Health implications of enduring and emerging stressors:

Design of the prospective New Jersey Population Health Cohort (NJHealth) Study

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ABSTRACT

Introduction. Some stressors, like unemployment, are common and rigorously studied, while others, such as those related to climate change or social media are just emerging and in need of systematic research. The New Jersey Population Health Cohort (NJHealth) Study aims to characterize enduring and emerging stressors and delineate the pathways through which they influence health, especially among groups likely to experience chronic exposure to stressors including immigrants, people of color, multi-generational families, and low-income families.

Methods and analysis. A prospective cohort, the NJHealth Study is recruiting 8,000 NJ residents aged 14 and older using probabilistic and purposive methods to include members of multi-generational families, marginalized racial/ethnic and low-income populations, and recent immigrant groups.

Building on ecosocial, life course, and stress process models, the NJHealth Study employs multi-modal data collection to comprehensively measure stress-related factors at individual and societal levels. Interviews include self-assessments of individual and societal stressors, potential stress buffers and amplifiers, and health and well-being outcomes, including cognitive function, activity limitations, and self-reported health. In addition, salivary DNA, fasting plasma, health assessments, and actigraphy data are collected from selected participants; and existing electronic health records, health insurance claims, social service and employment data, vital records are linked.

NJ's socioeconomic and demographic diversity make it an exceptional setting for the study. Strong community and stakeholder engagement supports effective translation of research findings into practical policy and programmatic applications.

Ethics and dissemination. The study was approved by the WCGIRB (formerly Western IRB). Informed consent is obtained from participants for each source of participant-level data as well as linked administrative and clinical records. Findings will be reported to study participants, funding bodies, governmental and policy stakeholders, presented at scientific meetings, and submitted for peer-review publication.

Strengths and limitations of this study

- Guided by a comprehensive framework informed by key constructs from ecosocial and life course theories as well as stress process models.
- Dual probabilistic and purposive sampling incorporates a unique focus on under-studied groups likely to experience stressors, including immigrants from diverse sending countries, other groups experiencing discrimination, and multi-generational families.
- Comprehensive assessment of societal and individual stressors measured at micro- and macro-levels using multi-modal data collection, including survey interviews, actigraphy, DNA and biomarkers, health assessments, and linked administrative, clinical, social program, and environmental data sources.
- Consultation with community advisors, including members of groups likely to experience chronic exposures to stressors, and public policy advisors informs actionability of findings.
- High expense to maintain the cohort requiring intensive data collection and examining varied health outcomes.

INTRODUCTION

Recent decades have brought rapid social changes, technological developments, and a host of new stressors to human populations, with considerable implications for wellbeing, health, and life expectancy [1-7]. Despite advances in biomedicine, overall life expectancy in the United States (US), including New Jersey (NJ), a wealthy state, has been stagnant and recently declined, especially in comparison to peer countries [8-10]. Deaths due to drug overdoses and violence have become endemic in the US [11], while similar trends have not been observed in other wealthy countries [9]. Maternal mortality rates are troublingly high, particularly among African Americans, American Indians, and Alaska Natives [12]. Suicide rates have fluctuated somewhat but have generally increased over the past 35 years, including in 2022 [13], and rates are higher in the US than most other higher income countries [14]. Global political, social, and climate-related unrest have created stressors that were not experienced by prior generations and have led to sharp increases in the flow of immigrants and asylum seekers to the US.

Despite advances in the science of stress [15] and growing attention to systemic, sociocultural, and environmental stressors [16-19], little is known about the prevalence or health implications of emerging stressors. Moreover, despite strong temporal associations between common, routinely studied life-course events (e.g., unemployment) with some indicators of declining population health, little is understood about their distributions in understudied groups (e.g., immigrants) or the precise pathways through which these enduring stressors lead to premature morbidity and mortality. Even less is known about mutable factors that may mitigate or amplify the contribution of either enduring and emerging stressors to health, especially among historically minoritized groups and immigrants. Understanding influences of both enduring and emerging contemporary stressors on health is especially imperative in the context of an increasingly diverse and unequal society such as the US.

Research on the health implications of stressors has often been limited by inadequate or inconsistent measurement [15], confined to narrow population groups, and insufficiently conceptualized to discern mechanisms of action and identify buffers or amplifiers that may alter pathways to adverse outcomes. Guided by ecosocial theories of disease distribution [20-24], stress process models [25-30], life course theories [31-34], and National Institutes of Health's (NIH) health disparities research framework [21, 35, 36], the New Jersey Population Health Cohort (NJHealth) Study aims to: 1) Identify the prevalence and pathways through which enduring and emerging stressors across the life course contribute to health in diverse populations, and 2) Discover novel factors that buffer or amplify these influences on personal and population health. The NJHealth Study is designed to advance theory and generate practical, actionable knowledge for improving health and wellbeing in the population overall and specifically among diverse groups with a high likelihood of chronic exposure to stressors including those living in multi-generational families, immigrants, people of color, and low-income families. The study site, New Jersey, is among the most diverse states in the US, with dynamic patterns of immigration from diverse sending countries, and a high proportion of multi-generational families. The likely value of findings is further enhanced, from the outset, by active engagement with community and public policy stakeholders in designing the study.

The NJHealth Study design incorporates several features that strengthen its contribution beyond the scope of existing studies. A dual probabilistic and purposive sampling strategy incorporates a unique focus on under-studied groups likely to experience stressors, including discrimination or migration-related events, while at the same time supporting population estimates of key stressors as well as psychosocial and health indicators. Population estimates are critical for developing policies and interventions that specifically address the needs of specific communities or regions and assessing their impact over time. Second, the cohort design strengthens causal inferences and permits learning from natural experiments (e.g.,

climate-related events) through tracing changes in outcomes among affected populations over time. Third, the measurement of stressors is expanded beyond established domains, capturing emerging stressors at micro- and macro-levels of analysis (e.g., existential worry resulting from climate change, anxiety driven by algorithmic social media, public discord over gun regulation, ongoing shocks in immigration policy and enforcement). Finally, our multi-modal data collection plan includes survey interviews, measures of physical activity and movement, assessment of DNA and biomarkers, as well as linkage to extensive administrative and clinical data sources. These sources enrich operationalization of key outcomes as well as putative mechanisms of action along hypothesized causal pathways.

Conceptual framework

We designed our research and data collection strategies to investigate diverse pathways through which stressors may affect health. Development of the NJHealth Study conceptual framework (Figure 1) was guided by key constructs from ecosocial [20-24] and life course theories [31-34] as well as stress process models [25-30] and NIH's health disparities research framework [21, 35, 36].

Our framework distinguishes societal and individual stressors as well as macro- and micro-levels of analysis. *Societal stressors* are those that emanate from the physical or social environment (e.g., local crime or extreme weather events) or via social forces, typically through the exercise of power (e.g., structural racism or healthcare system commercialization [37-39]) that undermine the health of individuals and communities. Ideally, these stressors are studied at a macro, not micro, level of analysis [21, 23, 39]. *Individual stressors* refer to life events that are typically beyond the control of individuals such as bullying or unemployment or arise from normative transitions such as retirement or the death of a spouse. Many stressors, such as climate change, can act at both macro- and micro-levels, and are assessed accordingly in the NJ Health Study.

Figure 1 Here

Consistent with both life course theories and ecosocial theories, our framework is sensitive to the occurrence and influence of stressors across the life course [32-34]. In addition, consistent with stress process models [25, 26], we place special emphasis on the role of factors that may either buffer (mitigate) or amplify (exacerbate) the impact of stressors on health. Given the framework's grounding in life course theory, we consider how resilience [40] might lead individuals to flourish despite the presence of stressors [41]. The model also reflects relevant dimensions of the NIH health disparities research framework, including the concept of "Domains of Influence," underscoring the fact that stress influences health through biological, behavioral, and environmental processes [21, 29, 35, 36].

Environmental stressors

Stress is registered in neural circuits and often experienced consciously but its origins are commonly environmental. Some environments are more likely to engender a stress response than others. Children who are maltreated or exposed to community violence have worse health outcomes than those who grow up in less challenging surroundings, due largely to their higher levels of chronic strains [42]. Moreover, social scientists acknowledge that stress is generated at levels of influence that extend well beyond the family or even the local neighborhood. In our measurement strategy, we distinguish between exposure to societal stress at a macro level of analysis and individual subjective experiences of such stressors at a micro level.

We conceptualize *societal stressors* as occurring at various possible levels of influence. Measurement of stressors at the macro level [21, 35, 36], such as poor air quality, crime, or extreme weather events, can be operationalized at the neighborhood or other appropriate

geographic unit. Although advances in measurements of such environmental stressors have existed for decades [43, 44], it is increasingly recognized that the conceptualization and measurement of the social environment and societal stressors in stress research has been inadequate. Some societal stressors, those engendered by government actions for example, have been largely ignored in stress research. As Krieger put it, "State-sanctioned discrimination, past and present, is of particular concern." [45]. Our strategy for addressing this gap necessarily relies on assessing both publicly available indicators of structural discrimination alongside individuals' self-reports of their subjective experiences of discrimination.

Given the scarcity of research on emerging societal stressors stemming from advances in technology, climate change, and other contemporary trends, we augment available measures with novel assessments of stress from evolving social forces, including social media, politics, race relations, climate change, income inequality, immigration trends, reproductive and trans rights, and gun violence. While regional variations in such stressors may allow for geographic-based assessment, their ubiquity (e.g., climate change) and broader societal impacts dictate the need for new measures of perceived effects of contemporary stressors that will be developed using data collected in the NJHealth Study.

Social scientists have distinguished multiple domains of stressors experienced by *individuals* including [15]: early life events (e.g., childhood sexual abuse), recent life events (e.g., death of a spouse), chronic strains (e.g., ongoing family discord, perceived racism), normative life transitions (e.g., retirement), the subjective experience of stress [46-48], and structural oppression (e.g., structural racism). Even ostensibly objective life events have a subjective component, and the subjective experience of stress is predictive of health outcomes. For these reasons, the NJHealth Study draws on extensive survey items to assess the presence and timing of life events, strains, and life transitions while also assessing perceived stress.

Stress buffers and amplifiers

Although stressors can confer risk for some adverse outcomes, their influence is often modified by the presence of risk-buffers or risk-amplifiers. The shortcomings of more restricted analyses, ignoring this layer of influences, are highlighted by the salience of the buffering theory of social support [48]. Beyond social support, other potential buffers and amplifiers include resilience [40, 41, 49], religious practices, genetic predisposition, and health-related behaviors (e.g., physical activity, sleep, exercise). Planned analyses of stress effects will also include an examination of putative buffers and amplifiers.

Health outcomes

There are many possible health and wellbeing outcomes for which stressors can play determinative or influential roles over time. Accordingly, the NJHealth Study examines a broad range of outcomes assessed by participant self-reports, biometric assessments, and rich linked external data sources (insurance claims, hospital billing records, electronic health records, and death records). Information on new diagnoses or clinical episodes of stroke, heart disease (angina, arrhythmia, myocardial infarction, heart failure), cancer (solid vs. hematological malignancy, primary vs. metastatic vs. recurrent), COVID-19, liver disease/failure, kidney disease/failure, injuries (e.g., falls with and without fracture), self-directed violence (e.g., self-harm, suicide attempt), and behavioral health disorders (e.g., depression, substance use disorder diagnoses), and dementia are collected by self-report and linked clinical records, as well as their associated predisposing factors such as hypertension, diabetes, hyperlipidemia, and head trauma. Data from these sources are also collected on conditions that lead to significant disability in the US such as chronic pain, symptoms of depression and anxiety, substance misuse, hearing and vision loss, chronic obstructive pulmonary disease, asthma, and arthritis [50]. Given the on-going COVID-19 pandemic, persistent symptoms evident in linked clinical records implicated in long COVID are noted [51]. These conditions were chosen to

enable examination of their suspected role in stress mechanisms and as outcomes of those processes [52-55]. For diseases which develop over years or decades, validated plasma biomarkers (e.g., plasma p-Tau$_{181}$ for Alzheimer's disease, interleukin- and tumor necrosis factor-associated proteins for chronic inflammation) will be examined as intermediate outcomes.

DESIGN AND METHODS

Design overview

The NJHealth Study is a prospective cohort of about 8,000 NJ residents ages 14 or older. Half of participants are being recruited using a four-stage probability sample design with the aim of representing the state's household population, with oversampling to ensure representation of individuals in multi-generational families and from lower socio-economic and minoritized racial/ethnic groups.

The remaining half of the sample, recruited using purposive methods adapted from snowball sampling, comprises families with at least one first- or second-generation immigrant member. To adequately represent a diverse group of the largest and fastest growing immigrant populations in NJ, recruitment activities are focused on families with at least one first- or second-generation immigrant from China, Dominican Republic, Haiti, India, Jamaica, Korea, Mexico, Nigeria, or the Philippines. Those who entered the US seeking asylum, under temporary protected status, or related immigration authorities are also included. Multiple participants are being recruited in multi-generational households.

Participants are administered an extensive set of interview questions, including psychometric scales assessing the domains described in the conceptual framework. Cognitive testing and biometric measures are administered to participants aged 50 and older. All participants are also asked to provide consent to link their study data to existing administrative records such as health insurance claims, electronic health records, wage history and social

program data, as well as to provide DNA samples. In addition, subgroups of participants are asked to provide blood samples for measurement of biomarkers as well as to participate in actigraphy data collection over a two-week period. Finally, participant home addresses are geocoded to enable linkage of area measures of social and environmental conditions.

Full scale study recruitment began in late 2023 and is expected to conclude in 2025. The probability sample is being fielded in three replicates, each designed to be representative of the target population to enable early preliminary studies of a statewide cross-section. Sampling weights will be applied to improve population-based estimation. In the probability sample, weights will adjust for differential probabilities of selection and non-response. In the purposive immigrant sample, weights will be calculated to support the adjustment of estimates to distributions of known population characteristics.

Study setting

New Jersey, as the study site, offers several key strengths. It is among the most diverse states in the U.S., ranking among the top five states according to a prominent multidimensional diversity index [56], population share that is foreign-born [57], and in the number of multi-generational households [58]. Further, the study builds on long-standing collaborations with community organizations and public policy stakeholders, based on strong and trusting relationships that will ensure the success of study implementation and value of study findings for communities of interest. These relationships also ensure access to rich secondary data resources for linkage to the primary data collected for the NJHealth Study.

Eligibility and sampling

The NJHealth Study includes youth and adults, aged 14 and older, who live in NJ. Those living in institutional arrangements, such as a nursing facility or prison, and those unable to provide informed consent are ineligible. The address-based probability sample also excludes persons who are unhoused.

Probability sample. Four-stage probability sampling is used to select N=4,000 individuals living in NJ households. In addition to being designed to represent the State's household population overall, it oversamples multi-generational and low-income families and non-Hispanic black and Hispanic individuals. We use a clustered, address-based sample (ABS) to enable efficient in-person data collection. Sampling is performed by RTI International using its augmented ABS sampling frame [59, 60].

Families (defined as a group of persons living in a household who are related by blood, marriage/cohabitation, adoption, or guardianship) are considered multi-generational if they have members in more than one of four age groups: teens (ages 14-17), young adults (18-39), middle-aged adults (40-59) and older adults (60+). In such families, we probabilistically select and recruit one member from each generation. The geographic sampling design is also intended to support sub-state regional representation, including urban and non-urban areas.

The four probability sampling stages are:

1. Select 30 primary sampling units (PSUs), constructed from 73 US Census Public Use Microdata Areas (PUMS). Seven diverse PSUs of special public policy interest are selected with certainty and the others are selected probabilistically, oversampling areas with high shares of immigrants.
2. Select 23 Secondary Sampling Units (SSUs) per PSU, constructed from Census Block Groups. High-immigrant SSUs are oversampled.
3. Select 200 Housing Units (HUs) in each SSU. Using models developed by RTI, addresses likely to have multi-generational families are oversampled [61]. Additional subsampling of the HUs in each SSU is then undertaken to achieve completion of the necessary number of household interviews to yield 4,000 completed individual interviews.
4. Within selected HUs, probabilistically select families (if more than one is present) and family members aged 14 and older to be invited for participation.

To implement stage 4 of the sampling strategy, we ask a knowledgeable resident of each sampled household to complete a web-based or telephone enumeration questionnaire, administered by SSRS, a survey research firm. This brief enumeration survey records the number and demographic characteristics of each household resident from which one family (in multi-family households) and individual family members are selected to recruit for study participation.

Immigrant sample. The time surrounding migration to a new host country is often characterized by acute stressors such as disruption of social ties, language barriers, fluctuation in legal status, and insecure employment [62]. This is especially the case among migrants leaving unfavorable conditions in their home countries (e.g., poverty, violence, natural disasters, religious or political persecution). The acculturative stress that ensues post-migration can also be challenging for migrants [63]. Yet surprisingly, research has documented an "immigrant health paradox," demonstrated by the often-superior health status of some immigrants relative to their same-race/ethnic U.S.-born counterparts [64-66]. Although much is known about immigration-related stressors and health in some groups of immigrants, comparatively less is known about the factors that confer health resilience (stress buffers) among immigrants. Further, few studies enable disaggregated assessment of immigrant experiences across diverse sending counties and ethnic groups.

Immigrants are of special interest to the NJHealth Study given shifting and uncertain immigration policy in the United States, including recent anti-immigrant policies [67]. The diversity of the NJ population allows us to draw a multi-ethnic immigrant sample with diverse migration experiences. We project that the *probability* sample will include 1,200 foreign-born individuals, about a quarter of whom arrived in the past decade. To supplement this sample, we are conducting *purposeful* sampling of additional families with members who are immigrants, with a focus on nine countries of origin that have substantial representation in NJ (China,

Dominican Republic, Haiti, India, Jamaica, Korea, Mexico, Nigeria, and the Philippines). In addition, we are recruiting asylum seekers and others entering the US under temporary or uncertain immigrant status. Our recruitment strategy does not distinguish between legally present and undocumented immigrants.

Any New Jersey households with at least one first- or second-generation immigrant member is eligible for inclusion in the immigrant sample. We rely on two procedures to concentrate our sample on the focal immigrant groups. First, we conduct recruitment activities with community partner organizations affiliated with the focal groups. Second, we adapt respondent-driven sampling (RDS), a non-probabilistic sampling technique that is used to recruit populations that cannot feasibly be recruited using probabilistic methods [68, 69]. RDS recruitment begins with "seeds", who are members of a focal community, to participate in the study. Using these methods, immigrant study participants from the probability or immigrant samples are asked to refer up to three additional households with immigrant members. They will be permitted to refer immigrant families from non-focal immigrant groups, but those participants will not be asked to provide further referrals. We suggest, but do not require, that they refer their own family members who live in NJ but not in their household (e.g., a parent or grandparent). We monitor the composition of the immigrant sample and adjust recruitment strategies (e.g., by varying the intensity of joint-recruitment activities with community partners) and inclusion criteria (e.g., by limiting eligibility to households with first-generation immigrants) over time to ensure a balanced immigrant sample.

Sampling weights. Sample weights will be developed for both the probability and immigrant samples to enable population estimates of the NJ household population. The sample *design weight* for the probability sample is specified as the inverse of the probability of selection for the sample members, capturing the respective probabilities of selection at PSU, SSU, HU, family, and person levels and accounting for differential sampling rates. The sum of the design weights

serves as an initial estimate of the total household population in NJ. The weights will then be adjusted to account for differential nonresponse and subsequently post-stratified to ensure they sum to NJ population control totals obtained from an accurate population survey source such as American Community Survey (ACS) [70], correcting for sample frame under-coverage. Nonresponse and poststratification adjustments will be accomplished either through weighting class ratio adjustments, or through calibration using generalized exponential models [71] or similar techniques. We will also deploy quasi-population weights for the immigrant sample, adjusting to distributions of the respective immigrant group available in the ACS. Variances of estimates derived from the multi-stage survey design employed for the probability-based sample will be adjusted to account for the underlying design complexities.

Study data

To support a comprehensive assessment of stress exposures, stress responses, stress buffers and amplifiers, and health outcomes, the NJHealth Study draws on multi-modal data collection, including in-depth interviews and health assessments, actigraphy devices, saliva (for DNA), and blood plasma samples (for biomarkers). Further, administrative and clinical data will be linked to individual participants, and environmental data will be geospatially linked (e.g., by neighborhood, governmental jurisdiction, or other geographic unit).

Interviews and health assessments. Interviews are conducted by trained research assistants with consenting participants in their preferred modality (telephone, in-person, video conferences) and language (e.g., English, Spanish, Hindi, Gujarati, Mandarin, Korean, Creole and Tagalog), with some items such as cognitive assessments (English and Spanish) collected in-person only. Whenever feasible, we use validated instruments, making modifications or developing new items when needed. Table 1 lists major interview and health assessment domains and topics.

342 **Table 1: NJHealth Study Interview and Health Assessment Domains and Topics**

Population Characteristics	**Stress Buffers and Amplifiers**
Demographic characteristics	Health services access and use
Age	Barriers to care[b]
Family size and composition	Health insurance status
Gender identity and expression	Health services use, US and overseas
Sexual orientation	Usual place of care[b]
Marital status[b]	Individual and family socioeconomic status
Sex assigned at birth	Education
Immigration	Employment[b]
Age at immigration and length of time in US	Family income and wealth[b]
Language preference and spoken at home	Psychological assessment
Nativity and citizenship	Life satisfaction & quality of life
Reasons for immigration	Loneliness
Self-assessed English proficiency	Meaning in life
Individual Stressors	Optimism
Life events & experiences	Personality
Adverse childhood events	Rumination
Bullying[a]	Psychosocial assessment
Caregiving	Health risk and service use attitudes[b]
Criminal justice involvement	Religious practices
Elder mistreatment[d]	Social circumstances and engagement
Grandparent burden[c]	Civic engagement
Intimate partner violence[b]	News media engagement
Race/ethnic discrimination experiences	Social network size
Perceived stress scale	Social support
Perceptions of emerging societal stressors[e]	Volunteerism
Social determinants of health	**Health Outcomes and Assessments**
Financial and material hardship[b]	Cognitive function[c]
Food insecurity	Disability and limitations
Housing quality and stability[b]	Activities of daily living[d]
Utility security	Disability assessment
Societal Stressors	Physical performance measurement[c]
Neighborhood conditions	Health-related behaviors
Deprivation index	Daily physical activity[f]
Racial and ethnic segregation	Sleep
Crime rates, hate crime rates	Vaccination
Extreme weather events	Mental and behavioral health
Exposure to environmental toxins	Alcohol, cannabis, other substance use
Physical activity opportunities, walkability	Anxiety symptoms
Food, alcohol, cannabis outlets	Depressive symptoms
Local policies	Tobacco dependence
Local budgets (e.g., police, social services)	Suicide risk
Public libraries (e.g., book bans, services)	Physical health
School policies (e.g., curricular, speech)	Health conditions, medical history
	Height, weight, waist, hip measurement
	Self-assessed health and change in health

Limited to age groups: [a]14-17, [b]18 and older; [c]50 and older, [d]60 and older. [e]e.g., role of social media, politics, income inequality, race relations, and societal trends. [f]Limited to the actigraphy sample.

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Core interview items are administered to all participants, requiring an average of 90 minutes. A supplemental interview that includes a cognitive assessment for those aged 50 years and older is conducted in a second session that averages 35 minutes. Participants are given the option of completing interviews over multiple sessions.

Exposures to societal stressors. Societal stressors include a broad array of spatially delimited exposures ranging from environmental toxins to governmental spending on social programs and local education policy. Table 1 provides examples of societal stress measures measured at the macro (i.e., local area or jurisdiction) level. Geocoded location information for home addresses of participants will enable linkage to additional local area stressor data over time. In addition, for participants in the actigraphy subsample (described below), detailed geocoded location information will be available for a two-week period supporting assessment of community and environmental exposures in locations other than their residence (e.g., places of work).

Linked administrative and clinical records. Four types of medical and non-medical records will be linked to the study data of consenting participants (Table 2) including detailed health care claims and encounters, clinical measures, social services enrollment and benefits programs, and education and wage history. The linked data will provide rich, objective, longitudinal information that aligns with the study conceptual framework. These data include laboratory-based measures such as confirmed COVID-19 test results (from a NJ state registry) and outcomes such as HgbA1c (electronic health records), detailed clinical assessments including the Edinburgh Depression Scale scores (birth records) and cancer diagnoses (state cancer registry). Health care utilization data include all-payer hospital emergency department and inpatient billing records, and mortality data are collected from NJ vital records and the National Death Index. Historical data from these sources are linked when available, with regular updates planned over time. Except for national Medicare and Medicaid claims and the National Death Index, the linked data sources are limited to NJ programs, facilities, or populations. The study

interview will collect basic health care and social program utilization and health condition data, enabling investigators to fill gaps in administrative records (and vice versa) when needed.

Table 2: Participant-Level Data Linkages

Data Source	**Scope** (Earliest Dates and Source)
Health care claims and encounters	
Medicare and Medicaid claims	Services received anywhere in the US (2017, ResDAC)
Commercial insurance claims	Medical and surgical claims (2017-, Selected NJ insurers)
All-payer hospital billing records	Inpatient and emergency department records from all NJ acute care hospitals (201, iPHD)
Emergency Medical Services (EMS) encounters	NJ EMS encounters (2017, iPHD)
Clinical measures	
Maternal Edinburgh Depression Scale[a] and birth vital status	Birth records (2000, iPHD)
Ambulatory visits, diagnostic, lab test values	Electronic health records (2019, selected NJ providers)
Covid-19 lab confirmed diagnosis	NJ residents, (2020-2021 only, iPHD)
Covid-19 vaccination status	NJ residents, (Dec. 2020, iPHD)
Cancer diagnoses and tumor characteristics	Cancers diagnosed or treated in NJ (2017, NJSCR)
Causes of death	Mortality anywhere in the US (2022, NDI and iPHD)
Social service program enrollment and benefit levels	
Supplemental Nutrition Assistance Program (SNAP)	NJ program enrollment and benefits records (2017, NJDHS)
Temporary Assistance for Needy Families (TANF)	
General Assistance (GA)	
Emergency Assistance (EA)	
Employment and education	
Wage history	Employees of NJ employers (2001, NJEEDS)
Unemployment insurance (UI)	NJ UI program claims (2008, NJEEDS)
K-12 education history	NJ primary education and career and technical education (2010, NJEEDS)
Higher education history	NJ higher education institutions (1998, NJEEDS)
Higher education financial aid	NJ higher education institutions (2018, NJEEDS)

[a]2006 forward. Abbreviations: ResDAC = Research Data and Assistance Center; iPHD = NJ Integrated Population Health Data Project; NJSCR = NJ State Cancer Registry; NDI = National Death Index; NJDHS = NJ Dept. of Human Services; NJEEDS = NJ Education to Earning Data System

373 *Actigraphy*. Activity and sleep data from actigraphy devices allow for more in-depth and
374 objective measures of movement and rest than self-reports in study interviews. Selected
375 participants wear a tri-axial accelerometer watch (CentrePoint® Insight Watch) and complete a
376 daily participant-reported sleep and activity questionnaire [adapted from IPAQ and SIMPAQ; 72,
377 73]. Data can be processed with various software packages (e.g., GGIR, Actilife), generating
378 variables such as activity type, moderate to vigorous physical activity, sedentary bouts, and
379 sleep efficiency.

380 *Plasma and DNA biomarkers*. Stressful life events, chronic strains, and perceived stress
381 interact with genetic, behavioral, and environmental factors to modulate biological risks, onset,
382 and progression of disease. Beyond its impact on mood, stress acutely and chronically affects
383 cognitive [74, 75], cardiovascular [76-78], and intestinal [79, 80] functions as well as cancer [81-
384 83] and frailty [78]. Stress also impacts the immune system [84, 85] either directly (e.g.,
385 neuroinflammation in depression, [86, 87]) or indirectly (e.g., gut-brain axis, [88, 89]) worsen
386 health outcomes and even promote autoimmunity [90]. How the immune system is influenced
387 by acute or chronic stressors thus represents a useful proxy for short-term physiologic impact as
388 well as long-term disease risks.

389 To assess acute and chronic inflammatory effects of stress, prior studies often measured
390 circulating levels of proteins such as the general marker C-reactive protein (CRP), those
391 implicated in pro-inflammatory processes (interleukin 6 [IL-6], tumor necrosis factor alpha [TNF-
392 a]), and proteins associated with anti-inflammatory responses (interleukin 10 [IL-10]). While
393 examining these markers' concentrations is useful in people with acute illnesses (e.g., COVID-
394 19) or certain autoimmune disorders (e.g., rheumatoid arthritis), this approach has several
395 limitations. IL-10 can be increased by elevated IL-6 as a homeostatic response and is not the
396 only IL-6 antagonist (Table 3). Concentrations of other inflammatory proteins are also
397 coordinated as groups or modules to physiologically "put the brakes on" pro-inflammatory

stressors (e.g., to avoid sepsis after vaccination). Accordingly, our updated approach is to examine the equilibrium between markers of pro- and anti-inflammatory processes [91-93], which additionally makes possible investigation into how stressors impact inflammaging [94, 95] – life course immune changes as cumulative outcomes of exposures to pathogens, illnesses, autoimmunity, and immunosenescence.

To detect short-term changes temporally associated with recent or on-going stressors as well as long-term inflammaging, fasting plasma will be collected and banked from a subset (~20-40%) of study participants. NJHealth will directly measure a panel of highly precise inflammatory biomarkers (Table 3) derived from a larger panel through pilot studies. Protein markers associated with clinical endpoints (e.g., HbA1c, Alzheimer's disease) will also be measured, and plasma aliquots will be stored for future multi-omics studies.

Table 3. Examples of plasma inflammatory proteins to be measured in the NJHealth Study according to empirically derived groups or modules through factor analysis

	Group 1	Group 2	Group 3	Group 4
Inflammatory proteins	C1q C3 IL-8 IL-17D sIL-6ST/gp130 sICAM-1	CCL3 IL-10 IL-12B/IL-12p40 sIL-2RA sTNFR2	CCL2 CCL20 CCL4L1 VEGF sIL-6R	C5 CXCL1-GROa IL-6
Proteins which reduce IL-6 concentrations	sIL-6ST/gp130	IL-10	sIL-6R	
Proteins with pro-inflammatory functions	IL-8 IL-17D C1q C3	CCL3 IL-12B/IL-12p40	CCL2 CCL20 CCL4L1	IL-6 C5
Proteins with anti-inflammatory functions	IL-17D C1q sIL-6ST/gp130	sIL-2RA sTNFR2 IL-10	sIL-6R	CXCL1-GROa

Because genetic variants influence protein expression levels, immunity, response to exogenous chemicals/toxins, and future disease risks (for polygenic diseases), salivary DNA will be collected from consenting participants for genotype array analysis. Genotyping information will additionally inform genetic ancestry (global and local) to better account for population admixture

when examining polygenic disease risks. Additionally genetic materials will be stored for future whole genome/exosome sequencing and epigenetic analysis.

Data management

Limitations to existing data collection platforms with respect to one-to-many language mapping, outdated technology stacks, and data storage structure, made them unsuitable for use in this study. Thus, to meet the multi-faceted nature and complex needs of the NJHealth Study, we developed a custom multimodal data collection system called Adhi. Expanding on a previously developed multilingual, longitudinal survey data collection platform [96], Adhi integrates multiple applications on a single platform, facilitating the management of each participant's progress within the study while minimizing data inconsistencies and potential for lapses in data security. The platform includes tools allowing for the management of participant consent information and incentive payments. The platform also supports customizable staff roles/permissions allowing for the members of the project team to record data and ensure compliance with privacy and security requirements on a single location while limiting data access to study staff on need-to-know basis. The platform also permits the generation of customized real-time reports on data quality and study progress such as enrollment progress, consent rates, missing data rates, completeness of study components, and individual staff productivity and data quality. Study data can be exported in formats suitable for analysis requirements, including options for flat files or relational databases. Last, data linkages or additional study components can be easily added to the secure database as study needs evolve.

ETHICS AND DISSEMINATION

Patient and Public Involvement

Members of communities that are the focus of the study are consulted in all phases of the NJHealth Study including its design and implementation and will be involved in data analysis

and dissemination. Study investigators and staff met with community organizations, representatives of public agencies and other stakeholders in all phases of the study.

Ethics

The study was reviewed and approved by the WCGIRB (formerly Western IRB). Informed consent is obtained from participants for each source of participant-level data collection, including interviews, DNA and biomarkers, actigraphy data, and for linkage to external source data. HIPAA authorizations are also obtained for release of health services data, when applicable. Study consent forms are available upon request.

Participant safety

Risks to participants are mitigated thorough training and supervision of study staff, incorporating awareness of cultural and linguistic needs of participants. Data are available only to authorized study personnel and stored in secured, password protected files requiring multifactor identify authentication. A protocol developed by clinical staff is in place to address needs of participants who are deemed at risk of suicidality.

Availability of data and materials

De-identified data will be made available upon the completion of the initial round of data collection through public archives to be determined.

Dissemination

Findings will be reported to NJHealth study participants, funding bodies, governmental and policy stakeholders, presented at scientific meetings, and submitted for peer-review publication.

DISCUSSION

Stress is a significant driver of health over the life course, yet prior research has often been based on relatively narrow definitions of stress exposures and limited to selected groups [15] [15]. The New Jersey Population Health (NJHealth) Study seeks to address these gaps. Based

on a comprehensive conceptual framework that adapts elements of ecosocial [20, 21, 35, 36, 39] and life course theories [31, 32], along with stress process models [25, 26], the NJHealth Study will enable assessment of the impact of enduring and emerging stressors (e.g., rapidly evolving algorithm-driven social media, existential threats from climate change, and growing partisan discord) on health. As such, the study promises to produce actionable findings characterizing these stressors and delineating the pathways through which they influence population health overall and especially among understudied subgroups with a high likelihood of chronic exposure to stressors.

The NJHealth Study has key distinguishing features that will support comprehensive analyses of the prevalence and mechanisms through which stressors and stress moderators lead to health outcomes. First, the study expands the measurement of stressors and potential stress buffers and amplifiers beyond those measured at the micro-level to broader, societal-level stressors that exert their influence at macro-levels of analyses, including spatially defined exposures that have rarely been studied in research on stress and health. Second, the study's dual sampling strategy, using probabilistic and non-probabilistic methods, ensures inclusion of the full diversity of the NJ household population with augmented samples of immigrants from racially, ethnically, linguistically, and socioeconomically diverse sending countries fostering distinctive migration experiences. Third, it uses multi-modal data collection to capture interview responses drawing on established psychometric scales and health assessments, augmented with DNA, biomarker, and movement data. It also includes linkages to an extensive array of relevant external data sources that supports objective health measures and markers of stress (e.g., unemployment, engagement in social services) dating back to as early as 2000 with opportunities for routine updating.

New Jersey is an exceptional setting for the NJHealth Study because of its socioeconomic and demographic diversity, having among the highest share of immigrants in the

US. The state also has a strong data infrastructure with continuously updated systems of integrated health and socioeconomic administrative data. Finally, the NJ Health study builds on the study team's long-standing relationships with diverse communities and policy stakeholders, which has informed the design and analysis priorities.

Limitations

The NJHealth Study's comprehensiveness and innovation must be considered in light of accompanying limitations. While New Jersey is an exceptional setting for the study, single-state studies cannot be fully representative of the US population. For example, while NJ is among the most diverse states, some groups experiencing structural discrimination or other disadvantages such as Native Americans are not well represented. In addition, while the NJHealth Study interview domains draw on well validated measures, some measures have not been specifically tested in cultural and language groups that are part of the study. The NJHealth Study will enable further evaluation of the properties of such scales in new populations, but caution is warranted in their current application to some groups.

In addition, although the NJHealth Study is implementing distinctive strategies to enroll immigrant and other at-risk populations, gaps and challenges remain. Complementing its probabilistic sampling plan, it incorporates purposive, respondent-driven sampling techniques to recruit members of key populations that are rarely included in research; and the NJHealth Study has translated its survey instruments into multiple languages and employs a multi-cultural, multi-lingual field staff. Still, it is not feasible to reflect the full cultural diversity or include all languages spoken by immigrants in NJ. Like any study of its kind, despite offering monetary participation incentives, the NJHealth Study faces challenges in achieving high participation rates. The use of sampling weights will improve population representativeness, but gaps in representation remain inevitable.

The baseline round of the NJHealth Study will be a valuable source for studies of the epidemiology of emerging and evolving stressors including interpersonal and structural racism, social media usage, and financial stressors, among others. Achieving its full potential will require additional interviews over time and recruitment of future generations of participants. While not yet funded, preliminary studies of baseline data will support proposals to the National Institute of Health and other research sponsors for longitudinal data collection and analysis.

Conclusion

The NJHealth Study design has important advantages compared to prior work on stress and health. As noted, New Jersey offers key advantages including population diversity and data infrastructure. The survey interview's comprehensive assessment of stressors at the micro-level is complemented by the capacity for extensive objective measurement of stressors and health made through rich external data linkages at the individual and geographic area levels. Data on physical activity, sleep, genotype, and biomarkers add critical depth to analysis of disease risk and outcomes. Strong community support and stakeholder engagement underpinning the NJHealth Study will ensure the effective translation of research findings to benefit practical policy and programmatic applications.

Authors' contributions

JC, DMM, WTH, SB, MY, and PD led the conceptualization and design of the NJHealth Study. SBC and KBM developed the study probability sampling and weighting design. SB and JC led the development of the non-probability immigrant sample design. DM and SB developed the data collection and management platform and procedures. SB and MK developed field operations strategy and oversee study management. All authors contributed to the study design, instrument development, and data collection strategies.

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Competing interest statement

The authors declare no competing interests.

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List of Figures

REFERENCES

1. McMichael AJ. Globalization, Climate Change, and Human Health. N Engl J Med. 2013;368(14):1335-43.

2. Xu R, Yu P, Abramson MJ, et al. Wildfires, Global Climate Change, and Human Health. N Engl J Med. 2020;383(22):2173-81.

3. Palinkas LA, Wong M. Global climate change and mental health. Curr Opin Psychol. 2020;32:12-6.

4. Twenge JM, Joiner TE, Rogers ML, Martin GN. Increases in Depressive Symptoms, Suicide-Related Outcomes, and Suicide Rates Among U.S. Adolescents After 2010 and Links to Increased New Media Screen Time. Clin Psychol Sci. 2017;6(1):3-17.

5. Hooper MW, Nápoles AM, Pérez-Stable EJ. COVID-19 and Racial/Ethnic Disparities. JAMA. 2020;323(24):2466-7.

6. Montez JK. US State Polarization, Policymaking Power, and Population Health. Milbank Q. 2020;98(4):1033-52.

7. Montez JK, Beckfield J, Cooney JK, et al. US State Policies, Politics, and Life Expectancy. Milbank Q. 2020;98(3):668-99.

8. Center for Health Statistics. Life Expectancy at Birth by Year, New Jersey, 2000-2020 [online]. 2022. https://www-doh.state.nj.us/doh-shad/indicator/complete_profile/LifeExpectancy.html (accessed 27 Jun 2023).

9. Ho JY. Causes of America's Lagging Life Expectancy: An International Comparative Perspective. J Gerontol B Psychol Sci Soc Sci. 2022;77(Supplement_2):S117-S26.

10. Bor J, Stokes AC, Raifman J, et al. Missing Americans: Early death in the United States—1933–2021. PNAS Nexus. 2023;2(6):pgad173.

11. Lawrence WR, Freedman ND, McGee-Avila JK, et al. Trends in Mortality From Poisonings, Firearms, and All Other Injuries by Intent in the US, 1999-2020. JAMA Intern Med. 2023;183(8):849-56.

12. Wang S, Rexrode KM, Florio AA, et al. Maternal Mortality in the United States: Trends and Opportunities for Prevention. Annu Rev Med. 2023;74(1):199-216.

13. Centers for Disease Control and Prevention. Suicide rates and statistics [online]. 2023. https://www.cdc.gov/suicide/suicide-data-statistics.html (accessed 14 Aug 2023).

14. OECD. Suicide rates (indicator) [online]. 2023. https://data.oecd.org/healthstat/suicide-rates.htm (accessed 28 Mar 2023).

15. Stress Measurement Network. [online]. San Francisco, CA: University of California, San Francisco and National Institute on Aging; 2015. https://www.stressmeasurement.org (accessed 9 Apr 2024).

16. Flaskerud JH. Stress in the Age of COVID-19. Issues Ment Health Nurs. 2020;42(1):99-102.

17. Wu C, Louie P, Bierman A, Schieman S. Assessment of Sociodemographics and Inflation-Related Stress in the US. JAMA Netw Open. 2023;6(5):e2313431-e.

18. Clayton S. Climate anxiety: Psychological responses to climate change. J Anxiety Disord. 2020;74:102263.

19. WHO. Mental health and Climate Change: Policy Brief [online]. 2022. https://www.who.int/publications/i/item/9789240045125 (accessed 23 Oct 2023).

20. Krieger N. Theories for social epidemiology in the 21st century: an ecosocial perspective. Int J Epidemiol. 2001;30(4):668-77.

21. Anderson NB. Levels of Analysis in Health Science: A Framework for Integrating Sociobehavioral and Biomedical Research. Ann NY Acad Sci. 1998;840(1):563-76.

22. Bronfenbrenner U. Toward an experimental ecology of human development. Am Psychol. 1977;32(7):513-31.

23. Engel GL. The clinical application of the biopsychosocial model. Am J Psychiatry. 1980;137(5):535-44.

24. Engel GL. How much longer must medicine's science be bound by a seventeenth century world view? Psychother Psychosom. 1992;57(1-2):3-16.
25. Pearlin LI. The Sociological Study of Stress. J Health Soc Behav. 1989;30(3):241-56.
26. Pearlin LI, Bierman A. Current Issues and Future Directions in Research into the Stress Process. In: Aneshensel CS, Phelan JC, Bierman A, editors. Handbook of the Sociology of Mental Health. Dordrecht, Netherlands: Springer Netherlands; 2012. p. 325-40.
27. Biggs A, Brough P, Drummond S. Lazarus and Folkman's Psychological Stress and Coping Theory. In: Cooper CL, Quick JC, editors. The Handbook of Stress and Health: A Guide to Research and Practice. Hoboken, NJ: Wiley-Blackwell; 2017. p. 349-64.
28. Sterling P, Eyer J. Biological basis of stress-related mortality. Soc Sci Med E. 1981;15(1):3-42.
29. McEwen BS. Protective and Damaging Effects of Stress Mediators. N Engl J Med. 1998;338(3):171-9.
30. Sterling P, Platt ML. Why Deaths of Despair Are Increasing in the US and Not Other Industrial Nations—Insights From Neuroscience and Anthropology. JAMA Psychiat. 2022;79(4):368-74.
31. Kuh D, Ben-Shlomo Y, Lynch J, et al. Life Course Epidemiology. J Epidemiol Commun H. 2003;57(10):778-83.
32. Elder GH. The Life Course as Developmental Theory. Child Dev. 1998;69(1):1-12.
33. Elder GH. Time, Human Agency, and Social Change: Perspectives on the Life Course. Soc Psychol Quart. 1994;57(1):4-15.
34. Dannefer D. Aging as intracohort differentiation: Accentuation, the Matthew effect, and the life course. Sociol Forum. 1987;2(2):211-36.
35. Hill CV, Pérez-Stable EJ, Anderson NA, Bernard MA. The National Institute on Aging Health Disparities Research Framework. Ethn Dis. 2015;25(3):245-54.

36. National Institute on Minority Health and Health Disparities. NIMHD Research Framework [online]. 2017. https://nimhd.nih.gov/researchFramework (accessed 23 May 2023).
37. Lee K, Freudenberg N, Zenone M, et al. Measuring the Commercial Determinants of Health and Disease: A Proposed Framework. Int J Health Serv. 2021;52(1):115-28.
38. Freudenberg N, Lee K, Buse K, et al. Defining Priorities for Action and Research on the Commercial Determinants of Health: A Conceptual Review. Am J Public Health. 2021;111(12):2202-11.
39. Krieger N. Proximal, Distal, and the Politics of Causation: What's Level Got to Do With It? Am J Public Health. 2008;98(2):221-30.
40. National Institutes of Health. Defining and Conceptualizing Resilience [online]. 2019. https://ods.od.nih.gov/Research/resilience.aspx (accessed 29 Jul 2023).
41. Bonanno GA. Loss, Trauma, and Human Resilience: Have We Underestimated the Human Capacity to Thrive After Extremely Aversive Events? Am Psychol. 2004;59(1):20-8.
42. Lynch M, Cicchetti D. An ecological-transactional analysis of children and contexts: the longitudinal interplay among child maltreatment, community violence, and children's symptomatology. Dev Psychopathol. 1998;10(2):235-57.
43. Sampson RJ, Morenoff JD, Gannon-Rowley T. Assessing "Neighborhood Effects": Social Processes and New Directions in Research. Annu Rev Sociol. 2002;28:443-78.
44. Kawachi I, Subramanian SV. Measuring and modeling the social and geographic context of trauma: A multilevel modeling approach. J Trauma Stress. 2006;19(2):195-203.
45. Krieger N. Methods for the Scientific Study of Discrimination and Health: An Ecosocial Approach. Am J Public Health. 2012;102(5):936-44.
46. Crosswell AD, Lockwood KG. Best practices for stress measurement: How to measure psychological stress in health research. Health Psychol Open. 2020;7(2):2055102920933072.
47. Epel ES, Crosswell AD, Mayer SE, et al. More than a feeling: A unified view of stress measurement for population science. Front Neuroendocrinol. 2018;49:146-69.

48. Cohen S, Wills TA. Stress, Social Support, and the Buffering Hypothesis. Psychol Bull. 1985;98(2):310-57.

49. Southwick SM, Bonanno GA, Masten AS, et al. Resilience definitions, theory, and challenges: interdisciplinary perspectives. Eur J Psychotraumatol. 2014;5(1):25338.

50. The U.S. Burden of Disease Collaborators. The State of US Health, 1990-2016: Burden of Diseases, Injuries, and Risk Factors Among US States. JAMA. 2018;319(14):1444-72.

51. Gebeyehu DT, East L, Wark S, Islam MS. Disability-adjusted life years (DALYs) based COVID-19 health impact assessment: a systematic review. BMC Public Health. 2023;23(1):334.

52. Garfin DR, Thompson RR, Holman EA. Acute stress and subsequent health outcomes: A systematic review. J Psychosom Res. 2018;112:107-13.

53. Lagraauw HM, Kuiper J, Bot I. Acute and chronic psychological stress as risk factors for cardiovascular disease: Insights gained from epidemiological, clinical and experimental studies. Brain Behav Immun. 2015;50:18-30.

54. Ruisoto P, Contador I. The role of stress in drug addiction. An integrative review. Physiol Behav. 2019;202:62-8.

55. Yang L, Zhao Y, Wang Y, et al. The Effects of Psychological Stress on Depression. Curr Neuropharmacol. 2015;13(4):494-504.

56. McCann A. Most & Least Diverse States in America [online]. 2022. https://wallethub.com/edu/most-least-diverse-states-in-america/38262 (accessed 28 Mar 2023).

57. United States Census Bureau. 2021: ACS 1-Year Estimates Data Profiles [online]. 2021. https://data.census.gov/table?q=foreign-born+share&g=010XX00US$0400000&tid=ACSDP1Y2021.DP02 (accessed 17 Jul 2023).

58. Hoff M. Social distancing may be harder for families who live with elderly relatives. Here are the 15 states with the largest share of multigenerational households. Insider. 2020.

59. Amaya A, Zimmer S, Morton K, Harter R. Does Undercoverage on the U.S. Address-based Sampling Frame Translate to Coverage Bias? Sociol Method Res. 2018;50(2):812-36.

60. English N, Kennel T, Buskirk T, Harter R. The Construction, Maintenance, and Enhancement of Address-Based Sampling Frames. J Surv Stat Methodol. 2019;7(1):66-92.

61. Morton K, Cohen S, Zimmer S, Cantor J, editors. Oversampling multigenerational families & immigrant groups in the NJ Population Health Cohort Study. In Proceedings of the 2023 International Conference on Health Policy Statistics, American Statistical Association, Health Policy Statistics Section; 2023: Alexandria, VA: American Statistical Association.

62. Mak J, Roberts B, Zimmerman C. Coping with Migration-Related Stressors: A Systematic Review of the Literature. J Immigr Minor Healt. 2021;23(2):389-404.

63. Fanfan D, Stacciarini J-MR. Social-ecological correlates of acculturative stress among Latina/o and Black Caribbean immigrants in the United States: A scoping review. Int J Intercult Rel. 2020;79:211-26.

64. Langellier BA, Fleming PJ, Kemmick Pintor JB, Stimpson JP. Allostatic Load Among U.S.- and Foreign-Born Whites, Blacks, and Latinx. Am J Prev Med. 2021;60(2):159-68.

65. Markides KS, Coreil J. The Health of Hispanics in the Southwestern United States: An Epidemiologic Paradox. Public Health Rep. 1986;101(3):253-65.

66. Alegría M, Álvarez K, DiMarzio K. Immigration and Mental Health. Curr Epidemiol Rep. 2017;4(2):145-55.

67. Samari G, Nagle A, Coleman-Minahan K. Measuring structural xenophobia: US State immigration policy climates over ten years. SSM Popul Health. 2021;16:100938.

68. Gile KJ, Handcock MS. 7. Respondent-Driven Sampling: An Assessment of Current Methodology. Sociol Methodol. 2010;40(1):285-327.

69. Heckathorn DD, Cameron CJ. Network Sampling: From Snowball and Multiplicity to Respondent-Driven Sampling. 2017;43(1):101-19.

70. United States Census Bureau. American Community Survey (ACS) [online]. 2024. https://www.census.gov/programs-surveys/acs (accessed 21 Apr 2024).

71. Folsom RE, Singh AC, editors. The generalized exponential model for sampling weight calibration for extreme values, nonresponse, and poststratification. In Proceedings of the 2000 Joint Statistical Meetings, American Statistical Association, Survey Research Methods Section; 2000; Indianapolis, IN: Alexandria, VA: American Statistical Association.

72. Craig CL, Marshall AL, Sjöström M, et al. International Physical Activity Questionnaire: 12-Country Reliability and Validity. Med Sci Sports Exerc. 2003;35(8):1381-95.

73. Rosenbaum S, Ward PB. The Simple Physical Activity Questionnaire. Lancet Psychiatry. 2016;3(1):e1.

74. McEwen BS, Sapolsky RM. Stress and cognitive function. Curr Opin Neurobiol. 1995;5(2):205-16.

75. Gould E, Tanapat P. Stress and hippocampal neurogenesis. Biol Psychiatry. 1999;46(11):1472-9.

76. Dakak N, Quyyumi AA, Eisenhofer G, et al. Sympathetically mediated effects of mental stress on the cardiac microcirculation of patients with coronary artery disease. Am J Cardiol. 1995;76(3):125-30.

77. Vrijkotte TG, van Doornen LJ, de Geus EJ. Effects of work stress on ambulatory blood pressure, heart rate, and heart rate variability. Hypertension. 2000;35(4):880-6.

78. Ferrucci L, Fabbri E. Inflammageing: chronic inflammation in ageing, cardiovascular disease, and frailty. Nat Rev Cardiol. 2018;15(9):505-22.

79. Söderholm JD, Perdue MH. Stress and gastrointestinal tract. II. Stress and intestinal barrier function. Am J Physiol Gastrointest Liver Physiol. 2001;280(1):G7-g13.

80. McClave SA, Lowen CC, Martindale RG. The 2016 ESPEN Arvid Wretlind lecture: The gut in stress. Clin Nutr. 2018;37(1):19-36.

81. Reiche EM, Nunes SO, Morimoto HK. Stress, depression, the immune system, and cancer. Lancet Oncol. 2004;5(10):617-25.

731 82. Chida Y, Hamer M, Wardle J, Steptoe A. Do stress-related psychosocial factors
732 contribute to cancer incidence and survival? Nat Clin Pract Oncol. 2008;5(8):466-75.
733 83. Batty GD, Russ TC, Stamatakis E, Kivimäki M. Psychological distress in relation to site
734 specific cancer mortality: pooling of unpublished data from 16 prospective cohort studies. BMJ.
735 2017;356:j108.
736 84. Calabrese JR, Kling MA, Gold PW. Alterations in immunocompetence during stress,
737 bereavement, and depression: focus on neuroendocrine regulation. Am J Psychiatry.
738 1987;144(9):1123-34.
739 85. Barrett TJ, Corr EM, van Solingen C, et al. Chronic stress primes innate immune
740 responses in mice and humans. Cell Rep. 2021;36(10):109595.
741 86. Yirmiya R, Rimmerman N, Reshef R. Depression as a microglial disease. Trends
742 Neurosci. 2015;38(10):637-58.
743 87. Troubat R, Barone P, Leman S, et al. Neuroinflammation and depression: A review. Eur
744 J Neurosci. 2021;53(1):151-71.
745 88. Gao X, Cao Q, Cheng Y, et al. Chronic stress promotes colitis by disturbing the gut
746 microbiota and triggering immune system response. Proc Natl Acad Sci. 2018;115(13):E2960-
747 E9.
748 89. Rutsch A, Kantsjö JB, Ronchi F. The Gut-Brain Axis: How Microbiota and Host
749 Inflammasome Influence Brain Physiology and Pathology. Front Immunol. 2020;11:604179.
750 90. Stojanovich L, Marisavljevich D. Stress as a trigger of autoimmune disease. Autoimmun
751 Rev. 2008;7(3):209-13.
752 91. de Brito RC, Lucena-Silva N, Torres LC, et al. The balance between the serum levels of
753 IL-6 and IL-10 cytokines discriminates mild and severe acute pneumonia. BMC Pulm Med.
754 2016;16(1):170.
755 92. Wharton W, Kollhoff AL, Gangishetti U, et al. Interleukin 9 alterations linked to alzheimer
756 disease in african americans. Ann Neurol. 2019;86(3):407-18.

93. Hu WT, Ozturk T, Kollhoff A, et al. Higher CSF sTNFR1-related proteins associate with better prognosis in very early Alzheimer's disease. Nat Commun. 2021;12(1):4001.

94. Franceschi C, Garagnani P, Parini P, et al. Inflammaging: a new immune–metabolic viewpoint for age-related diseases. Nat Rev Endocrinol. 2018;14(10):576-90.

95. Hu WT, Howell JC, Ozturk T, et al. CSF Cytokines in Aging, Multiple Sclerosis, and Dementia. Front Immunol. 2019;10:480.

96. Dong X, Kong D, Mendhe D, Bergren SM. Leveraging Technology to Improve Health Disparity Research: Trilingual Data Collection Using Tablets. J Am Geriatr Soc. 2019;67(S3):S479-S85.