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The Weathering Hypothesis as an Explanation for Racial Disparities in Health: A Systematic Review

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Abstract

Purpose.—The weathering hypothesis states that chronic exposure to social and economic disadvantage leads to accelerated decline in physical health outcomes and could partially explain racial disparities in a wide array of health conditions. This systematic review summarizes the literature empirically testing the weathering hypothesis and assesses the quality of the evidence regarding weathering as a determinant of racial disparities in health.

Methods.—Databases (Web of Science, Ovid MEDLINE, PubMed and Embase) were searched for studies published in English up to July 1, 2017. Studies that tested the weathering hypothesis for any physical health outcome and included at least one socially or economically disadvantaged group (e.g., Blacks) for whom the weathering hypothesis applies were assessed for eligibility. Threats to validity were assessed using the Quality in Prognostic Studies tool.

Results.—The 41 included studies were rated as having overall good methodological quality. Most studies found evidence in support of the weathering hypothesis, although the magnitude of support varied by the health outcome and population studied.

Conclusions.—Future evaluations of the weathering hypothesis should include an examination of additional health outcomes and interrogate mechanisms that could link weathering to poor health.

Keywords

weathering; race; health disparities; health inequalities

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INTRODUCTION

Blacks have higher rates of morbidity and mortality than Whites for almost all health outcomes in the United States (U.S.) and this inequality increases with age. [1–8] While these racial disparities are notable, their underlying causes are unclear. [9, 10] The weathering hypothesis was proposed to explain racial health disparities. Weathering is the result of chronic exposure to social and economic disadvantage that leads to the acceleration of normal aging and earlier onset of unfavorable physical health conditions among disadvantaged (versus advantaged) persons of similar age (i.e. weathering pattern). [11–15]

The weathering hypothesis was motivated by observations of earlier onset of chronic diseases (e.g. hypertension) impacting birth outcomes in Blacks relative to Whites [16] and originated from Geronimus' empirical studies on racial disparities in birth outcomes. [15] Contrary to the well-documented curvilinear relationship between maternal age and birth outcomes, where teenage and 30+ year old pregnant women are expected to have a higher risk for adverse birth outcomes than women in their mid-20s, studies by Geronimus revealed variations by race. She found that White teenage mothers had a higher risk for infant mortality and low birthweight than White mothers in their mid-to-late 20s, but Black teenage mothers had a lower risk for infant mortality and low birthweight than older Black mothers. [14, 15, 17]

Many studies use this hypothesis as an explanatory framework for racial disparities in health, but a systematic review of the studies that explicitly test this hypothesis has not been previously conducted. The goals of this systematic review are to: 1) provide an overview of the existing literature that empirically tests the weathering hypothesis across a variety of physical health outcomes; 2) assess the evidence for weathering as a determinant of racial disparities in health; and 3) evaluate the threats to validity of existing studies.

METHODS

Search Strategy

The systematic review methodology and reporting followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines for a review that does not contain a meta-analysis of studies. [18] First, a citation search was conducted in Web of Science to identify all articles published by Geronimus as well as articles that cited her original publications [14, 15] describing the weathering hypothesis. Second, keyword and medical subject headings searches in Ovid MEDLINE (MeSH), PubMed (MeSH) and Embase (Emtree) electronic databases were employed from the first mention of the hypothesis in 1986 to July 1, 2017; the keyword "weathering" was combined with the keyword "racial disparities" and MeSH terms (e.g. health status disparities, health care disparities, inequalities, ethnic group, race difference) to identify relevant articles for the systematic review. Third, the reference lists of the: 1) included studies, 2) conceptual/review articles identified in the search process, and 3) grey literature (non-peer reviewed) were examined to identify additional studies. All retrieved articles were imported and stored in an EndNote database.

Inclusion and Exclusion Criteria

Inclusion criteria for articles included in this review were as follows: 1) published in English-language peer-reviewed journals; 2) contained a statement in the abstract, introduction or methods that the weathering hypothesis was being tested in relation to physical health outcomes; and 3) compared at least one disadvantaged group with one advantaged group.

Study Selection

Applying the selection criteria to the retrieved articles, one reviewer examined the titles and abstracts for full text review and two reviewers independently assessed the eligibility of the full text articles, reaching a consensus on the final articles to include in the systematic review.

Data Extraction

One reviewer used a data collection form (Supplemental Table 2) to extract data from the included articles and a second reviewer verified the extracted data to ensure accuracy. The publication characteristics (author name, publication year), study characteristics (data source), participant characteristics (age, sex), weathering hypothesis characteristics (type of test employed to test the weathering hypothesis); and study characteristics related to potential risks of bias (participant selection and retention) were recorded for each article.

Risk of Bias Assessment

The methodological quality of the included articles was assessed using the Quality in Prognostic Studies (QUIPS) tool, [19] which we adapted for this review (Supplemental Table 2) by dichotomizing studies as low (combined original QUIPS criteria for low and moderate risk) or high (original QUIPS criteria for high risk) risk, and replacing the term prognostic factor with exposure.

Two reviewers independently assessed the likelihood of bias by examining the extracted study information on potential risk of bias (Supplemental Table 1) and then using the QUIPS (Supplemental Table 2) ‘basis for judgment’ criteria for six bias domains (study participation, study attrition, exposure measurement, outcome measurement, confounding, and statistical analysis and reporting) as a guide for evaluating the likelihood of bias. When reviewers disagreed on bias assessments, the studies in question (n=4) were formally discussed by both reviewers to arrive at a final decision.

RESULTS

The citation and database searches identified 817 records (Figure 1). After removal of duplicates, 617 articles were eligible for the title and abstract review, of which 341 articles underwent full-text review. Of these, 298 were excluded because they did not test the weathering hypothesis. Three studies were excluded because they lacked a comparison group. One additional article was added after reviewing the reference lists. In total, 41 articles were included in this review.

Study and Participant Characteristics

The study and participant characteristics are presented in Table 1. The 41 studies in the review were published between 1996 and 2017. Most studies (78%) used a cross-sectional design and the remaining 22% of studies employed a cohort design. Only two studies were conducted outside of the U.S. (Taiwan and the United Kingdom). Study participant data were obtained from vital statistics and/or census data alone in 46% of studies or solely from survey data in 54% of studies. Sample sizes ranged from 100 to 26,578,118 participants, ages 10 to 86+ years. Females were the focus of 73% of studies, while 2% of studies included men only and 25% included both men and women.

The weathering hypothesis was tested most often for birth outcomes (58%). Potentially disadvantaged racial or ethnic groups to whom the weathering hypothesis was applied included U.S.-born Blacks, non-U.S.-born Blacks, Puerto Ricans, Black Hispanics, U.S.-born Mexican Americans, and Taiwan-born Aboriginals. In comparison, advantaged groups included Whites, White Hispanics, foreign-born Mexican Americans, and Non-Aboriginals. (Table 1) Black and White racial group comparisons appeared the most frequently across the studies (80%). Fifty one percent of the studies included disadvantaged groups other than Blacks and 22% of studies examined weathering by nativity status.

Overview of the Evidence by Type of Test of the Weathering Hypothesis

Age patterns.—Comparing the age patterns of health outcomes was employed as one of the first approaches to determine the presence of weathering. Among the 28 studies that used the age patterns test of weathering (Table 2a, Table 2b), evidence of weathering was more likely to be observed in studies on birth outcomes (37/44 tests) *[low birthweight (11/14)*, [15, 20–27] *mean birthweight (1/1)*, [28] *moderately low birthweight (5/5)*, [23, 29, 30] *very low birthweight (6/7)*, [15, 20, 23, 29] *infant mortality (5/5)*, [20, 31–33] *neonatal mortality (2/2)*, [20, 34] *postneonatal mortality (1/1)*, [20] *preterm birth (3/5)*, [35–37] *small for gestational age (3/3)*, [21, 24, 38] *and intrauterine growth retardation (0/1)]* and for non-birth outcomes (11/15) *[body mass index (1/1)*, [20] *diabetes (1/1)*, [39] *hypertension/blood pressure (4/4)*, [20, 34, 39, 40] *stroke (1/1)*, [39] *functional limitations (2/3)*, [41, 42] *longevity (1/1)*, [43] *self-reported health (1/1)*, [20] *cardiovascular disease (0/1), cholesterol (0/1), and anemia (0/1)]*.

While weathering age patterns were observed for most health outcomes, the results varied by the comparison group studied. Among the studies comparing the health of U.S. Blacks to Whites by age, all but four studies, (on preterm birth, [24] cholesterol level, [20] cardiovascular disease, [39] and functional limitations [44]) observed evidence of weathering. Given that this hypothesis is thought to have relevance for any disadvantaged population, evidence of weathering was also observed among disadvantaged groups, such as Blacks of Caribbean and African descent in the United Kingdom, [25] Puerto Ricans, [23] Mexican Americans [23, 31, 33, 34] and Black Hispanics. [42] However, evidence of weathering was not observed for any health outcome among the aggregated Hispanic ethnic group (for low birthweight, [22] mean birthweight, [28] small for gestational age, [38] functional limitations [41]) or among Taiwanese Aboriginals (for low birthweight [45]).

Socioeconomic Status.—In addition to studies that defined disadvantage by race or ethnicity, several studies [15, 21, 24–27, 29, 30, 35–37, 46] considered measures of socioeconomic disadvantage defined by individual or neighborhood poverty, education, and neighborhood segregation. Among these studies, 14/20 tests showed that weathering was more likely to be observed in the socioeconomically disadvantaged group than the socioeconomically advantaged group, and all studies supporting the weathering hypothesis were for birth outcomes [15, 21, 24–27, 29,30, 35–37] (Table 2a).

Biological/Physiological Mechanisms.—Several studies have investigated different biological/physiological mechanisms (i.e., allostatic load, telomere length, chronic stress, inflammation and epigenetics) hypothesized to link chronic exposure to social/economic disadvantage to racial or ethnic health disparities. Among thirteen studies, eight focused on allostatic load, two on telomere length and one study each on chronic stress, inflammation and epigenetics (Table 3).

Five studies [47–51] included allostatic load as the primary health outcome and reported results that were supportive of weathering when considering either race or ethnicity [47–51] or socioeconomic status [47, 51] as measures of disadvantage (Table 3). Three additional studies [52–54] examining allostatic load as the primary exposure also showed evidence of weathering, where higher allostatic load was associated with increased mortality rates [52, 53] and lower gestational age [54] (Table3).

Studies on telomere length, chronic stress, inflammation and epigenetics also found support for weathering. Regarding telomere length as a marker of biological age, one study [55] reported that Black women had shorter telomere length than White women and the difference was partially explained by perceived stress and poverty. Another study [56] showed decreasing telomere length with age and observed an interaction between poverty and race or ethnicity. Chronic stress was associated with lower birthweight in Blacks, Mexican-origin Latinas and Non-Mexican-origin Latinas compared to Whites. [57] Inflammation arising from cumulative exposure to stress placed Black men at a greater risk for developing diabetes and cardiovascular disease than White men. [58] Having lower income versus higher income resulted in accelerated aging (as measured by methylation changes) among Black women [59] (Table 3).

Overall, most studies provided evidence in support of weathering that was more pronounced in racial or ethnic minority groups, lower SES groups and segregated neighborhoods, but results for studies including biological mechanisms were not necessarily restricted to racial or ethnic minority groups. (Table 3). Most studies were of good methodological quality (Table 4), but there were potential threats to validity most likely arising from selection bias.

DISCUSSION

The weathering hypothesis has been tested for several health outcomes among a diverse group of participants. Most studies focused on birth outcomes for Blacks versus Whites, consistent with the original framing of the weathering hypothesis. Generally, however, findings supported the weathering hypothesis for both birth and non-birth outcomes.

The most common approach used to test the weathering hypothesis was to compare disadvantaged to advantaged groups across different ages to determine if age-related patterns of adverse health outcomes were accelerated among disadvantaged versus advantaged groups. Fewer studies focused on biological mechanisms explaining these patterns or how SES may exacerbate the relationship between age and poor health.

This review identified a diverse literature on the weathering hypothesis that was determined to be of good methodological quality, although there was some concern about the potential for selection bias and the temporal ambiguity. The cross-sectional nature of the data prevented the longitudinal examination of health outcomes over the life course and introduced potential selection bias. Specifically, prevalence-incidence bias or selective survival bias was a possibility because a disproportionately high percentage of cases with long duration (prevalent cases) and better average survival could have been included in cross-sectional studies, whereas, those with shorter duration (incident cases) who represented the complete range of severity of the health outcome would have a lower probability of being included. The studies that examined short-acting health conditions were less likely to be impacted by this bias. Among the cohort studies, there appeared to be adequate response rates and attempts to collect information on participants who were not included in the studies, but studies with significant differences in participation and attrition were judged as being more likely to have appreciable selection bias that impacted the results. In contrast, while temporality in cross-sectional studies is often difficult to establish, temporal inference in the context of weathering is less problematic, as weathering is presumed to begin at birth (or even in utero) and therefore precede the health outcome.

While measurement error was less likely, the few studies rated as high risk for measurement error either failed to use valid and reliable measurements (e.g. self-reported outcomes that would only be reported if notified by a physician). Confounding was also less likely since most studies included valid and reliable measurement and analysis of confounders that were clearly defined.

Some important limitations of our review should be noted. Relevant studies that may have inexplicitly tested the weathering hypothesis, but were omitted because weathering or Geronimus' seminal articles were not specified, were likely relevant to a comprehensive review of the weathering hypothesis. The presence of publications bias was likely, but there was not sufficient information to assess publication bias.

The weathering hypothesis has contributed significantly to the literature on racial disparities in birth outcomes. The number of studies that tested the applicability of this hypothesis to other outcomes and racial or ethnic groups has grown since the publication of Geronimus' earliest studies on weathering and birth outcomes. However, few studies examined weathering within the Hispanic population by race or within the Black population by nativity status, making this an important target for future research on weathering. While discrimination was not examined in any of the studies, it may be experienced differently by Blacks than other racial and ethnic minority groups and therefore could explain racial or ethnic differences in weathering patterns. The rigor of future research can be enhanced by (1) studying clinical disease outcomes using gold standard outcome assessments (rather than participant self-report), (2) including additional health outcomes (e.g., cancer, dementia, pulmonary disease), (3) conducting analyses on the health of ethnic groups by race and on racial groups by nativity status, (4) characterizing the precise nature of social and economic disadvantage of most relevance (e.g., racial discrimination, neighborhood effects, poverty), and (5) utilizing longitudinal studies beginning early in the life-course to better characterize how disadvantage and health co-evolve over the life course.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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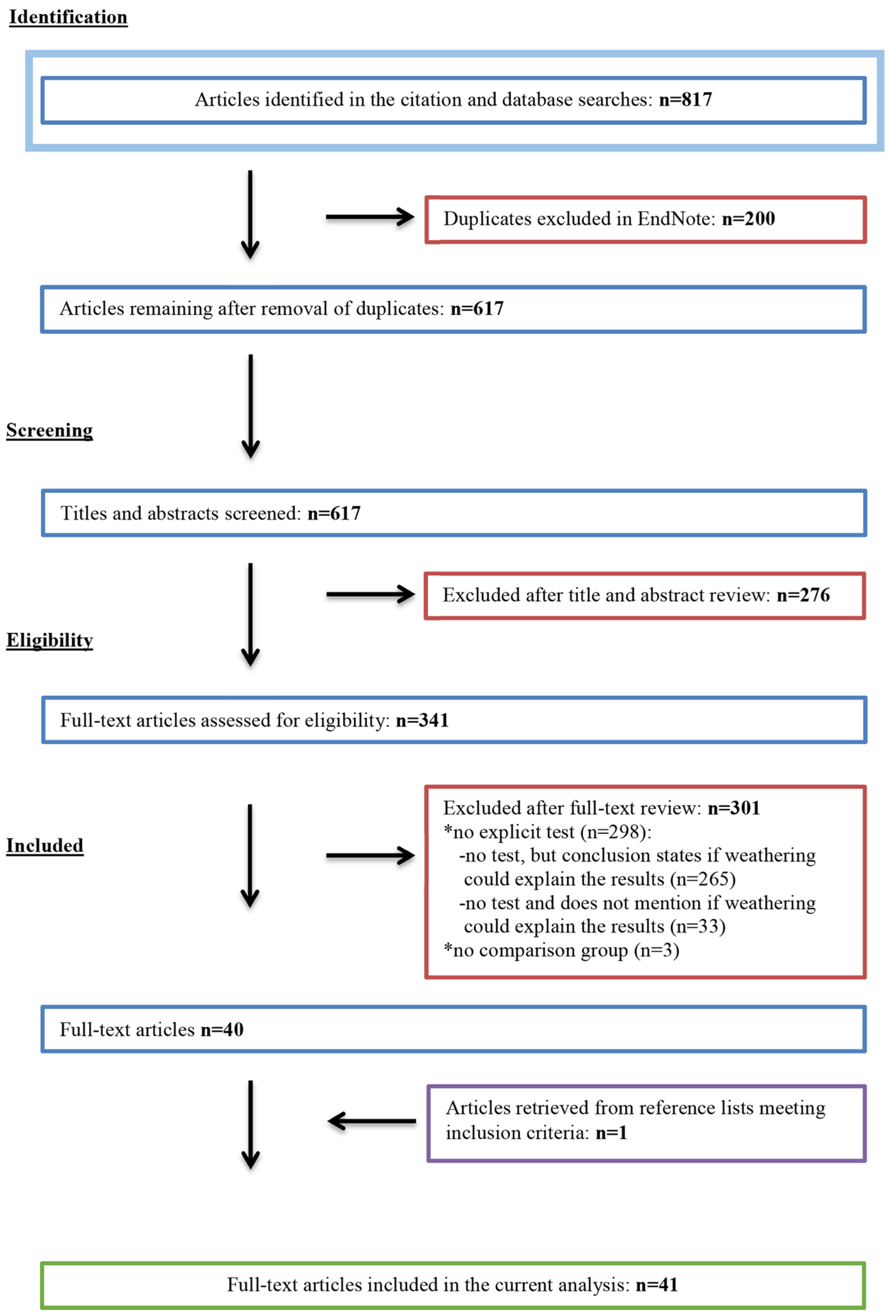

Figure 1.
Flow Chart

Table 1.

Characteristics of Selected Studies Explicitly Testing the Weathering Hypothesis

	Participant Characteristics				Study Characteristics				Weathering Hypothesis
Author & Publication Year	**Age**	**Sex**	**Race/Ethnicity/Nativity**	**Geographic Location**	**Data Source**	**Sample Size**	**Study Design**	**Physical Health Outcome**	**Evidence of Weathering**
Bird 2010	20–86y	Men & Women	-Blacks -Mexican Americans -Whites	U.S.	NHANES III	13,184	Cross-sectional	-Allostatic load	Yes
Borrell 2010	25–65+y	Men & Women	-Blacks -Mexican Americans -Whites	U.S.	NHANES III & NDI	13,715	Cohort	-All-cause mortality	Yes
Buescher 2006	15–35+y	Women	-Blacks -Whites	North Carolina	BRFSS & North Carolina birth & infant death records	495,551	Cross-sectional	-Low birthweight, -Very low birthweight -Infant mortality -Neonatal mortality -Postneonatal mortality -Body mass index -High blood pressure -High cholesterol -Poor self-reported health	Yes
Chinn 2016	18–85y	Women	-U.S.-born Black Hispanics -Foreign-born Black Hispanics -U.S.-born White Hispanics -Foreign-born White Hispanics -U.S.-born other-race Hispanics -Foreign-born other-race Hispanics	U.S.	NHIS	42,908	Cross-sectional	-Functional Limitations	Yes
Chyu 2011	18–70+y	Women	-Blacks -U.S.-born Mexican Americans -Foreign-born Mexican Americans -Whites	U.S.	NHANES IV	5765	Cross-sectional	-Allostatic load	Yes
Cohen 2016	12–40+y	Women	-Blacks -Mexican Americans -Whites	U.S.	NCHS	2,960,578	Cross-sectional	-Infant mortality	Yes
Collins 2006	<20–40+y	Women	-Extremely-Impoverished Blacks -Non-Impoverished Blacks	Illinois	Illinois Vital Records, U.S. Census &	46,725	Cross-sectional	-Very low birthweight -Moderately low birthweight	Yes

	Participant Characteristics				Study Characteristics				Weathering Hypothesis
Author & Publication Year	Age	Sex	Race/Ethnicity/Nativity	Geographic Location	Data Source	Sample Size	Study Design	Physical Health Outcome	Evidence of Weathering
					Chicago Department of Public Health data				
Collins 2009	14–35y	Women	-Blacks -Whites (stratified by early-life/ adulthood residence income: low/low, low/high, high/low, high/high)	Illinois	Illinois transgenerational dataset & U.S. Census	267,303	Cross-sectional	-Low birthweight	Yes
Collins 2012	<20–35y	Women	-U.S.-born Mexican Americans -Foreign-born Mexican Americans	Illinois	Illinois transgenerational dataset & U.S. Census	267,303	Cross-sectional	-Low birthweight -Preterm birth -Intrauterine growth retardation (IUGR)	No
Collins 2015	14–35y	Women	-Former-low birthweight Blacks -Former-low birthweight Whites -Non-low birthweight Blacks -Non-low birthweight Whites	Illinois	Illinois transgenerational dataset & U.S. Census	70,580	Cross-sectional	-Low birthweight -Small for gestational age	Yes
Das 2013	57–85y	Men	-Blacks -Whites	U.S.	NSHAP	1455	Cross-sectional	-Metabolic outcomes (blood sugar/diabetes, blood pressure, heart rate)	Yes
Dennis 2013	15–35y	Women	-Blacks -U.S.-born Hispanics -Foreign-born Hispanics -Whites	U.S.	ECLS-B	6150	Cross-sectional	-Low birthweight	Yes
Geronimus 1996	15–34y	Women	-Blacks -Whites	Michigan	Michigan Vital Records & U.S. Census	54,888	Cross-sectional	-Low birthweight -Very low birthweight	Yes
Geronimus 2006	18–64y	Men & Women	-Blacks -Whites	U.S.	NHANES IV	6586	Cross-sectional	-Allostatic load	Yes
Geronimus 2007	15–65y	Men & Women	-Blacks -Whites	U.S.	NHANESIV	5501	Cross-sectional	-Hypertension	Yes
Geronimus 2010	49–55y	Women	-Blacks -Whites	Boston, Chicago, Detroit, Oakland, Los Angeles, Newark, Pittsburgh	SWAN	215	Cohort	-Telomere length	Yes

	Participant Characteristics				Study Characteristics				Weathering Hypothesis
Author & Publication Year	**Age**	**Sex**	**Race/Ethnicity/Nativity**	**Geographic Location**	**Data Source**	**Sample Size**	**Study Design**	**Physical Health Outcome**	**Evidence of Weathering**
Geronimus 2015	25–75+y	Men & Women	-Blacks -Mexican Americans -Whites	Detroit	HEP Community Survey	202	Cross-sectional	-Telomere length	Yes
Goisis 2014	14–30+y	Women	-Blacks -Whites (stratified by area-level advantage/disadvantage, high/low education)	United Kingdom	ONSLS	45,856	Cross-sectional	-Low birthweight	Yes
Hibbs 2016	14–35y	Women	-Black smokers & nonsmokers -White smokers & nonsmokers (stratified by quartiles of neighborhood income)	Illinois	Illinois transgenerational dataset & U.S. Census	267,303	Cross-sectional	-Preterm birth	Yes
Holzman 2009	20–39y	Women	-Black smokers & nonsmokers -White smokers & nonsmokers (stratified by low/medium/ high neighborhood deprivation)	Philadelphia, Baltimore, 16 Michigan cities, 3 Maryland counties, 2 North Carolina counties	The Multilevel Modeling of Disparities Explaining Preterm Delivery Project & U.S. census	182,938	Cross-sectional	-Preterm birth	Yes
Howard 2016	25+y	Men & Women	-Blacks -Mexican Americans -Whites	U.S.	NHANES III & NDI	11,733	Cross-sectional	-Mortality	Yes
Kaestner 2009	30–60y	Men & Women	-Blacks -U.S.-born Mexican Americans -Foreign-born Mexican Americans -Whites	U.S.	NHANES III	7010	Cross-sectional	-Allostatic load	Yes
Khoshnood 2005	20–35+y	Women	-Blacks -Mexican Americans -Puerto Ricans -Whites	U.S.	NCHS	8,433,935	Cross-sectional	-Low birthweight -Moderately low birthweight -Very low birthweight	Yes
Kramer 2014	10–35+y	Women	-Blacks -Hispanics -Whites (stratified by low & high neighborhood deprivation)	Georgia	Georgia birth records & U.S. Census	1,000,437	Cohort	-Preterm-low birthweight	Yes

	Participant Characteristics				Study Characteristics				Weathering Hypothesis
Author & Publication Year	Age	Sex	Race/Ethnicity/Nativity	Geographic Location	Data Source	Sample Size	Study Design	Physical Health Outcome	Evidence of Weathering
Lin 2017	55–65y	Men & Women	-Blacks -Hispanics -Whites	U.S.	HRS	7715	Cohort	-Functional limitations	Yes
Love 2010	<20–35y	Women	-Blacks -Whites (stratified by early/adult neighborhood income: lower-lower, upper-lower, lower-upper, upperupper lifetime)	Illinois	Illinois transgenerational dataset & U.S. Census	70,615	Cross-sectional	-Low birthweight -Small for gestational age -Preterm birth	Yes
Osypuk 2008	15–45y	Women	-Blacks -Whites (stratified by segregation status: nonhypersegrated & hypersegregated metropolitan area)	U.S.	NCHS & U.S. Census	1,944,703	Cross-sectional	-Preterm birth	Yes
Peek 2010	25–65+y	Men & Women	-Blacks -U.S.-born Mexican Americans -Foreign-born Mexican Americans -Whites	Texas City	Texas City Stress & Health Study	1410	Cross-sectional	-Allostatic load	Yes
Powers 2013	<20–40+y	Women	-Blacks -U.S.-born Mexican Americans -Foreign-born Mexican Americans -Whites	U.S.	NCHS	26,578,118	Cross-sectional	-Infant mortality	Yes
Powers 2016	25–40+y	Women	-U.S.-born Mexican Americans -Foreign-born Mexicans Americans -Whites	U.S.	NCHS	14,542,120	Cross-sectional	-Infant Mortality	Yes
Rauh 2001	20–39y	Women	-Blacks -Whites	New York City	Bureau of vital statistics, New York City Department of Health & U.S. Census	158,174	Cross-sectional	-Moderately low birth weight -Very low birthweight	Yes
Sheeder 2006	18–34y	Women	-Blacks -Hispanics -Whites	Colorado	Colorado birth certificate data	91,061	Cross-sectional	-Small for gestational age	Yes

	Participant Characteristics				Study Characteristics				Weathering Hypothesis
Author & Publication Year	Age	Sex	Race/Ethnicity/Nativity	Geographic Location	Data Source	Sample Size	Study Design	Physical Health Outcome	Evidence of Weathering
Simons 2016	Mean=48.5y	Women	-Blacks	Georgia & Iowa	FACHS	100	Cohort	-Epigenetic measure of biological aging/ methylation	Yes
Spence 2008	65–83y	Women	-Blacks -Whites	U.S.	NLS-MW	1608	Cohort	-Functional limitations	No
Spence 2009	45–59y	Women	-Blacks -Whites	U.S.	NLS-MW	3769	Cohort	-Longevity (post reproductive mortality)	Yes
Strutz 2014	11–32y	Women	-Blacks -Mexican Americans -Non-Mexican Latinas -Whites	U.S.	Add Health	5413	Cohort	-Birthweight	Yes
Swamy 2012	15–44y	Women	-Blacks -Hispanics -Whites	North Carolina	North Carolina birth record database	510,288	Cross-sectional	-Mean birthweight	Yes
Thorpe 2016	18–75+	Men & Women	-Blacks -Whites	U.S.	NHIS	619,130	Cross-sectional	-Hypertension -Stroke -Diabetes -Cardiovascular Disease	Yes
Wallace 2013	20–35y	Women	-Blacks -Whites	New Orleans	Tulane-Lakeside Hospital Department of Obstetrics & Gynecology	123	Cohort	-Birthweight, -Birthweight ratio -Gestational age -Birth length -Head circumference	Yes
Wang 2012	15–35y	Women	-Aboriginals -Non-Aboriginals	Taiwan	Taiwan birth registration database	8432	Cross-sectional	-Low birthweight or preterm birth	No
Wildsmith 2002	15–34y	Women	-U.S.-born Mexican Americans -Foreign-born Mexican Americans	U.S.	NCHS	387,909	Cross-sectional	-Low birthweight -Anemia -Hypertension -Neonatal mortality	Yes

Add Health=National Longitudinal Study of Adolescent Health

BRFSS=Behavioral Risk Factor Surveillance System

ECLSB= Early Childhood Longitudinal Study-Birth Cohort

FACHS=Family and Community Health Study

HEP= The Healthy Environment Partnership

HRS=Health and Retirement Study

NCHS=National Center for Health Statistics

NDI=National Death Index

NHANES=National Health and Nutrition Examination Survey

NHIS=National Health Interview Survey

NLS-MW=National Longitudinal Survey of Mature Women

NSHAP= National Social Life, Health and Aging Project

ONSLS=Office for National Statistics longitudinal study

SWAN=Study of Women’s Health Across the Nation

Table 2a.

Summary of the Evidence Among Studies Supporting the Weathering Hypothesis

Author and Publication Year	Health Outcome	Population for Which Weathering was Hypothesized to Have the Greatest Impact	Comparison Population	Weathering Patterns by Socioeconomic Status (SES) *
	Birth Outcomes			
	Birthweight			
Buescher 2006	Low birthweight	Blacks	Whites	• N/A
Collins 2009	Low birthweight	N/A	N/A	• Weathering more pronounced in Blacks with lifelong residence in lower SES neighborhoods
Collins 2015	Low birthweight	Former non-low birthweight Blacks	Whites, Former low birthweight Blacks	• Weathering more pronounced in non-low birthweight Blacks in lower SES neighborhoods
Dennis 2013	Low birthweight	Blacks	Whites, Hispanics (U.S. born or Foreign-born)	• N/A
Geronimus 1996	Low birthweight	Blacks	Whites	• Weathering more pronounced in lower SES Blacks
Goisis 2014	Low birthweight	U.K. Blacks	U.K. Whites	• Weathering more pronounced in less-educated Blacks and Blacks in lower SES neighborhoods
Khoshnood 2005	Low birthweight	Blacks	Whites	• N/A
Khoshnood 2005	Low birthweight	Mexican Americans	Whites	• N/A
Khoshnood 2005	Low birthweight	Puerto Ricans	Whites	• N/A
Kramer 2014	Preterm-low birthweight	N/A	N/A	• Weathering more pronounced in Blacks with higher neighborhood deprivation
Love 2010	Low birthweight	Blacks	Whites	• Weathering more pronounced in Blacks with lifelong residence in lower SES neighborhoods
Swamy 2012	Mean birthweight	Blacks	Whites, Hispanics	• N/A
Collins 2006	Moderately low birthweight	N/A	N/A	• Weathering more pronounced in Blacks living in lower SES neighborhoods
Khoshnood 2005	Moderately low birthweight	Blacks	Whites	• N/A
Khoshnood 2005	Moderately low birthweight	Mexican Americans	Whites	• N/A
Khoshnood 2005	Moderately low birthweight	Puerto Ricans	Whites	• N/A
Rauh 2001	Moderately low birthweight	Blacks	Whites	• Weathering more pronounced in lower SES Blacks
Buescher 2006	Very low birthweight	Blacks	Whites	• N/A
Geronimus 1996	Very low birthweight	Blacks	Whites	• Weathering more pronounced in lower SES Blacks
Khoshnood 2005	Very low birthweight	Blacks	Whites	• N/A
Khoshnood 2005	Very low birthweight	Mexican Americans	Whites	• N/A

Author and Publication Year	Health Outcome	Population for Which Weathering was Hypothesized to Have the Greatest Impact	Comparison Population	Weathering Patterns by Socioeconomic Status (SES) *
Khoshnood 2005	Very low birthweight	Puerto Ricans	Whites	• N/A
Rauh 2001	Very low birthweight	Blacks	Whites	• No difference by SES
	Mortality			
Buescher 2006	Infant mortality	Blacks	Whites	• N/A
Cohen 2016	Infant mortality	Blacks	Whites, Mexican Americans	• N/A
Powers 2013	Infant mortality	Blacks	Whites	• N/A
Powers 2013	Infant mortality	Mexican Americans	Whites	• N/A
Powers 2016	Infant mortality	Mexican Americans	Whites	• N/A
Buescher 2006	Neonatal mortality	Blacks	Whites	• N/A
Wildsmith 2002	Neonatal mortality	U.S.-born Mexican Americans	Foreign-born Mexican Americans	• N/A
Buescher 2006	Postneonatal mortality	Blacks	Whites	• N/A
	Preterm birth			
Hibbs 2016	Preterm birth	N/A	N/A	• Weathering more pronounced among cigarette smoking Blacks with early-life or lifelong residence in lower SES neighborhoods
Holzman 2009	Preterm birth	Black smokers, Black nonsmokers, White smokers	White non-smokers	• Weathering more pronounced in Black and White smokers with higher neighborhood deprivation
Osypuk 2008	Preterm birth	Blacks	Whites	• Weathering more pronounced for Blacks in hypersegregated neighborhoods
	Small for gestational age			
Collins 2015	Small for gestational age	Former non-low birthweight Blacks	Whites, former low birth-weight Blacks	• Weathering more pronounced in former non-low birthweight Blacks in lower SES neighborhoods
Love 2010	Small for gestational age	Blacks	Whites	• Weathering more pronounced in Blacks with lifelong residence in lower SES neighborhoods
Sheeder 2006	Small for gestational age	Blacks	Whites, Hispanics	• N/A
	Non-Birth Outcomes			
	Cardiovascular health			
Buescher 2006	Body mass index	Blacks	Whites	• N/A
Thorpe 2016	Diabetes	Blacks	Whites	• N/A
Buescher 2006	High blood pressure	Blacks	Whites	• N/A
Geronimus 2007	Hypertension	Blacks	Whites	• N/A
Thorpe 2016	Hypertension	Blacks	Whites	• N/A

Author and Publication Year	Health Outcome	Population for Which Weathering was Hypothesized to Have the Greatest Impact	Comparison Population	Weathering Patterns by Socioeconomic Status (SES) *
Wildsmith 2002	Hypertension	U.S.-born Mexican Americans	Foreign-born Mexican Americans	• N/A
Thorpe 2016	Stroke	Blacks	Whites	• N/A
	Function			
Chinn 2016	Functional limitations	U.S.-born Black Hispanics	White, Other-race Hispanics (U.S. and foreign-born), Foreign-born Black Hispanics	• N/A
Lin 2017	Functional limitations	Blacks	Whites, Hispanics	• N/A
	Other physical health outcomes			
Spence 2009	Longevity	Blacks	Whites	• N/A
Buescher 2006	Poor self-reported health	Blacks	Whites	• N/A

* Represents studies for which a group comparison for testing the weathering hypothesis was defined by SES alone, or in addition to a comparison defined by membership in a historically disadvantaged minority group versus an advantaged group.

U.S.=United States. U.K.=United Kingdom. N/A=not applicable.

Table 2b.

Summary of the Evidence Among Studies Not Supporting the Weathering Hypothesis

Author and Publication Year	Health Outcome	Population for Which Weathering was Hypothesized to Have the Greatest Impact	Comparison Population	Weathering Patterns by Socioeconomic Status (SES) *
	Birth Outcomes			
	Birthweight			
Collins 2012	Low birthweight	U.S.-born Mexican Americans	Foreign-born Mexican Americans	• No difference by neighborhood SES
Wildsmith 2002	Low birthweight	U.S.-born Mexican Americans	Foreign-born Mexican Americans	• N/A
Wang 2013	Low birthweight or preterm birth	Aboriginal	Non-Aboriginal	• N/A
Collins 2006	Very low birthweight	N/A	N/A	• No difference by neighborhood SES
	Other birth outcome			
Collins 2012	Intrauterine growth retardation	U.S.-born Mexican Americans	Foreign-born Mexican Americans	• No difference by neighborhood SES
	Preterm birth			
Collins 2012	Preterm birth	U.S.-born Mexican Americans	Foreign-born Mexican Americans	• No difference by neighborhood SES
Love 2010	Preterm birth	Blacks	Whites	• No difference by neighborhood SES
	Non-Birth Outcomes			
	Cardiovascular health			
Thorpe 2016	Cardiovascular disease	Blacks	Whites	• N/A
Buescher 2006	High cholesterol	Blacks	Whites	• N/A
	Other physical health outcomes			
Spence 2008	Functional limitations	Blacks	Whites	• N/A
Wildsmith 2002	Anemia	U.S.-born Mexican Americans	Foreign-born Mexican Americans	• N/A

* Represents studies for which a group comparison for testing the weathering hypothesis was defined by SES alone, or in addition to a comparison defined by membership in a historically disadvantaged minority group versus an advantaged group.

U.S.=United States. N/A=not applicable.

Table 3.

Summary of the Evidence for Studies Exploring Biological/Physiological Mechanisms Underlying the Weathering Hypothesis

Author and Publication Y ear	Health Outcome	Evidence of Weathering in the Overall Population
	Birth outcomes	
	Birthweight	
Strutz 2014	Birthweight	• Chronic stress was associated with low birthweight
Wallace 2013	Birth length	• --
Wallace 2013	Birthweight	• --
Wallace 2013	Birthweight ratio	• --
Wallace 2013	Head circumference	• --
	Gestational age	
Wallace 2013	Gestational age	• Increasing allostatic load was associated with decreasing gestational age • No racial variation in the association
	Non-birth outcome	
	Allostatic load	
Bird 2010	Allostatic load	• Blacks had the highest allostatic load • Living in a lower SES neighborhood was associated with higher allostatic load, regardless of race and ethnicity
Chyu 2011	Allostatic load	• Allostatic load was higher for Blacks at earlier ages (more weathered) than Whites • Allostatic load was higher for U.S.-born Mexican Americans than foreign-born Mexican Americans
Geronimus 2006	Allostatic load	• Allostatic load was higher for Blacks at earlier ages (more weathered) than Whites • Weathering was more pronounced for those with lower SES than higher SES
Kaestner 2009	Allostatic load	• Allostatic load was higher for Blacks than Whites • Allostatic load was higher for U.S.-born Mexican Americans than foreign-born Mexican Americans
Peek 2010	Allostatic load	• Blacks had the highest allostatic load • U.S.-born Mexican Americans had higher allostatic load than foreign-born Mexican Americans

Author and Publication Y ear	Health Outcome	Evidence of Weathering in the Overall Population
	Cardiovascular Health	
Das 2013	Metabolic outcomes	• Inflammation was associated with an increased risk for diabetes and cardiovascular disease • The association was stronger for Blacks than Whites
	Genetic Outcomes	
Simons 2016	Epigenetic measure/Methylation	• Lower income was associated with accelerated aging
Geronimus 2010	Telomere length	• Telomere length was shorter for Blacks (more weathered) than Whites
Geronimus 2015	Telomere length	• Telomere length decreased with age • No racial/ethnic variation in telomere length for Blacks, Mexican Americans and Whites • Weathering was more pronounced in lower SES Whites than higher SES Whites
	Mortality	
Borrell 2010	All-cause mortality	• Higher allostatic load (≥ 3) was associated with increased mortality risk compared to lower allostatic load (≤ 1) • No racial and ethnic variation in the association
Howard 2016	Mortality	• Increasing allostatic load was associated with increased mortality risk • The association was stronger for Blacks than Whites

U.S.=United States. -- =no evidence of weathering.

Table 4.

Potential Risk of Bias Assessment for the Included Studies

Author & Publication Year	Evidence of Weathering	Health Outcome	Geographic Location	Dataset	Sample Size	Study Design	Study Participation	Study Attrition	Exposure Measurement	Outcome Measurement	Study Confounding	Statistical Analysis & Reporting	Overall Potential for Bias
Geronimus 2010	Yes	Telomere length	Boston, Chicago, Detroit, Oakland, Los Angeles, Newark, Pittsburgh	SWAN	215	Cohort	High	High	Low	Low	Low	Low	**High**
Simons 2016	Yes	Epigenetic measure of biological aging/ methylation	Georgia & Iowa	FACHS	100	Cohort	High	High	Low	Low	Low	Low	**High**
Wallace 2013	Yes	Gestational age	Louisiana	Tulane-Lakeside Hospital Department of Obstetrics &Gynecology	123	Cohort	High	High	Low	Low	Low	Low	**High**
Wallace 2013	No	Birthweight	Louisiana	Tulane-Lakeside Hospital Department of Obstetrics & Gynecology	123	Cohort	High	High	Low	Low	Low	Low	**High**
Wallace 2013	No	Birthweight ratio	Louisiana	Tulane-Lakeside Hospital Department of Obstetrics & Gynecology	123	Cohort	High	High	Low	Low	Low	Low	**High**
Wallace 2013	No	Birth length	Louisiana	Tulane-Lakeside Hospital Department of Obstetrics & Gynecology	123	Cohort	High	High	Low	Low	Low	Low	**High**
Wallace 2013	No	Head circumference	Louisiana	Tulane-Lakeside Hospital Department of	123	Cohort	High	High	Low	Low	Low	Low	**High**

Author & Publication Year	Evidence of Weathering	Health Outcome	Geographic Location	Dataset	Sample Size	Study Design	Study Participation	Study Attrition	Exposure Measurement	Outcome Measurement	Study Confounding	Statistical Analysis & Reporting	Overall Potential for Bias
				Obstetrics & Gynecology									
Spence 2008	No	Functional limitations	U.S.	NLS-MW	1608	Cohort	Low	High	Low	Low	Low	Low	**High**
Borrell 2010	Yes	All-cause mortality	U.S.	NHANES III & NDI	13,715	Cohort	Low	High	Low	Low	Low	Low	**High**
Kramer 2014	Yes	Preterm-low birthweight	Georgia	Georgia birth records & U.S. Census	1,000,437	Cohort	Low	High	Low	Low	Low	Low	**High**
Lin 2017	Yes	Functional limitations	U.S.	HRS	7715	Cohort	Low	High	Low	Low	Low	Low	**High**
Spence 2009	Yes	Longevity (post reproductive mortality)	U.S.	NLS-MW	3769	Cohort	Low	High	Low	Low	Low	Low	**High**
Strutz 2014	Yes	Birthweight	U.S.	Add Health	5413	Cohort	Low	High	Low	Low	Low	Low	**High**
Geronimus 2015	Yes	Telomere length	Detroit	HEP Community Survey	202	Cross-sectional	High	Low	Low	Low	Low	Low	**High**
Buescher 2006	Yes	High blood pressure	North Carolina	BRFSS & North Carolina birth & infant death records	495,551	Cross-sectional	Low	Low	Low	High	High	Low	**High**
Buescher 2006	Yes	Body mass index	North Carolina	Behavioral BRFSS & North Carolina birth & infant death records	495,551	Cross-sectional	Low	Low	Low	High	High	Low	**High**
Buescher 2006	No	Cholesterol	North Carolina	BRFSS & North Carolina birth & infant death records	495,551	Cross-sectional	Low	Low	Low	High	High	Low	**High**
Wildsmith 2002	Yes	Hypertension	U.S.	NCHS	387, 909	Cross-sectional	Low	Low	Low	High	High	Low	**High**
Wildsmith 2002	No	Anemia	U.S.	NCHS	387,909	Cross-sectional	Low	Low	Low	High	High	Low	**High**
Thorpe 2016	Yes	Diabetes	U.S.	NHIS	619,130	Cross-sectional	Low	Low	Low	High	Low	Low	**High**
Thorpe 2016	Yes	Hypertension	U.S.	NHIS	619,130	Cross-sectional	Low	Low	Low	High	Low	Low	**High**

Author & Publication Year	Evidence of Weathering	Health Outcome	Geographic Location	Dataset	Sample Size	Study Design	Study Participation	Study Attrition	Exposure Measurement	Outcome Measurement	Study Confounding	Statistical Analysis & Reporting	Overall Potential for Bias
Thorpe 2016	Yes	Stroke	U.S.	NHIS	619,130	Cross-sectional	Low	Low	Low	High	Low	Low	**High**
Thorpe 2016	No	Cardiovascular disease	U.S.	NHIS	619,130	Cross-sectional	Low	Low	Low	High	Low	Low	**High**
Buescher 2006	Yes	Infant mortality	North Carolina	BRFSS & North Carolina birth & infant death records	495,551	Cross-sectional	Low	Low	Low	Low	High	Low	**High**
Buescher 2006	Yes	Low birth weight	North Carolina	BRFSS & North Carolina birth & infant death records	495,551	Cross-sectional	Low	Low	Low	Low	High	Low	**High**
Buescher 2006	Yes	Neonatal mortality	North Carolina	BRFSS & North Carolina birth & infant death records	495,551	Cross-sectional	Low	Low	Low	Low	High	Low	**High**
Buescher 2006	Yes	Postneonatal mortality	North Carolina	Behavioral Risk Factor Surveillance System (BRFSS) & North Carolina birth & infant death records	495,551	Cross-sectional	Low	Low	Low	Low	High	Low	**High**
Buescher 2006	Yes	Self-reported health	North Carolina	BRFSS & North Carolina birth & infant death records	495,551	Cross-sectional	Low	Low	Low	Low	High	Low	**High**
Buescher 2006	Yes	Very low birth weight	North Carolina	BRFSS & North Carolina birth & infant death records	495,551	Cross-sectional	Low	Low	Low	Low	High	Low	**High**
Wildsmith 2002	Yes	Neonatal mortality	U.S.	NCHS	387, 909	Cross-sectional	Low	Low	Low	Low	High	Low	**High**
Wildsmith 2002	No	Low birthweight	U.S.	NCHS	387,909	Cross-sectional	Low	Low	Low	Low	High	Low	**High**
Bird 2010	Yes	Allostatic load	U.S.	NHANES III	13,184	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Chinn 2016	Yes	Functional limitations	U.S.	NHIS	42,908	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**

Author & Publication Year	Evidence of Weathering	Health Outcome	Geographic Location	Dataset	Sample Size	Study Design	Study Participation	Study Attrition	Exposure Measurement	Outcome Measurement	Study Confounding	Statistical Analysis & Reporting	Overall Potential for Bias
Collins 2006	No	Very low birth weight	Illinois	Illinois Vital Records, U.S. Census & Chicago Department of Public Health data	46,725	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Chyu 2011	Yes	Allostatic load	U.S.	NHANES IV	5765	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Cohen 2016	Yes	Infant mortality	U.S.	NCHS	2,960,578	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Collins 2006	Yes	Moderately low birth weight	Illinois	Illinois Vital Records, U.S. Census & Chicago Department of Public Health data	46,725	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Collins 2009	Yes	Low birth weight	Illinois	Illinois transgenerational dataset & U.S. Census	267,303	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Collins 2012	No	Low birthweight	Illinois	Illinois transgenerational dataset & U.S. Census	267,303	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Collins 2012	No	Preterm birth	Illinois	Illinois transgenerational dataset & U.S. Census	267,303	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Collins 2012	No	Intrauterine growth retardation	Illinois	Illinois transgenerational dataset & U.S. Census	267,303	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Collins 2015	Yes	Low birth weight	Illinois	Illinois transgenerational dataset & U.S. Census	70,580	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Collins 2015	Yes	Small for gestational age	Illinois	Illinois transgenerational dataset & U.S. Census	70,580	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**

Author & Publication Year	Evidence of Weathering	Health Outcome	Geographic Location	Dataset	Sample Size	Study Design	Study Participation	Study Attrition	Exposure Measurement	Outcome Measurement	Study Confounding	Statistical Analysis & Reporting	Overall Potential for Bias
Das 2013	Yes	Metabolic outcomes (blood sugar/ diabetes blood pressure, heart rate)	U.S.	NSHAP	1455	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Dennis 2013	Yes	Low birth weight	U.S.	ECLS-B	6150	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Geronimus 1996	Yes	Low birth weight	Michigan	Michigan Vital Records & U.S. Census	54,888	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Geronimus 1996	Yes	Very low birth weight	Michigan	Michigan Vital Records & U.S. Census	54,888	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Geronimus 2006	Yes	Allostatic load	U.S.	NHANESIV	6586	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Geronimus 2007	Yes	Hypertension	U.S.	NHANES IV	5501	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Goisis 2014	Yes	Low birth weight	United Kingdom	ONSLS	45,856	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Hibbs 2016	Yes	Preterm birth	Illinois	Illinois transgenerational dataset & U.S. Census	267,303	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Holzman 2009	Yes	Preterm birth	Philadelphia, Baltimore, 16 Michigan cities, 3 Maryland counties, 2 North Carolina counties	The Multilevel Modeling of DisparitiesExplaining Preterm Delivery Project & U.S. census	182,938	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Howard 2016	Yes	Mortality	U.S.	NHANES III & NDI	11,733	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Kaestner 2009	Yes	Allostatic load	U.S.	NHANES III	7010	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Khoshnood 2005	Yes	Low birth weight	U.S.	NCHS	8,433,935	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**

Author & Publication Year	Evidence of Weathering	Health Outcome	Geographic Location	Dataset	Sample Size	Study Design	Study Participation	Study Attrition	Exposure Measurement	Outcome Measurement	Study Confounding	Statistical Analysis & Reporting	Overall Potential for Bias
Khoshnood 2005	Yes	Moderately low birth weight	U.S.	NCHS	8,433,935	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Khoshnood 2005	Yes	Very low birth weight	U.S.	NCHS	8,433,935	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Love 2010	Yes	Low birth weight	Illinois	Illinois transgenerational dataset & U.S. Census	70,615	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Love 2010	Yes	Small for gestational age	Illinois	Illinois transgenerational dataset & U.S. Census	70,615	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Love 2010	No	Preterm birth	Illinois	Illinois transgenerational dataset & U.S. Census	70,615	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Osypuk 2008	Yes	Preterm birth	U.S.	NCHS & U.S. Census	1,944,703	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Peek 2010	Yes	Allostatic load	Texas City	Texas City Stress & Health Study	1410	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Powers 2013	Yes	Infant mortality	U.S.	NCHS	26,578,118	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Powers 2016	Yes	Infant mortality	U.S.	NCHS	14,542,120	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Rauh 2001	Yes	Moderately low birth weight	New York City	Bureau of vital statistics, New York City Department of Health & U.S. Census	158,174	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Rauh 2001	Yes	Very low birth weight	New York City	Bureau of vital statistics, New York City Department of Health & U.S. Census	158,174	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Sheeder 2006	Yes	Small for gestational age	Colorado	Colorado birth certificate data	91,061	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**

Author & Publication Year	Evidence of Weathering	Health Outcome	Geographic Location	Dataset	Sample Size	Study Design	Study Participation	Study Attrition	Exposure Measurement	Outcome Measurement	Study Confounding	Statistical Analysis & Reporting	Overall Potential for Bias
Swamy 2012	Yes	Mean birth weight	North Carolina	North Carolina birth record database	510,288	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**
Wang 2012	No	Low birthweight or preterm birth	Taiwan	Taiwan birth registration	8432	Cross-sectional	Low	Low	Low	Low	Low	Low	**Low**

Add Health=National Longitudinal Study of Adolescent Health

BRFSS=Behavioral Risk Factor Surveillance System

ECLSB= Early Childhood Longitudinal Study-Birth Cohort

FACHS=Family and Community Health Study

HEP= The Healthy Environment Partnership

HRS=Health and Retirement Study

NCHS=National Center for Health Statistics

NDI=National Death Index

NHANES=National Health and Nutrition Examination Survey

NHIS=National Health Interview Survey

NLS-MW=National Longitudinal Survey of Mature Women

NSHAP= National Social Life, Health and Aging Project

ONSLS=Office for National Statistics longitudinal study

SWAN= Study of Women's Health Across the Nation