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Health implications of established and emerging stressors: design of the prospective New Jersey Population Health Cohort (NJHealth) Study

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ABSTRACT

Introduction Some stressors, like the death of a partner, 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 characterise established 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 colour, multigenerational families and low-income families.

Methods and analysis A prospective cohort, the NJHealth Study is recruiting 8000 NJ residents aged 14 and older using probabilistic and purposive methods to include members of multigenerational families, marginalised racial/ethnic and low-income populations, and recent immigrant groups. Building on ecosocial, life course and stress process models, the NJHealth Study employs multimodal 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, and 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 programme applications.

Ethics and dissemination The study was approved by the WCGIRB (Study #1321099) (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

⇒ The study is guided by a comprehensive framework informed by key constructs from ecosocial and life course theories as well as stress process models.
⇒ The study of dual probabilistic and purposive sampling incorporates a unique focus on understudied groups likely to experience stressors, including immigrants from diverse sending countries, other groups experiencing discrimination and multigenerational families; additionally, sampling multiple participants in single households allows for analysis of stress proliferation across family members.
⇒ Study data include comprehensive assessments of individual and societal stressors measured at microlevels and macrolevels using multimodal data collection, including survey interviews, actigraphy, DNA and biomarkers, health assessments, and linked administrative, clinical, social programme 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.
⇒ The study setting, New Jersey, has high demographic diversity but does not fully represent the US population; further, even with a probability sample augmented with purposive immigrant recruitment and deployment of a multilingual, multicultural interview staff, it is likely gaps will remain or may emerge due to differential retention in how well the New Jersey Population Health Cohort Study represents New Jersey.

INTRODUCTION

Recent decades have brought rapid social changes, technological developments and a host of new stressors to human populations, with considerable implications for well-being, health and life expectancy.[1–7] Despite advances in biomedicine, overall life expectancy in the USA, 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 USA,[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 USA 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 USA.

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 (eg, death of a partner) with some indicators of declining population health, little is understood about their distributions in understudied groups (eg, immigrants) or the precise pathways through which these established stressors lead to premature morbidity and mortality. Even less is known about mutable factors that may mitigate or amplify the contribution of either established and emerging stressors to health, especially among historically minoritised groups and immigrants. Understanding the influences of both established and emerging contemporary stressors on health is especially imperative in the context of an increasingly diverse and unequal society such as the USA. Research on the health implications of stressors has often been limited by inadequate or inconsistent measurement,[15] confined to narrow population groups and insufficiently conceptualised 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 the National Institutes of Health's (NIH) health disparities research framework,[21 35 36] the NJ Population Health Cohort (NJHealth) Study aims to (1) identify the prevalence and pathways through which established 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 well-being in the population overall and specifically among diverse groups with a high likelihood of chronic exposure to stressors including those living in multigenerational families, immigrants, people of colour and low-income families. The study site, NJ, is among the most diverse states in the USA, with dynamic patterns of immigration from diverse sending countries and a high proportion of multigenerational 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 understudied 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 (eg, 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 microlevels and macrolevels of analysis (eg, 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 multimodal 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 operationalisation of key outcomes as well as putative mechanisms of action along hypothesised 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 macrolevels and microlevels of analysis. Societal stressors are those that emanate from the physical or social environment (eg, local crime or extreme weather events) or via social forces, typically through the exercise of power (eg, structural racism or healthcare system commercialisation[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 adverse childhood events or arise from normative transitions such as retirement or the death of a spouse. Many stressors, such as climate change, can act at both societal (macro) and individual (micro)levels and are assessed accordingly in the NJHealth Study.

Consistent with both life course theories and ecosocial theories, our framework is sensitive to the occurrence and

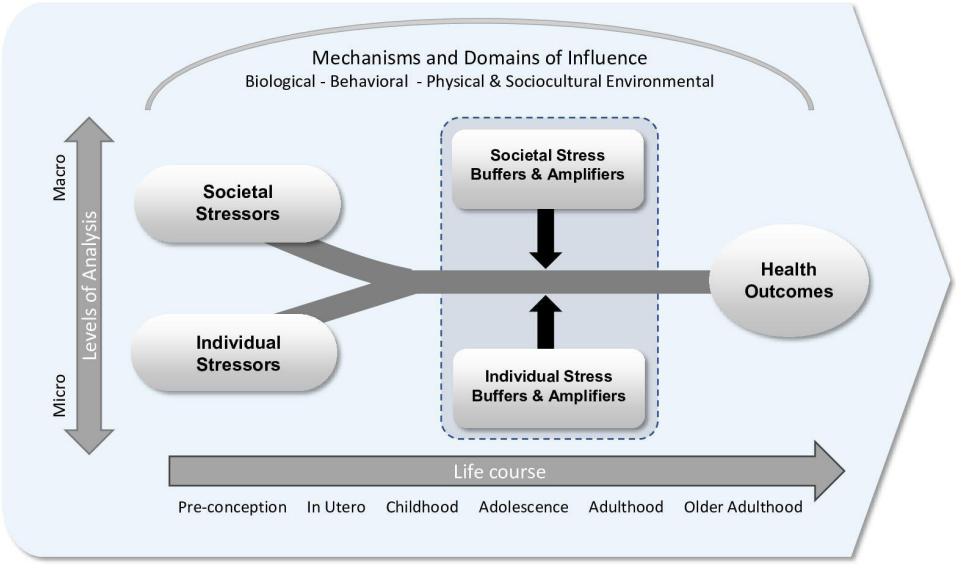

Figure 1 NJHealth Study model of stressors and health over the life course. Adapted from Krieger[20 39] and Pearlin[25 26] and other sources (see text). NJHealth, New Jersey Population Health Cohort.

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, behavioural 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 neighbourhood. 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 conceptualise societal stressors as occurring at various possible levels of influence. Measurement of stressors at the macrolevel,[21 35 36] such as poor air quality, crime, or extreme weather events, can be operationalised at the neighbourhood or other appropriate geographical units. Although advances in measurements of such environmental stressors have existed for decades,[43 44] it is increasingly recognised that the conceptualisation 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 (eg, 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]: adverse childhood events (eg, sexual abuse), recent life events (eg, death of a spouse), chronic strains (eg, ongoing family discord, perceived racism), normative life transitions (eg, retirement), the subjective experience of stress[46–48] and structural oppression (eg, 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 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 behaviours (eg, physical activity, sleep and exercise). Planned analyses of stress effects will also include an examination of putative buffers and amplifiers.

Health outcomes

There are many possible health and well-being 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). Diagnostic information on stroke, heart disease (angina, arrhythmia, myocardial infarction, heart failure), cancer (solid vs haematological malignancy, primary vs metastatic vs recurrent), COVID-19, liver disease/failure, kidney disease/failure, injuries (eg, falls with and without fracture), self-directed violence (eg, self-harm, suicide attempt) and behavioural health disorders (eg, depression, substance use disorder diagnoses) and dementia are collected by self-report and linked clinical records, as well as predisposing factors based on clinical exam or lab values (eg, hypertension, diabetes and hyperlipidaemia). Diagnostic and self-report data from these sources are also collected on conditions that lead to significant disability in the USA 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 ongoing 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 (eg, plasma p-Tau$_{181}$ for Alzheimer's disease, interleukin-associated and tumour necrosis factor-associated proteins for chronic inflammation) will be examined as intermediate outcomes.

METHODS AND ANALYSIS

Design overview

The NJHealth Study is a prospective cohort of about 8000 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 multigenerational families and from lower socioeconomic and minoritised racial/ethnic groups.

The remaining half of the sample, recruited using purposive methods adapted from snowball sampling, comprises families with at least one first-generation 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-generation 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 multigenerational 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 programme 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 2-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 the first wave of data collection 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

NJ, as the study site, offers several key strengths. It is among the most diverse states in the USA, 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 multigenerational households.[58] Further, the study builds on long-standing collaborations with community organisations and public policy stakeholders, based on strong and trusting relationships that will ensure the success of study implementation and the 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=4000 individuals living in NJ households. In addition to being designed to represent the state's household population overall, it oversamples multigenerational 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 Research Triangle Institute (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 multigenerational 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 geographical sampling design is also intended to support substate 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. 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 multigenerational 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 4000 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 multifamily 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 characterised 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 unfavourable conditions in their home countries (eg, poverty, violence, natural disasters, religious or political persecution). The acculturative stress that ensues postmigration 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 US-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 countries and ethnic groups.

Immigrants are of special interest to the NJHealth Study given shifting and uncertain immigration policy in the USA, 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 1200 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). We selected these origin countries because they are well represented among recently arriving immigrants to NJ and for diversity of region and demographics.[68] In addition, we are recruiting asylum seekers and others entering the USA under temporary or uncertain immigrant status. Our recruitment strategy does not distinguish between legally present and undocumented immigrants.

Any NJ households with at least one first-generation or second-generation immigrant member are 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 organisations 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.[69 70] 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 (eg, a parent or grandparent). We monitor the composition of the immigrant sample and adjust recruitment strategies (eg, by varying the intensity of joint recruitment activities with community partners) and inclusion criteria (eg, 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 non-response and subsequently poststratified to ensure they sum to NJ population control totals obtained from an accurate population survey source such as American Community Survey (ACS),[71] correcting for sample frame undercoverage. Non-response and poststratification adjustments will be accomplished either through weighting class ratio adjustments, or through calibration using generalised exponential models[72] 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 multistage 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 multimodal 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 (eg, by neighbourhood, governmental jurisdiction or another geographical unit).

Interviews and health assessments

Interviews are conducted by trained research assistants or online with consenting participants in their preferred modality (telephone, in-person, video conferences or online), location (participant's home, suitable public venue, virtual), and language (eg, English, Spanish, Hindi, Gujarati, Mandarin, Korean, Haitian Creole and Tagalog), with some items such as cognitive assessments (English and Spanish) collected in-person only. Questionnaires completed online are systematically reviewed by interview staff and followed up as needed. 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.

Core interview items are administered to all participants, requiring an average of 90 min. A supplemental interview that includes a cognitive assessment for those aged 50 years and older is conducted in a second session that averages 35 min. 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 toxicants to governmental spending on social programmes and local education policy. Table 1 provides examples of societal stress measures measured at the macro (ie, local area or jurisdiction) level. Geocoded location information for home addresses of participants will enable linkage to additional local area stressor data over time.

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 healthcare claims and encounters, clinical measures, social services enrolment and benefits programmes, 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 an NJ state registry) and outcomes such as HbA1c (electronic health records), detailed clinical assessments including the Edinburgh Depression Scale scores (birth records) and cancer diagnoses (state cancer registry). Healthcare utilisation 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. Employment and education information from NJ includes data on wages earned, industry of employment, whether unemployment compensation was claimed and how much was received, and indicators of educational achievement.

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 programmes, facilities or populations. The study interview will collect basic healthcare and social programme utilisation and health condition data, enabling investigators to fill gaps in administrative records (and vice versa) when needed.

Table 1 NJHealth Study interview and health assessment domains and topics

Individual stressors	Societal stressors
Life events	Neighbourhood conditions
Adverse childhood events	Deprivation index
Bullying*	Racial and ethnic segregation
Caregiving	Crime rates, hate crime rates
Criminal justice involvement	Extreme weather events
Elder mistreatment†	Exposure to environmental toxins
Grandparent burden‡	Physical activity opportunities, walkability
Intimate partner violence§	Food, alcohol, cannabis outlets
Race/ethnic discrimination experiences	Local policies
Perceived stress scale	Local budgets (eg, police, social services)
Perceptions of emerging societal stressors¶	Public libraries (eg, book bans, services)
Social determinants of health	School policies (eg, curricular, speech)
Financial and material hardship§	
Food insecurity	
Housing quality and stability§	
Utility security	
Stress buffers and amplifiers	**Health outcomes and assessments**
Health services access and use	Cognitive function‡
Barriers to care§	Disability and limitations
Health insurance status	Activities of daily living†
Health services use, US and overseas	Disability assessment
Usual place of care§	Physical performance measurement‡
Individual and family socioeconomic status	Health-related behaviours
Education	Daily physical activity**
Employment§	Sleep
Family income and wealth§	Vaccination
Psychological assessment	Mental and behavioural health
Life satisfaction & quality of life	Alcohol, cannabis, other substance use
Loneliness	Anxiety symptoms
Meaning in life	Depressive symptoms
Optimism	Tobacco dependence
Personality	Suicide risk
Rumination	Physical health
Psychosocial assessment	Health conditions, medical history
Health risk and service use attitudes§	Height, weight, waist, hip measurement
Religious practices	Self-assessed health and change in health
Social circumstances and engagement	
Civic engagement	
News media engagement	
Social network size	
Social support	
Volunteerism	
Population characteristics	
Demographic characteristics	
Age	
Family size and composition	
Gender identity and expression	
Sexual orientation	
Marital status§	
Sex assigned at birth	

Continued

Table 1 Continued

Immigration
Age at immigration and length of time in US
Language preference and spoken at home
Nativity and citizenship
Reasons for immigration
Self-assessed English proficiency

*Limited to ages 14-17 years
†Limited to ages 60 years and older
‡Limited to ages 50 years and older
§Limited to ages 18 years and older
¶For example, role of social media, politics, income inequality, race relations, and societal trends.
**Limited to the actigraphy sample.
NJHealth, New Jersey Population Health Cohort.

Actigraphy

Activity and sleep data from actigraphy devices allow for more in-depth and objective measures of movement and rest than self-reports in study interviews. Probabilistically selected participants wear a triaxial accelerometer watch (CentrePoint Insight Watch) and complete a daily participant-reported sleep and activity questionnaire for 2 weeks (adapted from IPAQ and SIMPAQ[73 74]). Data can be processed with various software packages (eg, GGIR, Actilife), generating variables such as activity type, moderate to vigorous physical activity, sedentary bouts and sleep efficiency.

Table 2 Participant-level data linkages

Data source	Scope (earliest dates and source)
Healthcare claims and encounters	
Medicare and Medicaid claims	Services received anywhere in the USA (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 (2010, iPHD)
Emergency Medical Services (EMS) encounters	NJ EMS encounters (2017, iPHD)
Clinical measures	
Maternal Edinburgh Depression Scale* 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 tumour characteristics	Cancers diagnosed or treated in NJ (2017 NJSCR)
Causes of death	Mortality anywhere in the USA (2022, NDI and iPHD)
Social service programme enrolment and benefit levels	
Supplemental Nutrition Assistance Programme	NJ programme enrolment and benefits records (2017, NJDHS)
Temporary Assistance for Needy Families	
General Assistance	
Emergency Assistance	
Employment and education	
Wage history	Employees of NJ employers (2001, NJEEDS)
Unemployment insurance (UI)	NJ UI programme 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)

*2006 forward.
iPHD, NJ Integrated Population Health Data Project; NDI, National Death Index; NJDHS, NJ Department of Human Services; NJEEDS, NJ Education to Earning Data system ; NJSCR, NJ State Cancer Registry; ResDAC, Research Data and Assistance Center.

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 proinflammatory 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

NJHealth, New Jersey Population Health Cohort.

Plasma and DNA biomarkers

Stressful life events, chronic strains and perceived stress interact with genetic, behavioural and environmental factors to modulate biological risks, onset and progression of disease. Beyond its impact on mood, stress acutely and chronically affects cognitive,[75 76] cardiovascular[77–79] and intestinal[80 81] functions as well as cancer[82–84] and frailty.[79] Stress also impacts the immune system[85 86] either directly (eg, neuroinflammation in depression,[87 88]) or indirectly (eg, gut–brain axis[89 90]) worsening health outcomes and even promoting autoimmunity.[91] How the immune system is influenced by acute or chronic stressors thus represents a useful proxy for short-term physiologic impact as well as long-term disease risks.

To assess acute and chronic inflammatory effects of stress, prior studies often measured circulating levels of proteins such as the general marker C reactive protein (CRP), those implicated in proinflammatory processes (interleukin 6 (IL-6), tumour necrosis factor alpha (TNF-a)) and proteins associated with anti-inflammatory responses (interleukin 10 (IL-10)). While examining these markers' concentrations is useful in people with acute illnesses (eg, COVID-19) or certain autoimmune disorders (eg, rheumatoid arthritis), this approach has several limitations. IL-10 can be increased by elevated IL-6 as a homeostatic response and is not the only IL-6 antagonist (table 3). Concentrations of other inflammatory proteins are also coordinated as groups or modules to physiologically 'put the brakes on' proinflammatory stressors (eg, to avoid sepsis after vaccination). Accordingly, our updated approach is to examine the equilibrium between markers of proinflammatory and anti-inflammatory processes,[92–94] which additionally makes possible investigation into how stressors impact inflammaging[95 96]—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 ongoing 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 (eg, HbA1c, Alzheimer's disease) will also be measured, and plasma aliquots will be stored for future multiomics studies.

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.

Statistical power

To detect differences of 0.10 or greater in proportional estimates when testing at an alpha level of 0.05 and statistical power of 0.80, assuming a survey design effect of 1.5, we will require n=588 or more in each of two groups. Statistical power at that level would enable us, for example, to detect differences in the proportion of Black participants reporting high levels of depressive symptoms by self-reported experiences of racism, consistent with prior literature.[97] We anticipate enrolling about n=1425 black participants, including about n=525 in the probability sample and n=900 in the immigrant sample.

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 multifaceted 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.[98] Adhi integrates multiple applications on a single platform, facilitating the management of each participant's progress within the study while minimising 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 customisable staff roles/permissions, allowing for the members of the project team to record data and ensure compliance with privacy and security requirements in a single location while limiting data access to study staff on a need-to-know basis. The platform also permits the generation of customised real-time reports on data quality and study progress such as enrolment 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.

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, implementation, data analysis and dissemination. Guided by a Community Advisory Board, study investigators and staff meet with community organisations, representatives of public agencies and other stakeholders to discuss all phases of the study.

ETHICS AND DISSEMINATION

Ethics

The study was reviewed and approved by the WCGIRB (Study #1321099) (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 authorisations are also obtained for release of health services data, when applicable. Study consent forms are available on request.

Participant safety

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

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.

Availability of data and materials

Deidentified data will be made available on the completion of the initial round of data collection through the Health and Medical Care Archive at the University of Michigan Inter-University Consortium for Political and Social Research.

DISCUSSION

Studies have linked stress to diminished health over the life course, yet prior research has often been based on narrow or outdated definitions of stress exposures, rarely employed dual probability and purposive samples, and rarely sampled multiple individuals from the same household, precluding the rigorous study of the mechanisms by which stress experienced by one household member affects other household members.[15–19 99 100] The 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 established and emerging stressors (eg, 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 characterising 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 macrolevels 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, the sample includes multiple individuals across age groups (a proxy for generations) within selected families, allowing for deeper analysis of intergenerational stressors and stress buffers than is common in similar studies. Fourth, NJHealth interviews can be conducted in multiple languages beyond English and Spanish (eg, Hindi, Gujarati, Mandarin, Korean, Haitian Creole and Tagalog). Fifth, it uses multimodal data collection to capture interview responses drawing on established psychometric

scales and health assessments, augmented with DNA, biomarker and movement data. Finally, NJHealth also includes linkages to a broader array of relevant external data sources that support objective health measures and markers of stress (eg, unemployment, engagement in social services) dating back to as early as 2000 with opportunities for routine updating.

With these key strengths, the NJHealth Study complements other epidemiological cohorts available for study of the stress and health nexus. Of note, the All of Us study, launched in 2018, addresses some of the key gaps in data available to examine stressors and health, including a large (N>200 000), diverse national (US) non-probability sample, some important stress-related measures (eg, access to care, personal and family health history, information from personal health devices such as Fitbit, biospecimen collection, and linkage to electronic health records and claims when available.[101] The NJHealth Study is distinct from All of Us in several important ways. NJHealth includes a broader approach to the assessment of stressors at both microlevels (eg, adverse childhood events, recent life events, perceived stress) and macrolevels of analysis (eg, exposures to climate events, pollution, structural discrimination). Microlevel individual assessments are not limited to English or Spanish; linkages are executed with a broader array of administrative data sources (although many limited to NJ), and it uses probabilistic and purposive sampling techniques to improve population representativeness (within NJ) and enable intergenerational analysis.

NJHealth is also distinct from several other surveys. First, by employing a dual sampling strategy, using probabilistic and non-probabilistic methods, NJHealth includes a diverse sample of immigrants from racially, ethnically, linguistically and socioeconomically diverse sending countries. This facilitates a study of stress in populations that have otherwise been precluded from other cohort studies used to study the stress-health relationship. For example, the samples represented in Midlife in the United States (MIDUS) and the National Study of Daily Experiences MIDUS substudy only enable an analysis of US-born non-Hispanic white and non-Hispanic black populations.[102] The Health and Retirement Study enables an investigation of stress and health among US-born and foreign-born Latinos older than 50 but only allows disaggregation of Mexican-origin individuals, which means that most research cannot consider unique origin-country context, history and migration experiences beyond the Mexican experience.[103] Second, by recruiting multiple respondents from multigenerational households and collecting data on both societal and individual stressors, NJHealth is uniquely suited to investigate stress cross-over and stress proliferation across family members. This distinguishes NJHealth from other surveys that collect data from multiple reporters in a single household, like the Panel Study of Income Dynamics or the Longitudinal Study of Generations, which only include measures of established, not emerging stressors.

NJ is an exceptional setting for the NJHealth Study because of its socioeconomic and demographic diversity, having among the highest share of immigrants in the USA. The state also has a strong data infrastructure with continuously updated systems of integrated health and socioeconomic administrative data. Finally, the NJHealth study builds on the study team's long-standing relationships with diverse communities and policy stakeholders, which has informed the design and analysis priorities.

The NJHealth Study's comprehensiveness and innovation must be considered in light of accompanying limitations. While NJ is an exceptional setting for the study, single-state studies cannot be fully representative of the US population. 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 enrol immigrant and other at-risk populations, gaps and challenges remain. Complementing its probabilistic sampling plan, it incorporates purposive RDS 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 multicultural, multilingual 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 NIH and other research sponsors for longitudinal data collection and analysis.

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Contributors JCC, DM, WTH, SMB and PD led the conceptualisation and design of the NJHealth Study. SBC and KBM developed the study probability sampling and weighting design. SMB and JCC led the development of the non-probability immigrant sample design. DM and SMB developed the data collection and management platform and procedures. SMB and MCK developed field operations strategy and oversee study management. MGS contributed to revisions to this manuscript and oversight of study implementation. All authors contributed to the study design, instrument development and data collection strategies. JCC is guarantor.

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