-month disorders (Ursano et al., 2014): Agoraphobia, Alcohol/drug problems, Anger control problems, Anxiety, Specific phobia, any Other serious emotional problem, Bipolar disorder/Manic-depression, Non-suicidal self-injurious behavior, Obsessions/compulsions, Panic attacks, Post-traumatic stress disorder, Social anxiety, Number of months in past 12 with disoder (Agoraphobia, Alcohol/drug problems, Anger control problems, Anxiety, Specific phobia, any Other serious emotional problem, Bipolar disorder/Manic-depression, Non-suicidal self-injurious behavior, Obsessions/compulsions, Panic attacks, Post-traumatic stress disorder, Social anxiety),
 |
| 1. Lifetime disorders (Ursano et al., 2014; Weissman et al., 2000): Lifetime history of Agoraphobia, Alcohol/drug problems, Anger control problems, Anxiety, Specific phobia, any Other serious emotional problem, Bipolar disorder/Manic-depression, Non-suicidal self-injurious behavior, Obsessions, Compulsions, Panic attacks, Post-traumatic stress disorder, Social anxiety, externalizing problems (any, 2 or more)w, Total number of lifetime Mental disorders/emotional problems (Anxiety problem, Externalizing problems) x,y Number of years in life with (Agoraphobia, Alcohol/drug problems, Anger control problems, Anxiety, Specific phobia, any Other serious emotional problem, Bipolar disorder/Manic-depression, Non-suicidal self-injurious behavior, Obsessions/compulsions, Panic attacks, Post-traumatic stress disorder, Social anxiety)
 |
| 1. 2-week PTSD (Zuromski et al., 2019): Score on PCL-5 screening scalez, Duration (months) of PTSD-related symptoms
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| **Supplementary Table 2 (continued). Survey predictorsa included in the full machine learning model predicting psychotherapy response** |
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| **Risk factor domain** |
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| **12. Protective factors/resilience** (Dew et al., 1997; Hallgren, Lundin, Tee, Burström & Forsell, 2017; Marquett et al., 2013; Moggia et al., 2020; Szádóczky et al., 2004) |
| 1. Social support (Kessler & Ustün, 2004; Schuster, Kessler & Aseltine, 1990): Religiosity, Social networks (Affliative interactions [frequency of interaction with friends/relatives, participation in social groups], Seeking help with personal problems [reach out to a lot of different people, only to family/friends, only to closest confidants, no one], Degree could rely on people for support with personal problems [some, a lot], Number of people could rely, Number of confidants), Negative social networks,
 |
| 1. Emotion regulation (Garnefski & Kraaij, 2007; Gross & John, 2003; Medrano & Trogolo, 2016; Schlotz, Yim, Zoccola, Jansen & Schulz, 2011): Cognitive reappraisal, Difficulties in regulation of emotional response, Putting things into perspective, Refocus on planning, Self-blame, Emotion regulation scale (Sum of Cognitive reappraisal subscale, Perceived stress reactivity scale, Difficulties in regulation of emotional response subscale, Difficulties in processing emotion subscale), Perceived stress reactivity scale
 |
| 1. Resilience (Campbell-Sills et al., 2018a; Campbell-Sills & Stein, 2007): Resilience scale score- Sum of 12 items
 |
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| **13. Neurocognition** (Fournier et al., 2009; Metts et al., 2018) |
| 1. Attentional control (Judah, Grant, Mills & Lechner, 2014): Distractability, Flexibility
 |
|  |
| **14. Dysfunctional cognitive schema** (Carter et al., 2018; Donker et al., 2013; Jarrett et al., 1998; Sotsky et al., 1991) |
| 1. Interpersonal needs (Van Orden, Cukrowicz, Witte & Joiner, 2012): Perceived burdensomeness, Thwarted belongingness
 |
| 1. Cognitive distortions (Akiskal et al., 2005; Roberts, 2015)
 |
|  |
| **15. Socio-demographic characteristics** (Dew et al., 1997; Donker et al., 2013; Fournier et al., 2009; Frank et al., 2011; Huibers et al., 2015; Jarrett et al., 1998; Jarrett et al., 2013; Marquett et al., 2013) |
| 1. Age: Age at baseline survey (19-34, 35-49, 50-59, 60+)
 |
| 1. Children: Any biological or stepchildren, number of children (0, 1, 2, 3+), age of oldest child (under 6, under 13, under 18), age of youngest child (under 6, under 13, under 18), Currently pregnant/partner currently pregnant
 |
| 1. Education: High school or less, some college, college graduate, graduate school or more
 |
| 1. Employment status: Employed, retired, student, disabled, unemployed, other
 |
| 1. Nativity: Born in the US
 |
| 1. Occupational category: Executive/administrator/senior manager, professional, technical support, sales, clerical/administrative support, service, precision production/crafts worker, operator/laborer, other)
 |
| 1. Race/ethnicity: Non-Hispanic white, Non-hispanic black, Hispanic, other
 |
| 1. Marital/relationship status: Marital status (currently married, divorced, separated, widowed, never married), Relationship status (married/cohabitating, engaged, steadily dating, dating but not in a steady relationship, not currently dating), Number of years married/steadily dating, Satisfaction with quality of marriage/relationship)
 |
| 1. Sex: male/female
 |
|  |
| **16. Treatment characteristics** (Castonguay, Goldfried, Wiser, Raue & Hayes, 1996; Hepner et al., 2007; Mergl et al., 2011; Raue, Schulberg, Heo, Klimstra & Bruce, 2009; Sotsky et al., 1991) |
| 1. Treatment preferences (Kessler & Ustün, 2004; Milosevic, Levy, Alcolado & Radomsky, 2015; Steidtmann et al., 2012): Likelihood to participate in a RCT of new antidepressant, Willingness to try other kinds of treatment, Willingness to try counseling/psychotherapy, Willingness to try medication, Willingness to try medication and counseling/psychotherapy, ADM preference (preferred specific type of antidepressant, preferred specific class)
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| **Supplementary Table 2 (continued). Survey predictorsa included in the full machine learning model predicting psychotherapy response** |
|  |
| **Risk factor domain** |
|  |
| 1. Treatment expectations (Curry et al., 2006; McHorney, Victor Spain, Alexander & Simmons, 2009; Unni, 2008; Unni, Olson & Farris, 2014; Vik, Maxwell & Hogan, 2004; Wisniewski, Rush, Balasubramani, Trivedi & Nierenberg, 2006): Expectation for combination of medication and counseling/psychotherapy to successfully treat depression (success, moderate success, complete failure), Expectation for electroconvulsive therapy to successfully treat depression (success, moderate success, complete failure), Expectation for ketamine to successfully treat depression (success, moderate success, complete failure), Expectation for counseling/psychotherapy to successfully treat depression (success, moderate success, complete failure), Expectation for medication to successfully treat depression (success, moderate success, complete failure), Level of agreement that assigned treatment is the best one (agree, neither, disagree), Expectation for success of current assigned treatment (success, moderate success, not successful), Expectation for medication side effects (none, mild but temporary, mild and long-term, moderate but temporary, moderate and long-term, severe but temporary, severe and long-term), Concerns about antidepressant medications
 |
| 1. Health literacy (Chew et al., 2008; Haun, Valerio, McCormack, Sørensen & Paasche-Orlow, 2014; Kessler & Ustün, 2004; Safran et al., 1998): Number of hours spent discussing depression treatment options before first visit, Number of hours spent researching depression treatment options before first visit, Total number of hours spent discussing/researching depression treatment options before first visit, Inadequate health literacy - Sum of 3 items
 |
| 1. Treatment provider (Baumann, Baumann, Le Bihan & Chau, 2008; Bieber, Müller, Nicolai, Hartmann & Eich, 2010): Type of provider currently treating depression (primary care doctor and nurse practitioner, primary care doctor and psychiatrist, primary care doctor and psychologist, psychiatrist and psychologist, psychiatrist only, psychologist only), Previously received mental health treatment from same provider currently treating depression
 |
| 1. Current assigned treatment: Individual or group counseling/psychotherapy
 |
| 1. Treatment history: Age of onset of first receiving treatment for depression, Number of times hospitalized overnight for depression, Percent of years in depression treatment, History of receiving treatment (first episode/first time in treatment, past treatment was helpful, past treatment was not helpful), Number of different types of depression treatment ever received, Current treatment is the same as previous self-reported treatment, Types of past depression treatment (received any time of treatment in the past, medication and 1 or more types of treatment, no medication and 1 or more types of treatment)a1, Past medication/psychotherapy treatment (received medication, group counseling/psychotherapy, individual counseling/psychotherapy, any psychotherapy, medication only, psychotherapy only, both psychotherapy and medication), Psychotherapy was at least somewhat effective in treating past depression, Effectiveness of psychotherapy in treating past depression (completely effective, very effective, somewhat, not very, not effective, never received counseling/psychotherapy in the past), Antidepressants were at least somewhat effective in treating past depression, Effectiveness of antidepressants in treating past depression (completely effective, very effective, somewhat, not very, not effective, never took medication in the past)
 |
| 1. Treatment adherence (Morisky, Ang, Krousel-Wood & Ward, 2008): Medication adherence scale
 |
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aWe included dichotomous variables, nested dichotomous variables, categorical and ordinal variables, continuous variables, standardized and stabilized continuous variables as potential predictors in the feature selection for additive algorithms.

bSleep problems included taking 30 minutes or more to fall asleep, waking up throughout the night, waking up too early most of the time, and sleeping longer than 9 hours a day.

cFour or more days with suicidal ideation or somewhat difficult to control thoughts or sometimes thought about tempting fate.

dThis variable was created by summing the standardized percent of life with depression variable, standardized duration (months) of longest depressive episode variable, and standardized depressive temperament item "People tell me I am often unable to see the lighter side of things".

eTotal frequency that any parent/caregiver experienced depression, panic attacks, and anxiety.

fHad mania/bipolar disorder, problems with anger control, problems with alcohol/drugs, and any other serious emotional problem.

gFrequency of anxiety, severity, time, interference.

hAnger problems as either a primary or secondary presenting problem as indicated by the patient or if the patient reported anger attacks 7+ of the past 12 months and reported that one or more of three statements described them either a lot or exactly (sometimes I get so furious that I could hurt someone; I snap at people when I get angry; sometimes I get so mad that I trash everything).

iGAD as either a primary or secondary presenting problem as indicated by the patient or if the patient reported anxiety 7+ of the past 12 months and reported symptoms of DSM-5 GAD Criteria A and C.

jOCD as either a primary or secondary presenting problem as indicated by the patient or if the patient reported having obsessions or compulsions every month for the past 12 months.

kPanic/phobia as either a primary or secondary presenting problem as indicated by the patient or if the patient reported panic/phobias 7+ of the past 12 months, PTSD (PTSD was only presenting problem, PTSD was primary presenting problem, PTSD was primary/secondary presenting problem.

lPTSD as either a primary or secondary presenting problem as indicated by the patient or a score in the clinical range of a PCL-5 screening scale calibrated to the full PCL-5.

mAlcohol/substance use disorder as either a primary or secondary presenting problem as indicated by the patient or if the patient met threshold scoring rules on the Patient-Reported Outcomes Measurement Information System (PROMIS) 30-day Alcohol/Substance Use Short Form-7a.

nAny other emotional serious problem as either a primary or secondary presenting problem as indicated by the patient or if the patient reported any other serious emotional problem 7+ of the past 12 months.

oDepression as either a primary or secondary presenting problem as indicated by the patient.

pAnxiety includes panic/phobias, OCD, and GAD.

qExternalizing problems include anger control problems, alcohol/drug problems, any other serious emotional problems.

rAnxiety includes panic/phobias, OCD, and GAD.

sExternalizing problems include anger control problems, alcohol/drug problems, any other serious emotional problems.

t30-day heavy drug use was defined as self-reported use of prescription opioids (either without a doctor’s prescription or more than prescribed to get high, buzzed, or numbed out) or heroin/street fentanyl at least once a month or using prescription stimulants, tranquilizers, muscle relaxers, or sedatives (either without a doctor’s prescription or more than prescribed to get high, buzzed, or numbed out) at least 1 day a week or using marijuana every or nearly every day or using any other illegal nonprescription drug at least 1 day a week in the past 30 days.

u30-day heavy smoking was defined as using 26 or more nicotine products per day.

v30-day heavy drinking was defined as alcohol quantity\*frequency >= 15.

wExternalizing problems include anger control problems, alcohol/drug problems, any other serious emotional problems).

xAnxiety problems include agoraphobia, specific phobia, anxiety, obsessions, compulsions, panic, PTSD, and social anxiety.

yExternalizing problems include anger control problems, alcohol/drug problems, any other serious emotional problems), Number of years in life with (Agoraphobia, Alcohol/drug problems, Anger control problems, Anxiety, Specific phobia, any Other serious emotional problem, Bipolar disorder/Manic-depression, Non-suicidal self-injurious behavior, Obsessions/compulsions, Panic attacks, Post-traumatic stress disorder, Social anxiety)

zDefined as a score of 38+ on the PTSD Checklist for DSM-5 based on responses to the 6-item short-form version of the PCL-5 calibrated to the full PCD-5.

a1Types of treatment include individual counseling/psychotherapy, group counseling/psychotherapy, internet guided self-help therapy, self-help support group, electroconvulsive therapy, ketamine, other.

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| --- |
| **Supplementary Table 3. Administrative predictorsa included in the full machine learning model predicting psychotherapy response** |
|  |
| **Risk factor domain** |
|  |
| **1. Recent environmental stressors** (Dew et al., 1997) |
| 1. Accidents: Number of visits with any ICD code for Accidents (past 6 months, past year, past 2 years, past 5 years)
 |
|  |
| **2. Physical comorbidities** (Dew et al., 1997; Frank et al., 2011; Kroenke et al., 2008; Troxel et al., 2012) |
| 1. Medications: Prescribed any Antimigraine Medications (past month, past 2 months, past 3 months, past 6 months, past 12 months, past 2 years, past 5 years), Prescribed any Non-Opioid Analgesic Medications (past month, past 2 months, past 3 months, past 6 months, past 12 months, past 2 years, past 5 years), Prescribed any Opioid Analgesic Medications (past month, past 2 months, past 3 months, past 6 months, past 12 months, past 2 years, past 5 years), Prescribed any Pain Medications (past month, past 2 months, past 3 months, past 6 months, past 12 months, past 2 years, past 5 years), Prescribed any Medications
 |
| 1. Health care visits (Chronic Pain Research Alliance, 2015; Lew et al., 2009; Mayhew et al., 2019): Number of visits with CPT code for any Pain related procedures (past month, past 2 months, past 3 months, past 6 months, past 12 months, past 2 years, past 5 years), Number of visits with CPT code for any Sleep apnea related procedures (past month, past 2 months, past 3 months, past 6 months, past 12 months, past 2 years, past 5 years), Number of visits with ICD code for diagnosis of any of the 10 Chronic Overlapping Pain Conditions (past month, past 2 months, past 3 months, past 6 months, past 12 months, past 2 years, past 5 years), Number of visits with ICD code for diagnosis of any of the 13 Pain Condition Crosswalk Clusters (past month, past 2 months, past 3 months, past 6 months, past 12 months, past 2 years, past 5 years), Any visit with ICD code for diagnosis of Polytrauma Clinical Triad - Chronic Pain (past month, past 2 months, past 3 months, past 6 months, past 12 months, past 2 years, past 5 years), Any visit with ICD code for diagnosis of Polytrauma Clinical Triad - Chronic Pain and Traumatic Brain Injury in the past 3 months, Any visit with ICD code for diagnosis of Polytrauma Clinical Triad - Traumatic Brain Injury (past month, past 2 months, past 3 months, past 6 months, past 12 months, past 2 years, past 5 years)
 |
| 1. Health indicators (Charlson, Pompei, Ales & MacKenzie, 1987): Charlson Comorbidity Index Score (0, 1, 2 or more), Worst pain on 0-10 NRS pain scale (past month, past 2 months, past 3 months, past 6 months, past 12 months, past 2 years, past 5 years)
 |
|  |
| **3. Antecedent and concomitant psychiatric conditions** (Dew et al., 1997; Feske et al., 1998; Frank et al., 2011; Huibers et al., 2015; Kuyken & Tsivrikos, 2009) |
| 1. Health care visits: Number of visits with any ICD code for Suicidal Ideation (past month, past 2 months, past 3 months, past 6 months, past 12 months, past 2 years, past 5 years), 2 or more substance visits in past year and at least 1 was face-to-face
 |
| 1. Diagnoses (Lew et al., 2009): ICD code for diagnosis of PTSD, Lifetime history of mental disorders: Any adjustment disorders, anxiety disorders, depressive disorders, PTSD, substance use disorders, other reactions to stress, other mental disorders, total number, Mental disorders in EMR at recruitment (Any adjustment disorder, anxiety disorder, depression, PTSD, substance use disorder, other reactions to stress, other mental disorders, total number), Primary mental disorder in EMR at recruitment (Any adjustment disorders, anxiety disorders, depressive disorders, PTSD, substance use disorders, other reactions to stress, other mental disorders), Primary diagnosis at initial visit (depression, a mental disorder other than depression, a physical disorder and not depression, other), Any visit with ICD code for diagnosis of Polytrauma Clinical Triad - Depression (past month, past 2 months, past 3 months, past 6 months, past 12 months, past 2 years, past 5 years), Any visit with ICD code for diagnosis of Polytrauma Clinical Triad - Post-Traumatic Stress Disorder (past month, past 2 months, past 3 months, past 6 months, past 12 months, past 2 years, past 5 years)
 |

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| **Supplementary Table 3 (continued). Administrative predictorsa included in the full machine learning model predicting psychotherapy response** |
|  |
| **Risk factor domain** |
|  |
| **4. Socio-demographic characteristics** (Dew et al., 1997; Donker et al., 2013; Fournier et al., 2009; Frank et al., 2011; Huibers et al., 2015; Jarrett et al., 1998; Jarrett et al., 2013; Marquett et al., 2013) |
| 1. Housing stability: Ever homeless (past month, past 2 months, past 3 months, past 6 months, past 12 months, past 2 years, past 5 years), Number of visits with any ICD code for Problems with housing, material resources, and social isolation (past month, past 2 months, past 3 months, past 6 months, past 12 months, past 2 years, past 5 years)
 |
| 1. Neighborhood characteristics: Census region (Northeast, Midwest, South, West), Driving time in minutes to the nearest VHA primary care facility
 |
|  |
| **5. Treatment characteristics** |
| 1. Current treatment characteristics: Received a collaborative care referral during recruitment week, Number of psychotherapy visits in the 84 days after the first visit
 |
| 1. Treatment provider: Treatment provider at initial visit was a primary care clinician (as opposed to a mental health specialist)
 |
| 1. Facility characteristics: Ratio of medical/social positions lost /onboards at the facility where the patient visited in the year prior to the visit, Setting of initial visit (community based outpatient clinic, specialty mental health, primary care), Facility of first visit has at least one full-time integrated mental health specialist on staff, does not have full-time integrated mental health specialist on staff, location received psychotherapy (primary care, at specialty MH),
 |
| 1. Treatment history (Kessler & Ustün, 2004): Number of visits with any ICD code for Noncompliance with treatment in the past 5 years
 |
|  |

aWe included dichotomous variables, nested dichotomous variables, categorical and ordinal variables, continuous variables, standardized and stabilized continuous variables as potential predictors in the feature selection for additive algorithms.

|  |
| --- |
| **Supplementary Table 4. Geospatial predictorsa included in the full machine learning model predicting psychotherapy response** |
|  |
| **Risk factor domain** |
|  |
| **1. Socio-demographic characteristics** (Dew et al., 1997; Donker et al., 2013; Fournier et al., 2009; Frank et al., 2011; Huibers et al., 2015; Jarrett et al., 1991; Jarrett et al., 2013; Marquett et al., 2013) |
| 1. GDP: Per capita county GDP in thousands of chain-linked 2012 dollars Footnote [Inflation-adjusted measure of area’s gross product, based on national prices for the goods and serviced produced within the area. The real estimates of GDP are measured in chained (2012) dollars], Per capita nominal county GDP in real-time dollars, Difference in per capita county GDP [chain-linked 2012 dollars] from previous year
 |
| 1. Poverty: Percent of population below 150% of the poverty line at the Census Block Group
 |
| 1. Income: Per capita personal income (by residence) in thousands of dollars in the county
 |
| 1. Homelessness: Annual rate of homelessness per 1,000 Census Track population on a single given night in January
 |
| 1. Quality of health: Composite health outcomes measure based on length of life and quality of life in the county, Overall health outcome summary score in the county (higher = worse), Years of potential life lost before age 75 (age-adjusted) per 100,000 in the county population
 |
| 1. Healthcare coverage: Medicaid eligible rate per capita in the county
 |
| 1. Mortality rates: Infant mortality rate (<1 year old) from all causes per 100,000 infants in the county, Mortality rate due to alcohol, drugs, external causes, HIV/AIDS, homicide, liver disease per 100,000 in the county population, Suicide rate (by any method) per 100,000 in the county population
 |
| 1. Urbanicity (Bureau of Economic Analysis, 2021; Centers for Medicare and Medicaid Services (CMS), 2018; National Center for Health Statistics (NCHS), 2019; United States Census Bureau, 2020; United States Department of Agriculture: Economic Research Service, 2020; United States Department of Commerce & Bureau of Economic Analysis, 2018; United States Department of Housing and Urban Development, 2014; University of Wisconsin Population Health Institute & Robert Wood Johnson Foundation, 2021): Major metro area, urban area, rural area
 |
|  |

aWe included dichotomous variables, nested dichotomous variables, categorical and ordinal variables, continuous variables, standardized and stabilized continuous variables as potential predictors in the feature selection for additive algorithms.

| **Supplementary Table 5. Algorithms used in the Super Learner ensemble machine learning analysisa** |
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|  |  |
| **Algorithm** | **Description** |
| I. Super Learner  | Super Learner is an ensemble machine learning approach that uses cross-validation (CV) to select a weighted combination of predicted outcome scores across a collection of candidate algorithms (learners) to yield an optimal combination according to a pre-specified criterion that performs at least as well as the best component algorithm. R package: *SuperLearner* (Polley, LeDell, Kennedy, Lendle & van der Laan, 2018; van der Laan, Polley & Hubbard, 2007) |
|  |  |
| II. Learners in the Super  Learner library |  |
|  |  |
| A. Logistic regression | Maximum likelihood estimation with logistic link function. R package: s*tats* (Nelder & Wedderburn, 1972) |
|  |  |
| B. Elastic Net  | Elastic net is a regularization method that minimizes the problem of overlap among predictors by explicitly penalizing over-fitting with a composite penalty λ{MPP x Plasso + (1- MPP) X Pridge}, where MPP is a mixing parameter penalty with values between 0 and 1 that controls relative weighting between the lasso penalty (Plasso) and the ridge penalty (Pridge). The parameter λ controls the total amount of penalization. The ridge penalty handles multicollinearity by shrinking all coefficients smoothly towards 0 but retains all variables in the model. The lasso penalty allows simultaneous coefficient shrinkage and variable selection, tending to select at most one predictor in each strongly correlated set, but at the expense of giving unstable estimates in the presence of high multicollinearity. The elastic net approach of combining the ridge and lasso penalties has the advantage of yielding more stable and accurate estimates than either ridge or lasso alone while maintaining model parsimony. R package: *glmnet* (Friedman, Hastie & Tibshirani, 2010)Hyperparameters: a=(0.0, 0.2, 0.4, 0.6, 0.8, 1.0). |
|  |  |
| C. Splines |  |
| C1. Adaptive splines  | Adaptive spline regression flexibly captures both linear and piecewise non-linear associations as well as interactions among these associations by connecting linear segments (splines) of varying slopes and smooths to create piece-wise curves (basis functions). Final fit is built using a stepwise procedure that selects the optimal combination of basis functions. R package:*earth* (Milborrow, 2016)Hyperparameters: degree = (1, 3, 5)  |
|  |  |
| C2. Adaptive  polynomial splines  | Adaptive polynomial splines are like adaptive splines but differ in the order in which basis functions (e.g., linear versus nonlinear) are added to build the final model. R package: *polspline* (Kooperberg, 2015) |
|  |  |
| D. Decision trees – bagging | Random Forest. Independent variables are partitioned (based on contiguous values) and stacked to build decision trees that are combined (ensemble) to create an aggregate “forest”. Random forest builds numerous trees in bootstrapped samples and generates an aggregate prediction by averaging across trees, thereby reducing over-fitting. R package: *ranger* (Wright & Ziegler, 2017)Hyperparameters:max.depth = (3, 4, 5), min.node.size = (1, 5, 10), num.trees = (3000, 3000, 3000), splitrule = ('gini', 'hellinger', 'extratrees'), num.random.splits (--, --, 1) |
|  |  |
| E. Support vector machines | Support vector machines treat independent variables as dimensions in high dimensional space and attempt to identify the best hyperplane (linear, polynomial, radial, or sigmoid kernel) to separate the sample into classes (e.g., cases and non-cases) with maximum distance between classes. R package: *WeightSVM* (Xu, 2020)Hyperparameters: kernel = (radial, radial, radial), cost = (10000, 1000, 100), gamma (0.0001, 0.0010, 0.0100) |

| **Supplementary Table 5 (continued). Algorithms used in the Super Learner ensemble machine learning analysisa** |
| --- |
|  |
| **Algorithm** | **Description** |
| F. Decision trees – boosting |  |
| F1. Gradient  Boosting Machine  | GBMs build a sequential ensemble of shallow successive decision trees that iteratively learn the residuals from prior trees. This is a flexible method, where the number of trees, interaction depth, and shrinkage are leveraged to build flexible models. R package: *CatBoost* (Prokhorenkova, Gusev, Vorobev, Dorogush & Gulin, 2019)Hyperparameters: Iterations = (500, 1000, 2000), learning rate = (0.05, 0.03, 0.01), depth = (3, 4, 5) |
|  |  |
| F2. Extreme  Gradient Boosting  | A fast and efficient implementation of gradient boosting. R package: *XGBoost* (Chen & Guestrin, 2016)Hyperparameters: ntrees = (5000, 5000, 5000), max\_depth = (3, 4, 5), shrinkage = (0.10, 0.05, 0.01)  gamma = (0.01, 0.10, 1.00), minobspernode = (1, 5, 10), colsample\_bytree = (1.0, 0.8, 0.6) |
|  |  |
| G. Discrete Bayesian  Additive Regression  Trees Sampler | Bayesian trees are based on an underlying probability model (priors) for the structure and likelihood for data in terminal nodes. The aggregate tree is generated by averaging across tree posteriors (reducing overfit). R package: *dbarts* (Dorie et al., 2021)ntree=100 |
|  |  |
| H. Mean | Arithmetic mean |
|  |  |
| I. Stratified outcome  prevalence | Stratified outcome prevalence |
|  |  |

 aHyperparameters: Default values were used unless otherwise noted.

| **Supplementary Table 6. Variation in associations (relative risk)a of patient socio-demographic characteristics with treatment response in the full sample as a function of predicted probability of the outcome** |
| --- |
|  | **Model 1a** |  | **Model 1b** |  | **Model 2a** |  | **Model 2b** |  | **Model 3a** |  | **Model 3b** |  | **Model 4a** |  | **Model 4b** |
|  | **RR** | **(95% CI)** |  | **RR** | **95% CI** |  | **RR** | **95% CI** |  | **RR** | **95% CI** |  | **RR** | **95% CI** |  | **RR** | **95% CI** |  | **RR** | **95% CI** |  | **RR** | **95% CI** |
| Top tertile | 3.37\*  | (2.70-4.20) |  | 3.48\* | (2.56-4.73) |  | 3.37\* | (2.71-4.18) |  | 2.95\* | (1.86-4.69) |  | 3.35\* | (2.70-4.17) |  | 3.27\* | (2.21-4.83) |  | 3.36\* | (2.70-4.18) |  | 3.60\* | (2.57-5.03) |
| 51 years or older | 0.99  | (0.81-1.21) |  | 1.03 | (0.71-1.49) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Male |  |  |  |  |  |  | 0.95 | (0.74-1.22) |  | 0.87 | (0.56-1.34) |  |  |  |  |  |  |  |  |  |  |  |  |
| Non-Hispanic White |  |  |  |  |  |  |  |  |  |  |  |  | 1.05 | (0.84-1.31) |  | 1.03 | (0.70-1.51) |  |  |  |  |  |  |
| College graduate or more |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1.01 | (0.82-1.24) |  | 1.09 | (0.75-1.57) |
| Interaction |  |  |  | 0.94 | (0.61-1.46) |  |  |  |  | 1.18 | (0.70-1.99) |  |  |  |  | 1.04 | (0.65-1.66) |  |  |  |  | 0.89 | (0.57-1.37) |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

Abbreviations: CI, confidence interval; RR, relative risk.

\*Significant at the .05 level, two-sided test.

aRelative risks were estimated using Poisson models with robust standard errors.

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