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Can Antipoverty Programs Save Lives? Quasi-experimental evidence from the Earned Income Tax Credit.

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Key Words (MeSH)

Health and Socio-Economic Status; Health Policy; Non-Medical Determinants of Health

Abstract

Objective: To examine whether state-level supplements to the Earned Income Tax Credit (EITC) reduce state-level mortality. The EITC is a Federal program that supplements the wages of lower-income workers by providing larger returns when taxes are filed.

Setting. Multi-year population census data linked to vital status.

Participants. 793,000 respondents within the National Longitudinal Mortality Survey (NLMS) between 1986-2011.

Intervention. We used a quasi-experimental difference-in-difference approach. We exploited state-level variation in EITC payouts to estimate the effects of EITC on adult survival among those who did and did not receive supplemental EITC payments between 1986-2011.

Results. We find that implementation of a state supplemental EITC program increased survival. EITC is associated with a hazard ratio of 0.97 (standard error = 0.01) for each $100 of EITC increase ($p<0.05$).

Conclusion. State-level supplemental EITC may be an effective means of increasing survival in the US.

Keywords: Health Policy; Earned Income Tax Credit; Socio-Economic Status and Health

Article summary

• Income support programs may improve human survival both by providing material support to purchase life-saving goods (e.g., medical care or healthy food) and by reducing psychological stress.

•We use a quasi-experimental design to investigate the independent effect of state-level Earned Income Tax Credit (EITC) supplements.

•We also identify individuals who are eligible to receive additional income and then follow the vital status of those individuals over many years.

•While our method is causal in design, it does not necessarily provide precise estimates because states that can afford EITC payments may also simultaneously invest in other life-saving interventions.

•We find that each $100 in additional EITC support provided by the state annually will increase survival by roughly 3% (2 weeks).

Introduction

In the US life expectancy has declined relative to other nations for decades as lower wages and higher health costs have reduced disposable income for households below the US median for earnings [1-3]. One policy that has promise to address declining income, and potentially declining health, is the Earned Income Tax Credit (EITC). The EITC is designed to supplement earnings in lower-paying jobs by providing a monetary credit to low-income workers who file taxes. This program has the effect of restoring some of the disposable income lost to lower-income households as high paying factory jobs have disappeared in the United States, thereby potentially also restoring health [4].

The EITC is the largest means-tested anti-poverty program in the United States [5]. Historically it has received broad bipartisan support, having been created under President Ford in 1975, and subsequently expanded during the terms of Presidents Clinton, Bush, and Obama [6].

Poverty is associated with a greater burden of disease than smoking and obesity combined in the US [7 8]. Poverty takes a toll on health by increasing one's risk of environmental exposures (e.g., living near freeway intersections or living in housing with peeling lead paint) and reducing purchasing power (e.g., of healthy food or out-of-pocket medical expenses) [4]. Likewise, EITC can increase employment, which is also associated with decreased mortality (possibly because it can increase access to employer-based health insurance, health savings accounts, and social capital) [9-12]. However, the largest health effects associated with EITC are now believed to arise from incremental changes in psychological stress, which causes the release of glucocorticoids that damage neural

structures associated with executive function, memory, and homeostatic processes, such as the regulation of blood sugar and blood pressure.[10 13-18]

Glucocorticoids are meant to increase survival among our hunter-gatherer ancestors by diverting glucose and oxygen from the brain and reproductive organs to muscles, allowing us to flee predators.[19 20] Modern-day society, unfortunately, is filled with stressors that activate these primitive, neurotoxic systems, leading to hypertension, obesity, and interfering with health behaviors.[18]

Notably, even small increases in income support among low-income households can lead to increased short-term perceived financial security even if the gains are too small to increase savings (and therefore demonstrable financial security).[10 21 22] Perceived security may be one of the most important determinants of stress among low-income households.[16 23-25]. By alleviating poverty, the EITC may also serve as a tool for reducing premature mortality in the US.[9]

The hypothesis that EITC might reduce premature mortality is supported by previous research [26-33]. Because some states have supplemented federal EITC and some have not, this invites a quasi-experimental analysis in which natural variation in state policies can be used to estimate the impact of state-level supplemental EITC on health or survival. However, to our knowledge, there is only one dataset that is capable of identifying large numbers of individuals who are eligible for EITC by their state of residence that also provides longer-term follow up of their survival effects—the National Longitudinal Mortality Survey (NLMS).[34]

The size of the EITC tax credit varies considerably by family size and marital status. While an adult with no children can earn up to $400 at tax time, single parent with 3

children can earn over $6,000. When EITC-eligible individuals are identified, it becomes possible to increase the accuracy of the analysis and to remove confounding of survival outcomes associated with emigration of healthier individuals to wealthier states [35 36]. Long-term follow up for survival is necessary because EITC-eligible individuals and families tend to be under age 65 and employed, and therefore tend to be healthier. The benefit of reduced exposure to poverty in early- and middle-aged adults is only likely to manifest after the age of 65 [37].

The NLMS is the largest mortality survey in the US, and allows us to conduct a targeted and comprehensive examination of the impact of state-level supplemental EITC on survival. Others have examined variation by family size [27-30 38] and by state level of supplementation [33]. However, these analyses are limited by assumptions necessary when using smaller and less detailed datasets.

A particular problem faced by some previous quasi-experimental analyses is that it was necessary to look at aggregate state-level effects (e.g., among those with family incomes close to the poverty line) rather than effects among individuals with a high-probability of EITC receipt. By using the very large and detailed NLMS, administered by the Census Bureau, we are able to identify individuals likely to receive supplemental EITC and to explore dose-response effects within a quasi-experimental design. According to NLMS and Census Bureau officials, ours is the first study to use longitudinal mortality data from the NLMS to assess the impacts of state-level supplemental EITC on survival.

Methods

Overview

We use survival models to estimate the impact of state-level supplemental EITC on survival. The time frame for our analysis is 1986-2011, with mortality follow-up through the end of 2011. During that time frame, federal and state EITC policies regarding eligible incomes and size of the tax credit changed considerably (Table 1). The tax years we analyzed were from 1985 to 2010, as the EITC rate applied to tax year *t* income would benefit the family income in year *t+1*. Non-recipients were excluded from the analysis.

Each respondent's record in our data set is recorded in person-years, extending from their year of CPS/ASEC interview for the NLMS to their year of exit by death or by reaching the end of mortality follow up at the end of 2011. We limited our analysis to individuals under the age of 65 because many Americans will have retired by then and are ineligible for EITC. However, mortality follow up extends beyond this window. A 64-year-old at the time of survey would be followed to 69, 74, or until December 31, 2011 depending on the analysis used.

Data

While the NLMS contains multiple census data sources, the primary source of data is from the March Annual and Social Economic Supplements of the Current Population Survey. This supplement is an annual survey designed to collect detailed information about income, migration, health insurance, and a broader range of general economic data for persons aged 15 years and over. Roughly 60,000 households are interviewed annually in

the March CPS. In that survey, one member of each household provides information for all family members.

The March CPS and NLMS are weighted and standardized to be reflective of the US population. The NLMS currently consists of approximately 3.8 million records with over 560,000 identified deaths up through December 31, 2011.[39] We use 793,000 records of adults aged 18-64 over 26 years (1986-2011). These data were weighted to be representative of the U.S. population under age 65 at the time of interview. The NLMS data from CPS/ASEC is periodically linked to the set of U.S. death certificates collected by the National Center for Health Statistics via the National Death Index (NDI).

Income cutoffs for supplemental EITC eligibility vary by state. Our information on state EITC cutoffs and eligibility for tax credits comes from source documents generously provided to us by TAXSIM [40 41]. We also added information from the Minnesota Working Family Credit from 1998 to 2010 [42], which differs somewhat from credits offered by other states.

Variables

Eligibility for EITC and the size of the tax credit received by eligible households, were estimated using reported family income, marital status, number of children, and the rules for supplemental EITC eligibility within each state. We use the March CPS to determine the number of children in each household, the marital status of the householders, and the inflation-adjusted household income. We then determine whether a household is eligible for EITC at the federal level as well as the additional credit, if any, for any given state.

Some identification problems that remain: (1) we don't know if the head of household is consistently employed (and thus eligible to claim EITC); (2) how many years of state EITC exposure a given family had, because of (a) moving, (b) divorce, (c) changes in number of kids, or (d) pay raises at work; (3) we were unable to estimate the effects of total EITC exposure over time based on the year the state adopted EITC (due to multicollinearity between year of supplemental EITC adoption and other control variables in the model).

The exposure variables of interest for the survival models are the estimated EITC receipts – "Federal EITC" and "state EITC" – in respondent year (*t*) from family income earned in year *t-1*, as reported in the interview in year *t*. The EITC receipts are calculated from the tax-year specific formulas from TAXSIM, and are applied to the subsequent person-year observation. Both the "Federal EITC" and "state EITC" receipts are divided into $100 units to help with the presentation of small parameter estimates from the regressions. The EITC receipts are converted into real $2015 using the Consumer Price Index (CPI).

To adjust for personal characteristics, we include control variables for (a) age at person-year, (b) sex, (c) marital status, (d) race or ethnicity, (e) educational attainment, (f) income, and (g) employment status in addition to the state and Federal EITC measures. Other than age, income, and EITC receipts, these variables are measured as binary indicators. The descriptive statistics for the proportions of those indicators are shown in Table 2 along with the means of the continuous variables. The central tendency is expressed as standard deviations (SD) of the continuous variables (SD (x)), and as standard errors (SE) for the proportion (SE (p)).

The categories for sex are male (reference group) and female. For marital status they are married (reference group) and not married, which includes widows, divorcees, separated persons, and the never married. The categories for race and ethnicity are Hispanic, White non-Hispanic (reference group), Black non-Hispanic, American Indian/Alaskan Native non-Hispanic, and Asian/Pacific Islander non-Hispanic. The categories for educational attainment are college degree, some college, high school diploma (reference group), and no diploma. The categories for employment are employed (reference group), unemployed, and "not in labor force." These binary indicators are assigned to each person based on their response at their CPS/ASEC interview (at baseline) and are used through all person-years. These demographic characteristics are liable to change as a result of exposure to EITC.

Family incomes are asked during their CPS/ASEC interview. The dollar amount at the time of interview is adjusted to the CPI-adjusted purchasing power of the person-year for calculation of nominal EITC receipts. Both the family income and EITC receipts are then adjusted to year 2015 dollars in the regression to keep purchasing power constant across the range of the time series. To correct for the right-skewed distribution of income, we use the natural logarithm for the variable and assign the value of zero when income is zero or negative. The regression uses age at person-year instead of age at interview in order to properly adjust for age-relative hazards of mortality.

Patient and public involvement

No patient involvement.

Model specification

In interpreting these results, it is important to consider that our final, statistically-significant models were not pre-specified. Rather, they were re-specified in response to reviewer comments over various revisions of this manuscript.

We use Cox proportional hazards models (with state level fixed effects and errors clustered at the primary sampling unit) to estimate the impact of state-level EITC generosity on 5-year, 10-year, and maximum survival among adults (ages 18-64) between 1986 and 2011. We used a difference-in-difference model with an intention-to-treat design, assessing mortality according to people's eligibility for EITC on a state-by-state basis. While eligibility will diverge from receipt of EITC funds, this design is the best way to assess the efficacy of the EITC program as it actually exists; discordance between the program's intended and actual recipients represents an important shortcoming in the program.

Selecting a length of follow-up time over which to measure EITC's effects on survival presents a conflict; shorter follow-up times are unlikely to capture EITC's effects on chronic disease and other conditions that may impact long-term survival. However, longer follow-up times introduce more uncertainty about possible changes in the socioeconomic status of the participants in our sample. Because individuals' incomes, household sizes, marital status, and states of residence are known only at the time of interview in the Current Population Survey, we do not know how social and demographic variables change over time.

We elected to use 10-year survival rates as our primary outcome measure because it represents a reasonable window for both capturing differences in survival between groups, and for minimizing error in our identification of EITC eligibility due to changes in family

income, marital status, or family size (which are increasingly likely with a longer follow-up window). As a sensitivity analysis, we also estimated models with a shorter follow-up window (using 5-year survival as the model outcome) as well as models with a longer follow-up window (using survival rates over the entire follow-up period available for each respondent in the NLMS).

Our set of person-year records consists of those records with "age at interview" of at least 18 years, and extending up through either (a) "age at person year" of 64 years, (b) the year of death (with "failure"=1), or (c) end of follow up at 2011. An additional inclusion rule includes only respondents with estimated family income that is less than twice the maximum Federal EITC income allowed for the respondent's family size. This income limit is to eliminate any possible regression distortions caused by observations on high-income individuals, who may have a different mortality risk pattern than the lower-income respondents we wish to analyze.

All models use the NLMS person weights, which are divided and distributed among the person-years of the individual. The results of the models report the hazard ratios of mortality for deviations of each independent variable relative to the reference respondent person-year, which would be (a) at the mean age at person-year, (b) male (c) married, (d) white non-Hispanic, (e) with a high school diploma, (f) with the average (logged) family income, and (g) employed, with zero dollars received from Federal or state EITC.

Results

Our analytic sample included 793,000 adults aged 18-64 from all 50 states and Washington D.C. Summary statistics for the analytic sample are presented in Table 2. Table

3 shows the results of three Cox proportional hazards regressions. The functional form of, and covariates within, all three regressions is the same. Only follow up differs (5-years, 10-years, and maximum).

Our control variables show associations with mortality that are statistically significant at $p<0.001$ and consistent with previous research.[34] For example, mortality risk declines with income and employment but increases with age and Black or Native American ethnicity (Table 3).

State EITC receipt is statistically-significant in all three models with a hazard ratio (HR) = 0.97 (standard error [SE] = 0.01) for the 5-year and 10-year follow up models. For maximum follow up, the HR = 0.98 (SE = 0.01).

Discussion

In this study, we examine the survival impact of state-level supplements to EITC using a quasi-experimental design and individual-level data for 793,000 adults aged 18-64. After adjusting for age, sex, race, education, family income, and employment status, we find evidence for mortality benefits conferred by state-level supplemental EITC.

It is difficult to precisely estimate the survival benefit associated with EITC because the we were unable to quantify the number of years that any given participant was exposed to the credit. Moreover, while quasi-experimental in nature, there could be state-level factors that confound estimates (e.g., states with EITC supplementation may also offer other social welfare programs, offer fewer worker protection regulations, or be more likely to receive healthy migrants from other states). Over time, federal regulations has disproportionately benefited poorer states that are less likely to implement supplemental

EITC because these states have historically been high risk, low regulation. With these limitations in mind, a hazard ratio of 0.97 over a 10-year period of follow-up corresponds to an increase in life expectancy of roughly 2 weeks for every $100 of state-level EITC supplementation (in constant 2015 US dollars).[43] The results of a recent randomized-controlled trial suggests that the average eligible recipient might receive hundreds of dollars in benefits per year, suggesting that the program has the potential to meaningfully improve population health.[8]

Our study explores temporal and spatial variation in outcome measures across states as well as dose-response effects across individuals. The NLMS affords a very large sample size, long-term mortality follow-up, and information on EITC eligibility at the individual level, providing a good deal of resolution relative to a previous study that examined aggregate state-level effects.[44] Our study is generally consistent with previous studies, which showed that, while EITC receipt may be a risk factor for obesity, overall health and survival benefits have been noted [26-32] [38].

While the EITC is an effective anti-poverty program, it tends to provide fairly modest income support [8]. These modest program effects may be offset by the fact that the vast majority of people who apply for EITC remain on EITC for many years [45]. The cumulative effects the income support provided by EITC over the years may therefore add up to survival benefits over time.

Our findings are very important from a policy perspective. There is now reasonable evidence that America's declining health and life expectancy are related to the declining fortunes of lower- and middle-class families.[46] While some of the decline must be

addressed with structural changes to the health system[3] and other anti-poverty policies,[24] we find encouraging evidence that changes to tax policy might also help.

Acknowledgments and Disclosures

Any opinions and conclusions expressed herein are those of the authors and do not necessarily reflect the views of the U.S. Census Bureau. All results have been reviewed to ensure that no confidential information is disclosed. The statistical summaries reported in this document have been cleared by the Census Bureau's Disclosure Review Board release authorization number CBDRB-FY19-366.

Contributorship statement
PM Conceived of the study and made significant contributions to the manuscript development. DV and JH led the direction and development of the methodological approach, and made

Competing interests
None

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Data sharing statement
Data contain identifiers and are not permissible for upload to public repository according

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Table 1. The Supplemental Earned Income Tax Credit (EITC) benefit by state and the year enacted.*

State	Year Enacted	Percent Addition to Federal EITC
California	2015†	85
Colorado	1999, 2013†	10
Connecticut	2011	30
Delaware	2005	20
District of Columbia	2000	40
Illinois	2000	10
Indiana	1999	9
Iowa	1989	15
Kansas	1998	17
Louisiana	2007	3.5
Maine	2000	5
Maryland	1987	25.5
Massachusetts	1997	23
Michigan	2006	6
Minnesota	1991	35
Nebraska	2006	10
New Jersey	2000	30
New Mexico	2007	10
New York	1994	30
Ohio	2013†	10
Oklahoma	2002	5
Oregon	1997	8
Rhode Island	1986	12.5
Vermont	1988	32
Virginia	2004	20
Washington	2000	10
Wisconsin	1989	11

*Details of implementation and variability by family size and year available from TAXSIM[24-25]

†Not included in analysis as having supplemental EITC because program implementation was after the period of our mortality follow-up.

Table 2: Descriptive statistics for lower-income adult person-years (ages 18-64 at initial interview) in the National Longitudinal Mortality Survey (NLMS), 1986-2011. (United States Bureau of the Census approval DRB approval number CBDRB-FY19-366.)

	Maximum follow up[1]		10-year follow up[1]		5-year follow-up[1]	
Variable	Mean	(SD(x)) SE(p)	Mean	(SD(x)) SE(p)	Mean	(SD(x)) SE(p)
Age at person-year	43.2	(13.5)	41.6	(13.2)	40.5	(13.2)
Female (%)	52.5	0.03	52.2	0.03	52.0	0.05
Married at interview (%)	47.5	0.03	46.5	0.03	45.8	0.04
Race/ethnicity:						
Hispanic (%)	15.1	0.02	15.9	0.02	16.5	0.03
White (%)	65.5	0.03	64.3	0.03	63.5	0.04
Black (%)	15.1	0.02	15.2	0.02	15.3	0.03
Native American (%)	0.87	0.004	0.88	0.005	0.86	0.007
Asian/ Pacific Islander (%)	3.5	0.010	3.7	0.013	3.8	0.016
Highest educational attainment at time of interview:						
No high school diploma (%)	20.1	0.02	19.8	0.03	19.3	0.03
High school diploma (%)	37.7	0.03	37.0	0.03	36.5	0.04
Some college education (%)	26.6	0.03	27.3	0.03	27.7	0.04
College degree or higher (%)	15.6	0.02	16.0	0.03	16.4	0.03
Family income at time of interview $2015; (mean, SD)	40,500	(22,500)	40,000	(22,500)	39,500	(22,500)
Family income, $2015 (as natural log. of income at time of interview; mean, (SD))	10.2	(1.8)	10.1	(1.8)	10.1	(1.9)
Employment status at time of interview:						

Employed	68.0	0.03	67.6	0.03	66.9	0.04
Unemployed	11.2	0.02	11.9	0.03	12.7	0.03
Not in labor force	20.8	0.02	20.5	0.03	20.4	0.04
Receiving State EITC (%)[1]	27.8	0.03	27.2	0.03	27.3	0.04
Federal EITC receipts (in $100 units; mean, (SD))[1]	14.8	(13.0)	15.9	(14.1)	16.3	(14.5)
State EITC receipts (in $100 units; mean (SD))[1]	3.26	(4.06)	3.29	(4.13)	3.32	(4.18)
Sample size (person-years) [2]	8,820,000		5,960,000		3,530,000	
Sample size (respondents) [2]	793,000		793,000		793,000	
Number of deaths [2]	48,000		24,000		12,000	

Note: results weighted to be representative of the 0-64 U.S. population in 2015.

[1]SD = standard deviation; SE = standard error; EITC = Earned Income Tax Credit.

For Tmax: Conditional means for <fed_eitc> on 2.250,000 PY (206,000 persons), conditional means for <st_eitc> on 281,000 PY (42,500 persons). [Correlation is 0.285 among Fed. EITC recipients.]

For T10: Conditional means for <fed_eitc> on 1,540,000 PY (206,000 persons), conditional means for <st_eitc> on 246,000 PY (42,500 persons). [Correlation is 0.291 among <fed_eitc> recipients.]

For T05: Conditional means for <fed_eitc> on 912,000 PY (206,000 persons), conditional means for <st_eitc> on168,000 PY (42,500 persons). [Correlation is 0.301 among <fed_eitc> recipients.]

[2]Sample counts are rounded according to the U.S. Census Bureau Disclosure Review Board Disclosure Avoidance Guidelines.

Table 3: Cox proportional hazard models of supplemental EITC's impact on mortality risk for lower-income adults for adult person-years (ages 18-64) in the NLMS, 1986-2011. (United States Bureau of the Census approval DRB approval number CBDRB-FY19-366.)

	Maximum follow-up		10-year follow-up		5-year follow-up	
Variable	Hazard ratio	SE (HR)	Hazard ratio	SE (HR)	Hazard ratio	SE (HR)
Age at person-year (years)	1.07***	0.0008	1.07***	0.0009	1.06***	0.0011
Female	0.595***	0.010	0.593***	0.012	0.586***	0.014
Married at time of interview	0.692***	0.012	0.685***	0.014	0.686***	0.017
Race/ethnicity (White, non-Hispanic is referent):						
Hispanic	0.588***	0.020	0.590***	0.023	0.600***	0.029
Black	1.09**	0.025	1.09***	0.028	1.09*	0.035
Native American	1.26***	0.087	1.28**	0.100	1.30**	0.123
Asian/ Pacific Islander	0.578***	0.038	0.579***	0.043	0.580***	0.052
Highest educational attainment at time of interview (High school diploma is referent):						
No high school diploma	1.11***	0.022	1.09***	0.025	1.07*	0.031
Some college education	0.889***	0.020	0.887***	0.023	0.884***	0.029
College degree or higher	0.701***	0.022	0.713***	0.026	0.729***	0.033
Family income, 2015 dollars (as natural log. of income at time of interview)	0.986***	0.005	0.988*	0.005	0.989^{NS}	0.006
Employment status at time of interview (Employed is referent):						
Unemployed	3.20***	0.071	3.47***	0.088	3.78***	0.117
Not in labor force	1.79***	0.035	1.91***	0.046	2.03***	0.063
Earned Income Tax Credit (EITC):						
Federal EITC (in $100 units of 2015$)	1.003*	0.0011	1.002^{NS}	0.0012	1.002^{NS}	0.0015
State EITC (in $100 units of 2015$)	0.979*	0.010	0.973*	0.011	0.968*	0.014
Sample size (N=person-years) [1]	8,820,000		5,960,000		3,530,000	

1

2 All three Cox proportional hazard models include state fixed-effects corrections
3 (state HRs not shown), and time-trends based on the year of the respondent's ACS
4 interview.

* p<0.05, ** p<0.01, *** p<0.001

[1] Sample counts are rounded according to the U.S. Census Bureau Disclosure Review Board Disclosure Avoidance Guidelines. All models included N=793,000 respondents.

[NS] Not statistically significant at p <= 0.05.

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7
Bias	9	Describe any efforts to address potential sources of bias	11
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	NA
		(*c*) Explain how missing data were addressed	4
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	6
		(*e*) Describe any sensitivity analyses	

Continued on next page

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	4
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6
		(b) Indicate number of participants with missing data for each variable of interest	NA
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	7
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	*10*
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	*NA*
		Cross-sectional study—Report numbers of outcome events or summary measures	*NA*
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10
		(*b*) Report category boundaries when continuous variables were categorized	NA
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13
Generalisability	21	Discuss the generalisability (external validity) of the study results	11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Can Antipoverty Programs Save Lives? Quasi-experimental evidence from the Earned Income Tax Credit in the United States

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Abstract

Objective: To estimate the impact of state-level supplements of the Earned Income Tax Credit (EITC) on mortality in the United States. The EITC supplements the wages of lower-income workers by providing larger returns when taxes are filed.

Setting: Nationwide sample spanning 25 cohorts of people across every state in the United States

Participants: 793,000 respondents within the National Longitudinal Mortality Survey (NLMS) between 1986-2011, a representative sample of the United States.

Intervention: State-level supplementation to the EITC program. Some, but not all, states added EITC supplementation to varying degrees beginning in 1986 (Wisconsin) and most recently in 2015 (California). Participants who were eligible in states with supplementary programs were compared with those who were not eligible for supplementation. Comparisons were made both before and after implementation of the supplementary program (a difference-in-difference, intent-to-treat analysis). This quasi-experimental approach further controls for age, gender, marital status, race or ethnicity, educational attainment, income, and employment status.

Primary and secondary outcome measure: the primary outcome measure was survival at 10 years. Secondary outcome measures included survival at 5 years and survival to the end of the intervention period.

Results: We find an association between state supplemental EITC and survival, with a hazard ratio of 0.97 (95% confidence interval = 0.951-0.996) for each $100 of EITC increase ($p<0.05$). **Conclusion:** State-level supplemental EITC may be an effective means of increasing survival in the US.

Strengths and limitations of this study

- Quasi-experimental design (difference-in-difference with intent-to-treat)
- Utilizes the largest health dataset in the United States
- Able to study individual-level impacts on mortality over many decades
- Uses a powerful identification strategy
- States that experience increases in wealth may also invest in social policies

Introduction

In the US life expectancy has declined relative to other nations for decades as lower wages and higher health costs have reduced disposable income for households below the US median for earnings [1-3]. One policy that has promise to address declining income, and potentially declining health, is the Earned Income Tax Credit (EITC). The EITC is designed to supplement earnings in lower-paying jobs by providing a monetary credit to low-income workers who file taxes. This program has the effect of restoring some of the disposable income lost to lower-income households as high paying factory jobs have disappeared in the United States, thereby potentially also restoring health [4].

The EITC is the largest means-tested anti-poverty program in the United States [5]. Historically it has received broad bipartisan support, having been created under President Ford in 1975, and subsequently expanded during the terms of Presidents Clinton, Bush, and Obama [6].

Poverty is associated with a greater burden of disease than smoking and obesity combined in the US [7 8]. Poverty takes a toll on health by increasing one's risk of environmental exposures (e.g., living near freeway intersections or living in housing with peeling lead paint) and reducing purchasing power (e.g., of healthy food or out-of-pocket medical expenses) [4]. Likewise, EITC can increase employment, which is also associated with decreased mortality (possibly because it can increase access to employer-based health insurance, health savings accounts, and social capital) [9-12]. However, the largest health effects associated with EITC are now believed to arise from incremental changes in psychological stress, which causes the release of glucocorticoids that damage neural

structures associated with executive function, memory, and homeostatic processes, such as the regulation of blood sugar and blood pressure.[10 13-18]

Glucocorticoids are meant to increase survival among our hunter-gatherer ancestors by diverting glucose and oxygen from the brain and reproductive organs to muscles, allowing us to flee predators.[19 20] Modern-day society, unfortunately, is filled with stressors that activate these primitive, neurotoxic systems, leading to hypertension, obesity, and interfering with health behaviors.[18]

Notably, even small increases in income support among low-income households can lead to increased short-term perceived financial security even if the gains are too small to increase savings (and therefore demonstrable financial security).[10 21 22] Financial security may be one of the most important determinants of stress among low-income households.[16 23-26]. By alleviating poverty, the EITC may also serve as a tool for reducing premature mortality in the US.[9 25]

The hypothesis that EITC might reduce premature mortality is generally supported by previous research, however some studies have shown null findings while at least one other has shown an increase in obesity associated with EITC [27-35]. Therefore, there is reasonable uncertainty as to whether the program improves health, and there is a strong need for more causal research. Because some states have supplemented federal EITC and some have not, this invites a quasi-experimental analysis in which natural variation in state policies can be used to estimate the impact of state-level supplemental EITC on health or survival. However, to our knowledge, there is only one dataset that is capable of identifying large numbers of individuals who are eligible for EITC by their state of residence that also

provides longer-term follow up of their survival effects—the National Longitudinal Mortality Survey (NLMS).[36]

The size of the EITC tax credit varies considerably by family size and marital status. While an adult with no children can earn up to $400 at tax time, single parent with 3 children can earn over $6,000. When EITC-eligible individuals are identified, it becomes possible to increase the accuracy of the analysis and to remove confounding of survival outcomes associated with emigration of healthier individuals to wealthier states [37 38]. Long-term follow up for survival is necessary because EITC-eligible individuals and families tend to be under age 65 and employed, and therefore tend to be healthier. The benefit of reduced exposure to poverty in early- and middle-aged adults is only likely to manifest after the age of 65 [39].

The NLMS is the largest mortality survey in the US, and allows us to conduct a targeted and comprehensive examination of the impact of state-level supplemental EITC on survival. Others have examined variation by family size [28-31 40] and by state level of supplementation [34]. However, these analyses are limited by assumptions necessary when using smaller and less detailed datasets.

A particular problem faced by some previous quasi-experimental analyses is that it was necessary to look at aggregate state-level effects (e.g., among those with family incomes close to the poverty line) rather than effects among individuals with a high-probability of EITC receipt. By using the very large and detailed NLMS, administered by the Census Bureau, we are able to identify individuals likely to receive supplemental EITC and to explore dose-response effects within a quasi-experimental design. According to NLMS

and Census Bureau officials, ours is the first study to use longitudinal mortality data from the NLMS to assess the impacts of state-level supplemental EITC on survival.

Methods

Overview

We use survival models to estimate the impact of state-level supplemental EITC on survival. The time frame for our analysis is 1986-2011, with mortality follow-up through the end of 2011. During that time frame, federal and state EITC policies regarding eligible incomes and size of the tax credit changed considerably (Table 1). The tax years we analyzed were from 1985 to 2010, as the EITC rate applied to tax year *t* income would benefit the family income in year *t+1*. Non-recipients were excluded from the analysis.

Each respondent's record in our data set is recorded in person-years, extending from their year of CPS/ASEC interview for the NLMS to their year of exit by death or by reaching the end of mortality follow up at the end of 2011. We limited our analysis to individuals under the age of 65 because many Americans will have retired by then and are ineligible for EITC. However, mortality follow up extends beyond this window. A 64-year-old at the time of survey would be followed to 69, 74, or until December 31, 2011 depending on the analysis used.

Patient and Public Involvement

There was no patient involvement in this study.

Data

While the NLMS contains multiple census data sources, the primary source of data is from the March Annual and Social Economic Supplements of the Current Population Survey. This supplement is an annual survey designed to collect detailed information about income, migration, health insurance, and a broader range of general economic data for persons aged 15 years and over. Roughly 60,000 households are interviewed annually in the March CPS. In that survey, one member of each household provides information for all family members.

The March CPS and NLMS are weighted and standardized to be reflective of the US population. The NLMS currently consists of approximately 3.8 million records with over 560,000 identified deaths up through December 31, 2011.[41] We use 793,000 records of adults aged 18-64 over 26 years (1986-2011, all years were included in our analysis). These data were weighted to be representative of the U.S. population under age 65 at the time of interview. The NLMS data from CPS/ASEC is linked to U.S. death certificates collected by the National Center for Health Statistics via the National Death Index (NDI).

Income cutoffs for supplemental EITC eligibility vary by state. Our information on state EITC cutoffs and eligibility for tax credits comes from source documents generously provided to us by TAXSIM [42 43]. We also added information from the Minnesota Working Family Credit from 1998 to 2010 [44], which differs somewhat from credits offered by other states.

Variables

Eligibility for EITC and the size of the tax credit received by eligible households, were estimated using reported family income, marital status, number of children, and the

rules for supplemental EITC eligibility within each state. We use the March CPS to determine the number of children in each household, the marital status of the householders, and the inflation-adjusted household income. We then determine whether a household is eligible for EITC at the federal level as well as the additional credit, if any, for any given state.

Some identification problems that remain: (1) we don't know if the head of household is consistently employed (and thus eligible to claim EITC); (2) how many years of state EITC exposure a given family had, because of (a) moving, (b) divorce, (c) changes in number of kids, or (d) pay raises at work; (3) we were unable to estimate the effects of total EITC exposure over time based on the year the state adopted EITC (due to multicollinearity between year of supplemental EITC adoption and other control variables in the model).

The exposure variables of interest for the survival models are the estimated EITC receipts – "Federal EITC" and "state EITC" – in respondent year (*t*) from family income earned in year *t-1*, as reported in the interview in year *t*. The EITC receipts are calculated from the tax-year specific formulas from TAXSIM, and are applied to the subsequent person-year observation. Both the "Federal EITC" and "state EITC" receipts are divided into $100 units to help with the presentation of parameter estimates from the regressions. The EITC receipts are converted into constant $2015 using the Consumer Price Index (CPI). 2015 was used as a year of reference as this was the year in which the variable was created.

To adjust for personal characteristics, we include control variables for (a) age at person-year, (b) sex, (c) marital status, (d) race or ethnicity, (e) educational attainment, (f) income, and (g) employment status in addition to the state and Federal EITC measures.

Other than age, income, and EITC receipts, these variables are measured as binary indicators. The descriptive statistics for the proportions of those indicators are shown in Table 2 along with the means of the continuous variables. The central tendency is expressed as standard deviations (SD) of the continuous variables (SD (x)), and as standard errors (SE) for the proportion (SE (p)).

The categories for sex are male (reference group) and female. For marital status they are married (reference group) and not married, which includes widows, divorcees, separated persons, and the never married. The categories for race and ethnicity are Hispanic, White non-Hispanic (reference group), Black non-Hispanic, American Indian/Alaskan Native non-Hispanic, and Asian/Pacific Islander non-Hispanic. The categories for educational attainment are college degree, some college, high school diploma (reference group), and no diploma. The categories for employment are employed (reference group), unemployed, and "not in labor force." These binary indicators are assigned to each person based on their response at their CPS/ASEC interview (at baseline) and are used through all person-years. These demographic characteristics are liable to change as a result of exposure to EITC.

Family incomes are asked during their CPS/ASEC interview. The dollar amount at the time of interview is adjusted to the CPI-adjusted purchasing power of the person-year for calculation of nominal EITC receipts. Both the family income and EITC receipts are then adjusted to year 2015 dollars in the regression to keep purchasing power constant across the range of the time series. We calculated the state EITC benefits received using income, marriage, and number of children. The maximum income for inclusion in the regression

sample also controlled for these variables and the Federal EITC income thresholds for various family situations.

To correct for the right-skewed distribution of income, we use the natural logarithm for the variable and assign the value of zero when income is zero or negative. The regression uses age at person-year instead of age at interview in order to properly adjust for age-relative hazards of mortality.

Model specification

We use Cox proportional hazards models (with state level fixed effects and errors clustered at the primary sampling unit) to estimate the impact of state-level EITC generosity on 5-year, 10-year, and maximum survival among adults (ages 18-64) between 1986 and 2011. State-level fixed effects, coupled with the use of constant (inflation-adjusted) $2015 dollars, are used to address differences between cohorts at each CPS year of interview. Assumptions for proportionality are met.

We used a difference-in-difference model with an intention-to-treat design, assessing mortality according to people's eligibility for EITC on a state-by-state basis. While eligibility will diverge from receipt of EITC funds, this design is the best way to assess the efficacy of the EITC program as it actually exists; discordance between the program's intended and actual recipients represents an important shortcoming in the program.

Selecting a length of follow-up time over which to measure EITC's effects on survival presents a conflict; shorter follow-up times are unlikely to capture EITC's effects on chronic disease and other conditions that may impact long-term survival. However, longer follow-up times introduce more uncertainty about possible changes in the socioeconomic status of

the participants in our sample. Because individuals' incomes, household sizes, marital status, and states of residence are known only at the time of interview in the Current Population Survey, we do not know how social and demographic variables change over time.

We elected to use 10-year survival rates as our primary outcome measure because it represents a reasonable window for both capturing differences in survival between groups, and for minimizing error in our identification of EITC eligibility due to changes in family income, marital status, or family size (which are increasingly likely with a longer follow-up window). As a sensitivity analysis, we also estimated models with a shorter follow-up window (using 5-year survival as the model outcome) as well as models with a longer follow-up window (using survival rates over the entire follow-up period available for each respondent in the NLMS).

Our set of person-year records consists of those records with "age at interview" of at least 18 years, and extending up through either (a) "age at person year" of 64 years, (b) the year of death (with "failure"=1), or (c) end of follow up at 2011. An additional inclusion rule includes only respondents with estimated family income that is less than twice the maximum Federal EITC income allowed for the respondent's family size. This income limit is to eliminate any possible regression distortions caused by observations on high-income individuals, who may have a different mortality risk pattern than the lower-income respondents we wish to analyze.

All models use the NLMS person weights, which are divided and distributed among the person-years of the individual. The results of the models report the hazard ratios of mortality for deviations of each independent variable relative to the reference respondent

person-year, which would be (a) at the mean age at person-year, (b) male (c) married, (d) white non-Hispanic, (e) with a high school diploma, (f) with the average (logged) family income, and (g) employed, with zero dollars received from Federal or state EITC.

Results

In interpreting these results, it is important to consider that our final models differed from their original specification. First, in the original specification, we did not control for state-level fixed effects. State-level fixed effects were added to control for differences in state-level policies that might correlate with state EITC benefits. Second, we had initially used a binary indicator to indicate state EITC receipt. Finally, it was recommended that we use $100 increments as a tangible unit of measure because some recipients less than $100 while others might receive thousands of dollars.

There was significant variation in EITC generosity by state, and there was also a good deal of variation in the time of program implementation (Table 1). Our analytic sample included 793,000 adults aged 18-64 from all 50 states and Washington D.C. Summary statistics for the analytic sample are presented in Table 2.

Table 3 shows the results of three Cox proportional hazards regressions. The functional form of, and covariates within, all three regressions is the same but the follow up time differs (5-years, 10-years, and maximum). Our control variables show associations with mortality that are statistically significant at $p<0.001$ and consistent with previous research.[36] For example, mortality risk declines with income and employment but increases with age (Table 3). Females have a lower mortality risk than males, and Blacks have a much higher risk than Whites. Asians have the lowest mortality risk of any group.

State EITC receipt is statistically-significant in all three models with a hazard ratio (HR) = 0.973 (95% confidence interval [CI] = 0.951-0.996) for the 10-year follow up model. Mortality hazards increased slightly as follow-up time increased (from 0.968 for the 5-year follow up model [95% CI = 0.941-0.995] to 0.979 for the maximum follow up [95% CI = 0.959-0.999]. Federal EITC shows a small but statistically-significant increase in mortality hazards in maximal follow up (1.003, 95% CI = 1.001-1005).

Discussion

In this study, we examine the survival impact of state-level supplements to EITC using a quasi-experimental design and individual-level data for 793,000 adults aged 18-64. After adjusting for age, sex, race, education, family income, and employment status, we find evidence for mortality benefits conferred by state-level supplemental EITC.

A hazard ratio of 0.97 over a 10-year period of follow-up corresponds to an increase in life expectancy of roughly 2 weeks for every $100 of state-level EITC supplementation (in constant 2015 US dollars).[45] The results of a recent randomized-controlled trial (RTC) suggests that the average eligible recipient might receive hundreds of dollars in benefits per year, suggesting that the program has the potential to meaningfully improve population health.[8 35]

We also find very small negative impacts from the Federal EITC in one of the three models (a 0.3% increase in hazards). We cannot rule out statistical artifact (collinearity with state EITC receipts, partially systematic residuals over income that ln(income) does not address, an imperfect control for state fixed effects). However, it is also possible that once state-level benefits are controlled for we are picking up the hazards associated with

employment (e.g., accidents while commuting or on the job) that are independent of the credits themselves.

Strengths and limitations

Our study explores temporal and spatial variation in outcome measures across states as well as dose-response effects across individuals. The NLMS affords a very large sample size, long-term mortality follow-up, and information on EITC eligibility at the individual level, providing a good deal of resolution relative to a previous study that examined aggregate state-level effects.[46] Moreover, because the sample size is very large and the NDI covers all states, it is possible to identify individual-level effects, and to do so irrespective of where the individual died. We were able to identify those participants who were eligible for EITC using TAXSIM, and to compare across states that did and did not have supplemental programs. Our study is consistent with previous studies, which showed that, while EITC receipt may be a risk factor for obesity, overall health and survival benefits have been noted [27-33 35 40].

However, our study is subject to a number of important limitations. First, it is difficult to precisely estimate the survival benefit associated with EITC because we were unable to quantify the number of years that any given participant was exposed to the credit. Moreover, while quasi-experimental in nature, there could be state-level factors that confound estimates (e.g., states with EITC supplementation may also offer other social welfare programs, offer fewer worker protection regulations, or be more likely to receive healthy migrants from other states). On the other hand, Federal regulations have disproportionately benefited poorer states that are less likely to implement supplemental EITC because these states have historically been high risk, low regulation. Despite the

potential for states to implement EITC in ways that may also correlate with mortality, our quasi-experimental design coupled with controls for income and employment produces estimates that should have a much higher degree of internal validity than associational studies.

Additionally, our results include both states with refundable tax credits and non-refundable tax credits. While we know which states offer refundable or non-refundable credits, we simply don't know enough about individual household deductions or eligibility for other credits to know when non-refundability is a constraining limit or not, or how large a portion of the credit is retained by the state (on average) when there are non-refundability rules. What we do know is that non-refundable credits mean that our calculated benefits represent the top-level estimate of state EITC receipts, so that our test for a significant effect (possibly from a smaller number of state EITC benefit dollars) is conservative (that is, less likely to produce a low p-value). Finally, in a related limitation, we only observe EITC receipt in the year that the participant was interviewed, but record deaths no matter which state they occurred in. To the extent that a participant moved from a state with benefits to one without (or vice versa), the signal in our estimate is weakened, again rendering the estimate more conservative.

Conclusions

While the EITC is an effective anti-poverty program, it tends to provide fairly modest income support [8]. These modest program effects may be offset by the fact that the vast majority of people who apply for EITC remain on EITC for many years [47]. The cumulative effects the income support provided by EITC over the years may therefore add

up to survival benefits over time. Nevertheless, a recent RCT showed that just three years of exposure to supplemental income from EITC can produce measurable impacts on health-related quality of life, at least among females.[26]

Our findings are important from a policy perspective. There is now reasonable evidence that America's declining health and life expectancy are related to the declining fortunes of lower- and middle-class families.[48] While some of the decline must be addressed with structural changes to the health system[3] and other anti-poverty policies,[25 49] we find encouraging evidence that expanding the EITC could produce significant benefits for health.

Contributorship statement

The paper topic and analytical approach were conceived of by PM. PM led the final drafting of the paper and helped guide the analysis. JH conducted the statistical analyses, and made major contributions to the revisions of the manuscript. DV drafted much of the first version of the paper, particularly the methods and results, and helped guide the analysis in collaboration with JH. All authors made substantial efforts in responding to reviewer comments.

Competing interests

The authors have no competing interests to disclose.

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Any opinions and conclusions expressed herein are those of the authors and do not necessarily reflect the views of the U.S. Census Bureau. All results have been reviewed to ensure that no confidential information is disclosed. The statistical summaries reported in this document have been cleared by the Census Bureau's Disclosure Review Board release authorization number CBDRB-FY19-366. This project was funded by the National Institute on Aging (5R01AG054466).

Data sharing statement

The National Longitudinal Mortality Survey (NLMS) is maintained by the United States Bureau of the Census and contains identified data. These data can be accessed only by certified personnel.

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Table 1. The Supplemental Earned Income Tax Credit (EITC) benefit by state and the year enacted.*

State	Year Enacted	Percent Addition to Federal EITC
California	2015†	85
Colorado	1999, 2013†	10
Connecticut	2011	30
Delaware	2005	20
District of Columbia	2000	40
Illinois	2000	10
Indiana	1999	9
Iowa	1989	15
Kansas	1998	17
Louisiana	2007	3.5
Maine	2000	5
Maryland	1987	25.5
Massachusetts	1997	23
Michigan	2006	6
Minnesota	1991	35
Nebraska	2006	10
New Jersey	2000	30
New Mexico	2007	10
New York	1994	30
Ohio	2013†	10
Oklahoma	2002	5
Oregon	1997	8
Rhode Island	1986	12.5
Vermont	1988	32
Virginia	2004	20
Washington	2000	10
Wisconsin	1989	11

*Details of implementation and variability by family size and year available from TAXSIM[24-25]

†Not included in analysis as having supplemental EITC because program implementation was after the period of our mortality follow-up.

Table 2: Descriptive statistics for lower-income adult person-years (ages 18-64 at initial interview) in the National Longitudinal Mortality Survey (NLMS), 1986-2011. (United States Bureau of the Census approval DRB approval number CBDRB-FY19-366.)

	Maximum follow up[1]		10-year follow up[1]		5-year follow-up[1]	
Variable	Mean	(SD(x)) SE(p)	Mean	(SD(x)) SE(p)	Mean	(SD(x)) SE(p)
Age at person-year	43.2	(13.5)	41.6	(13.2)	40.5	(13.2)
Female (%)	52.5	0.03	52.2	0.03	52.0	0.05
Married at interview (%)	47.5	0.03	46.5	0.03	45.8	0.04
Race/ethnicity:						
Hispanic (%)	15.1	0.02	15.9	0.02	16.5	0.03
White (%)	65.5	0.03	64.3	0.03	63.5	0.04
Black (%)	15.1	0.02	15.2	0.02	15.3	0.03
Native American (%)	0.87	0.004	0.88	0.005	0.86	0.007
Asian/ Pacific Islander (%)	3.5	0.010	3.7	0.013	3.8	0.016
Highest educational attainment at time of interview:						
No high school diploma (%)	20.1	0.02	19.8	0.03	19.3	0.03
High school diploma (%)	37.7	0.03	37.0	0.03	36.5	0.04
Some college education (%)	26.6	0.03	27.3	0.03	27.7	0.04
College degree or higher (%)	15.6	0.02	16.0	0.03	16.4	0.03
Family income at time of interview $2015; (mean, SD)	40,500	(22,500)	40,000	(22,500)	39,500	(22,500)
Family income, $2015 (as natural log. of income at time of interview; mean, (SD))	10.2	(1.8)	10.1	(1.8)	10.1	(1.9)
Employment status at time of interview:						
Employed	68.0	0.03	67.6	0.03	66.9	0.04
Unemployed	11.2	0.02	11.9	0.03	12.7	0.03
Not in labor force	20.8	0.02	20.5	0.03	20.4	0.04
Receiving State EITC (%)[1]	27.8	0.03	27.2	0.03	27.3	0.04
Federal EITC receipts (in $100 units; mean, (SD))[1]	14.8	(13.0)	15.9	(14.1)	16.3	(14.5)
State EITC receipts (in $100 units; mean (SD))[1]	3.26	(4.06)	3.29	(4.13)	3.32	(4.18)
Sample size (person-years) [2]	8,820,000		5,960,000		3,530,000	
Sample size (respondents) [2]	793,000		793,000		793,000	

Number of deaths [2]	48,000	24,000	12,000

Note: results weighted to be representative of the 0-64 U.S. population in 2015.
[1]SD = standard deviation; SE = standard error; EITC = Earned Income Tax Credit.

For Tmax: Conditional means for <fed_eitc> on 2.250,000 PY (206,000 persons), conditional means for <st_eitc> on 281,000 PY (42,500 persons). [Correlation is 0.285 among Fed. EITC recipients.]

For T10: Conditional means for <fed_eitc> on 1,540,000 PY (206,000 persons), conditional means for <st_eitc> on 246,000 PY (42,500 persons). [Correlation is 0.291 among <fed_eitc> recipients.]

For T05: Conditional means for <fed_eitc> on 912,000 PY (206,000 persons), conditional means for <st_eitc> on168,000 PY (42,500 persons). [Correlation is 0.301 among <fed_eitc> recipients.]

[2]Sample counts are rounded according to the U.S. Census Bureau Disclosure Review Board Disclosure Avoidance Guidelines.
Note: The statistics in this table have been cleared by the Census Bureau's Disclosure Review Board with release authorization number CBDRB-FY19-366.

Table 3: Cox proportional hazard models of supplemental EITC's impact on mortality risk for lower-income adults for adult person-years (ages 18-64) in the NLMS, 1986-2011. (United States Bureau of the Census approval DRB approval number CBDRB-FY19-366.)

	Maximum follow-up		10-year follow-up		5-year follow-up	
Variable	Hazard ratio	95% CI	Hazard ratio	95% CI	Hazard ratio	95% CI
Age at person-year (years)	1.071***	1.070-1.073	1.067***	1.066-1.069	1.064***	1.062-1.066
Female	0.595***	0.576-0.614	0.593***	0.571-0.616	0.586***	0.559-0.614
Married at time of interview	0.692***	0.669-0.715	0.685***	0.658-0.712	0.686***	0.653-0.720
Race/ethnicity (White, non-Hispanic is referent):						
Hispanic	0.588***	0.550-0.629	0.590***	0.546-0.638	0.600***	0.547-0.659
Black	1.086**	1.039-1.135	1.091***	1.037-1.149	1.085*	1.019-1.156
Native American	1.26***	1.10-1.45	1.28**	1.10-1.49	1.30**	1.08-1.56
Asian/ Pacific Islander	0.578***	0.509-0.657	0.579***	0.500-0.670	0.580***	0.486-0.691
Highest educational attainment at time of interview (High school diploma is referent):						
No high school diploma	1.111***	1.070-1.154	1.087***	1.039-1.137	1.072*	1.013-1.134
Some college education	0.889***	0.850-0.929	0.887***	0.842-0.934	0.884***	0.829-0.941
College degree or higher	0.701***	0.659-0.746	0.713***	0.663-0.767	0.729***	0.667-0.796
Family income, 2015 dollars (as natural log. of income at time of interview)	0.986***	0.977-0.995	0.988*	0.978-0.998	0.989^{NS}	0.977-1.001
Employment status at time of interview (Employed is referent):						
Unemployed	3.20***	3.06-3.34	3.47***	3.30-3.6	3.78***	3.56-4.01
Not in labor force	1.79***	1.72-1.86	1.91***	1.82-2.00	2.03***	1.91-2.15
Earned Income Tax Credit (EITC) in $100 units of 2015$						

Federal EITC	1.003*	1.001-1005	1.002[NS]	1.000-1.005	1.002[NS]	0.999-1.005
State EITC	0.979*	0.959-0.999	0.973*	0.951-0.996	0.968*	0.941-0.995
Sample size (N=person-years) [1]	8,820,000		5,960,000		3,530,000	

All three Cox proportional hazard models include state fixed-effects corrections (state HRs not shown), and time-trends based on the year of the respondent's ACS interview.

* p<0.05, ** p<0.01, *** p<0.001

[1] Sample counts are rounded according to the U.S. Census Bureau Disclosure Review Board Disclosure Avoidance Guidelines. All models included N=793,000 respondents.

[NS] Not statistically significant at p <= 0.05.

Note: The statistics in this table have been cleared by the Census Bureau's Disclosure Review Board with release authorization number CBDRB-FY19-366.

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7
Bias	9	Describe any efforts to address potential sources of bias	11
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	NA
		(*c*) Explain how missing data were addressed	4
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	6
		(*e*) Describe any sensitivity analyses	

Continued on next page

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	4
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6
		(b) Indicate number of participants with missing data for each variable of interest	NA
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	7
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	*10*
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	*NA*
		Cross-sectional study—Report numbers of outcome events or summary measures	*NA*
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10
		(*b*) Report category boundaries when continuous variables were categorized	NA
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13
Generalisability	21	Discuss the generalisability (external validity) of the study results	11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Can Antipoverty Programs Save Lives? Quasi-experimental evidence from the Earned Income Tax Credit in the United States

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Abstract

Objective: To estimate the impact of state-level supplements of the Earned Income Tax Credit (EITC) on mortality in the United States. The EITC supplements the wages of lower-income workers by providing larger returns when taxes are filed.

Setting: Nationwide sample spanning 25 cohorts of people across every state in the United States

Participants: 793,000 respondents within the National Longitudinal Mortality Survey (NLMS) between 1986-2011, a representative sample of the United States.

Intervention: State-level supplementation to the EITC program. Some, but not all, states added EITC supplementation to varying degrees beginning in 1986 (Wisconsin) and most recently in 2015 (California). Participants who were eligible in states with supplementary programs were compared with those who were not eligible for supplementation. Comparisons were made both before and after implementation of the supplementary program (a difference-in-difference, intent-to-treat analysis). This quasi-experimental approach further controls for age, gender, marital status, race or ethnicity, educational attainment, income, and employment status.

Primary and secondary outcome measure: the primary outcome measure was survival at 10 years. Secondary outcome measures included survival at 5 years and survival to the end of the intervention period.

Results: We find an association between state supplemental EITC and survival, with a hazard ratio of 0.97 (95% confidence interval = 0.951-0.996) for each $100 of EITC increase ($p<0.05$). **Conclusion:** State-level supplemental EITC may be an effective means of increasing survival in the US.

Strengths and limitations of this study

- We use a quasi-experimental design (difference-in-difference with intent-to-treat), which allows for stronger inference than an associational study
- We utilize the largest health dataset in the United States, which allows us to study individual-level impacts on mortality, a definitive health outcome, over many decades
- We use a powerful identification strategy that allows us to identify individuals who were eligble for the program that we evaluate and those who are not
- Nevertheless, it is possible that states that become rich can subsequently afford other health-producing investments, and these changes in state-level wealth could explain our observed effects

Introduction

In the US life expectancy has declined relative to other nations for decades as lower wages and higher health costs have reduced disposable income for households below the US median for earnings [1-3]. One policy that has promise to address declining income, and potentially declining health, is the Earned Income Tax Credit (EITC). The EITC is designed to supplement earnings in lower-paying jobs by providing a monetary credit to low-income workers who file taxes. This program has the effect of restoring some of the disposable income lost to lower-income households as high paying factory jobs have disappeared in the United States, thereby potentially also restoring health [4].

The EITC is the largest means-tested anti-poverty program in the United States [5]. Historically it has received broad bipartisan support, having been created under President Ford in 1975, and subsequently expanded during the terms of Presidents Clinton, Bush, and Obama [6].

Poverty is associated with a greater burden of disease than smoking and obesity combined in the US [7 8]. Poverty takes a toll on health by increasing one's risk of environmental exposures (e.g., living near freeway intersections or living in housing with peeling lead paint) and reducing purchasing power (e.g., of healthy food or out-of-pocket medical expenses) [4]. Likewise, EITC can increase employment, which is also associated with decreased mortality (possibly because it can increase access to employer-based health insurance, health savings accounts, and social capital) [9-12]. However, the largest health effects associated with EITC are now believed to arise from incremental changes in psychological stress, which causes the release of glucocorticoids that damage neural

structures associated with executive function, memory, and homeostatic processes, such as the regulation of blood sugar and blood pressure.[10 13-18]

Glucocorticoids are meant to increase survival among our hunter-gatherer ancestors by diverting glucose and oxygen from the brain and reproductive organs to muscles, allowing us to flee predators.[19 20] Modern-day society, unfortunately, is filled with stressors that activate these primitive, neurotoxic systems, leading to hypertension, obesity, and interfering with health behaviors.[18]

Notably, even small increases in income support among low-income households can lead to increased short-term perceived financial security even if the gains are too small to increase savings (and therefore demonstrable financial security).[10 21 22] Financial security may be one of the most important determinants of stress among low-income households.[16 23-26]. By alleviating poverty, the EITC may also serve as a tool for reducing premature mortality in the US.[9 25]

The hypothesis that EITC might reduce premature mortality is generally supported by previous research, however some studies have shown null findings while at least one other has shown an increase in obesity associated with EITC [27-35]. Therefore, there is reasonable uncertainty as to whether the program improves health, and there is a strong need for more causal research. Because some states have supplemented federal EITC and some have not, this invites a quasi-experimental analysis in which natural variation in state policies can be used to estimate the impact of state-level supplemental EITC on health or survival. However, to our knowledge, there is only one dataset that is capable of identifying large numbers of individuals who are eligible for EITC by their state of residence that also

provides longer-term follow up of their survival effects—the National Longitudinal Mortality Survey (NLMS).[36]

The size of the EITC tax credit varies considerably by family size and marital status. While an adult with no children can earn up to $400 at tax time, single parent with 3 children can earn over $6,000. When EITC-eligible individuals are identified, it becomes possible to increase the accuracy of the analysis and to remove confounding of survival outcomes associated with emigration of healthier individuals to wealthier states [37 38]. Long-term follow up for survival is necessary because EITC-eligible individuals and families tend to be under age 65 and employed, and therefore tend to be healthier. The benefit of reduced exposure to poverty in early- and middle-aged adults is only likely to manifest after the age of 65 [39].

The NLMS is the largest mortality survey in the US, and allows us to conduct a targeted and comprehensive examination of the impact of state-level supplemental EITC on survival. Others have examined variation by family size [28-31 40] and by state level of supplementation [34]. However, these analyses are limited by assumptions necessary when using smaller and less detailed datasets.

A particular problem faced by some previous quasi-experimental analyses is that it was necessary to look at aggregate state-level effects (e.g., among those with family incomes close to the poverty line) rather than effects among individuals with a high-probability of EITC receipt. By using the very large and detailed NLMS, administered by the Census Bureau, we are able to identify individuals likely to receive supplemental EITC and to explore dose-response effects within a quasi-experimental design. According to NLMS

and Census Bureau officials, ours is the first study to use longitudinal mortality data from the NLMS to assess the impacts of state-level supplemental EITC on survival.

Methods

Overview

We use survival models to estimate the impact of state-level supplemental EITC on survival. The time frame for our analysis is 1986-2011, with mortality follow-up through the end of 2011. During that time frame, federal and state EITC policies regarding eligible incomes and size of the tax credit changed considerably (Table 1). The tax years we analyzed were from 1985 to 2010, as the EITC rate applied to tax year *t* income would benefit the family income in year *t+1*. Non-recipients were excluded from the analysis.

Each respondent's record in our data set is recorded in person-years, extending from their year of CPS/ASEC interview for the NLMS to their year of exit by death or by reaching the end of mortality follow up at the end of 2011. We limited our analysis to individuals under the age of 65 because many Americans will have retired by then and are ineligible for EITC. However, mortality follow up extends beyond this window. A 64-year-old at the time of survey would be followed to 69, 74, or until December 31, 2011 depending on the analysis used.

Patient and Public Involvement

There was no patient involvement in this study.

Data

While the NLMS contains multiple census data sources, the primary source of data is from the March Annual and Social Economic Supplements of the Current Population Survey. This supplement is an annual survey designed to collect detailed information about income, migration, health insurance, and a broader range of general economic data for persons aged 15 years and over. Roughly 60,000 households are interviewed annually in the March CPS. In that survey, one member of each household provides information for all family members.

The March CPS and NLMS are weighted and standardized to be reflective of the US population. The NLMS currently consists of approximately 3.8 million records with over 560,000 identified deaths up through December 31, 2011.[41] We use 793,000 records of adults aged 18-64 over 26 years (1986-2011, all years were included in our analysis). These data were weighted to be representative of the U.S. population under age 65 at the time of interview. The NLMS data from CPS/ASEC is linked to U.S. death certificates collected by the National Center for Health Statistics via the National Death Index (NDI).

Income cutoffs for supplemental EITC eligibility vary by state. Our information on state EITC cutoffs and eligibility for tax credits comes from source documents generously provided to us by TAXSIM [42 43]. We also added information from the Minnesota Working Family Credit from 1998 to 2010 [44], which differs somewhat from credits offered by other states.

Variables

Eligibility for EITC and the size of the tax credit received by eligible households, were estimated using reported family income, marital status, number of children, and the

rules for supplemental EITC eligibility within each state. We use the March CPS to determine the number of children in each household, the marital status of the householders, and the inflation-adjusted household income. We then determine whether a household is eligible for EITC at the federal level as well as the additional credit, if any, for any given state.

Some identification problems that remain: (1) we don't know if the head of household is consistently employed (and thus eligible to claim EITC); (2) how many years of state EITC exposure a given family had, because of (a) moving, (b) divorce, (c) changes in number of kids, or (d) pay raises at work; (3) we were unable to estimate the effects of total EITC exposure over time based on the year the state adopted EITC (due to multicollinearity between year of supplemental EITC adoption and other control variables in the model).

The exposure variables of interest for the survival models are the estimated EITC receipts – "Federal EITC" and "state EITC" – in respondent year (*t*) from family income earned in year *t-1*, as reported in the interview in year *t*. The EITC receipts are calculated from the tax-year specific formulas from TAXSIM, and are applied to the subsequent person-year observation. Both the "Federal EITC" and "state EITC" receipts are divided into $100 units to help with the presentation of parameter estimates from the regressions. The EITC receipts are converted into constant $2015 using the Consumer Price Index (CPI). 2015 was used as a year of reference as this was the year in which the variable was created.

To adjust for personal characteristics, we include control variables for (a) age at person-year, (b) sex, (c) marital status, (d) race or ethnicity, (e) educational attainment, (f) income, and (g) employment status in addition to the state and Federal EITC measures.

Other than age, income, and EITC receipts, these variables are measured as binary indicators. The descriptive statistics for the proportions of those indicators are shown in Table 2 along with the means of the continuous variables. The central tendency is expressed as standard deviations (SD) of the continuous variables (SD (x)), and as standard errors (SE) for the proportion (SE (p)).

The categories for sex are male (reference group) and female. For marital status they are married (reference group) and not married, which includes widows, divorcees, separated persons, and the never married. The categories for race and ethnicity are Hispanic, White non-Hispanic (reference group), Black non-Hispanic, American Indian/Alaskan Native non-Hispanic, and Asian/Pacific Islander non-Hispanic. The categories for educational attainment are college degree, some college, high school diploma (reference group), and no diploma. The categories for employment are employed (reference group), unemployed, and "not in labor force." These binary indicators are assigned to each person based on their response at their CPS/ASEC interview (at baseline) and are used through all person-years. These demographic characteristics are liable to change as a result of exposure to EITC.

Family incomes are asked during their CPS/ASEC interview. The dollar amount at the time of interview is adjusted to the CPI-adjusted purchasing power of the person-year for calculation of nominal EITC receipts. Both the family income and EITC receipts are then adjusted to year 2015 dollars in the regression to keep purchasing power constant across the range of the time series. We calculated the state EITC benefits received using income, marriage, and number of children. The maximum income for inclusion in the regression

sample also controlled for these variables and the Federal EITC income thresholds for various family situations.

To correct for the right-skewed distribution of income, we use the natural logarithm for the variable and assign the value of zero when income is zero or negative. The regression uses age at person-year instead of age at interview in order to properly adjust for age-relative hazards of mortality.

Model specification

We use Cox proportional hazards models (with state level fixed effects and errors clustered at the primary sampling unit) to estimate the impact of state-level EITC generosity on 5-year, 10-year, and maximum survival among adults (ages 18-64) between 1986 and 2011. State-level fixed effects, coupled with the use of constant (inflation-adjusted) $2015 dollars, are used to address differences between cohorts at each CPS year of interview. Assumptions for proportionality are met.

We used a difference-in-difference model with an intention-to-treat design, assessing mortality according to people's eligibility for EITC on a state-by-state basis. While eligibility will diverge from receipt of EITC funds, this design is the best way to assess the efficacy of the EITC program as it actually exists; discordance between the program's intended and actual recipients represents an important shortcoming in the program.

Selecting a length of follow-up time over which to measure EITC's effects on survival presents a conflict; shorter follow-up times are unlikely to capture EITC's effects on chronic disease and other conditions that may impact long-term survival. However, longer follow-up times introduce more uncertainty about possible changes in the socioeconomic status of

the participants in our sample. Because individuals' incomes, household sizes, marital status, and states of residence are known only at the time of interview in the Current Population Survey, we do not know how social and demographic variables change over time.

We elected to use 10-year survival rates as our primary outcome measure because it represents a reasonable window for both capturing differences in survival between groups, and for minimizing error in our identification of EITC eligibility due to changes in family income, marital status, or family size (which are increasingly likely with a longer follow-up window). As a sensitivity analysis, we also estimated models with a shorter follow-up window (using 5-year survival as the model outcome) as well as models with a longer follow-up window (using survival rates over the entire follow-up period available for each respondent in the NLMS).

Our set of person-year records consists of those records with "age at interview" of at least 18 years, and extending up through either (a) "age at person year" of 64 years, (b) the year of death (with "failure"=1), or (c) end of follow up at 2011. An additional inclusion rule includes only respondents with estimated family income that is less than twice the maximum Federal EITC income allowed for the respondent's family size. This income limit is to eliminate any possible regression distortions caused by observations on high-income individuals, who may have a different mortality risk pattern than the lower-income respondents we wish to analyze.

All models use the NLMS person weights, which are divided and distributed among the person-years of the individual. The results of the models report the hazard ratios of mortality for deviations of each independent variable relative to the reference respondent

person-year, which would be (a) at the mean age at person-year, (b) male (c) married, (d) white non-Hispanic, (e) with a high school diploma, (f) with the average (logged) family income, and (g) employed, with zero dollars received from Federal or state EITC.

Results

In interpreting these results, it is important to consider that our final models differed from their original specification. First, in the original specification, we did not control for state-level fixed effects. State-level fixed effects were added to control for differences in state-level policies that might correlate with state EITC benefits. Second, we had initially used a binary indicator to indicate state EITC receipt. Finally, it was recommended that we use $100 increments as a tangible unit of measure because some recipients less than $100 while others might receive thousands of dollars.

There was significant variation in EITC generosity by state, and there was also a good deal of variation in the time of program implementation (Table 1). Our analytic sample included 793,000 adults aged 18-64 from all 50 states and Washington D.C. Summary statistics for the analytic sample are presented in Table 2.

Table 3 shows the results of three Cox proportional hazards regressions. The functional form of, and covariates within, all three regressions is the same but the follow up time differs (5-years, 10-years, and maximum). Our control variables show associations with mortality that are statistically significant at $p<0.001$ and consistent with previous research.[36] For example, mortality risk declines with income and employment but increases with age (Table 3). Females have a lower mortality risk than males, and Blacks have a much higher risk than Whites. Asians have the lowest mortality risk of any group.

State EITC receipt is statistically-significant in all three models with a hazard ratio (HR) = 0.973 (95% confidence interval [CI] = 0.951-0.996) for the 10-year follow up model. Mortality hazards increased slightly as follow-up time increased (from 0.968 for the 5-year follow up model [95% CI = 0.941-0.995] to 0.979 for the maximum follow up [95% CI = 0.959-0.999]. Federal EITC shows a small but statistically-significant increase in mortality hazards in maximal follow up (1.003, 95% CI = 1.001-1005).

Discussion

In this study, we examine the survival impact of state-level supplements to EITC using a quasi-experimental design and individual-level data for 793,000 adults aged 18-64. After adjusting for age, sex, race, education, family income, and employment status, we find evidence for mortality benefits conferred by state-level supplemental EITC.

A hazard ratio of 0.97 over a 10-year period of follow-up corresponds to an increase in life expectancy of roughly 2 weeks for every $100 of state-level EITC supplementation (in constant 2015 US dollars).[45] The results of a recent randomized-controlled trial (RTC) suggests that the average eligible recipient might receive hundreds of dollars in benefits per year, suggesting that the program has the potential to meaningfully improve population health.[8 35]

We also find very small negative impacts from the Federal EITC in one of the three models (a 0.3% increase in hazards). We cannot rule out statistical artifact (collinearity with state EITC receipts, partially systematic residuals over income that ln(income) does not address, an imperfect control for state fixed effects). However, it is also possible that once state-level benefits are controlled for we are picking up the hazards associated with

employment (e.g., accidents while commuting or on the job) that are independent of the credits themselves.

Strengths and limitations

Our study explores temporal and spatial variation in outcome measures across states as well as dose-response effects across individuals. The NLMS affords a very large sample size, long-term mortality follow-up, and information on EITC eligibility at the individual level, providing a good deal of resolution relative to a previous study that examined aggregate state-level effects.[46] Moreover, because the sample size is very large and the NDI covers all states, it is possible to identify individual-level effects, and to do so irrespective of where the individual died. We were able to identify those participants who were eligible for EITC using TAXSIM, and to compare across states that did and did not have supplemental programs. Our study is consistent with previous studies, which showed that, while EITC receipt may be a risk factor for obesity, overall health and survival benefits have been noted [27-33 35 40].

However, our study is subject to a number of important limitations. First, it is difficult to precisely estimate the survival benefit associated with EITC because we were unable to quantify the number of years that any given participant was exposed to the credit. Moreover, while quasi-experimental in nature, there could be state-level factors that confound estimates (e.g., states with EITC supplementation may also offer other social welfare programs, offer fewer worker protection regulations, or be more likely to receive healthy migrants from other states). On the other hand, Federal regulations have disproportionately benefited poorer states that are less likely to implement supplemental EITC because these states have historically been high risk, low regulation. Despite the

potential for states to implement EITC in ways that may also correlate with mortality, our quasi-experimental design coupled with controls for income and employment produces estimates that should have a much higher degree of internal validity than associational studies.

Additionally, our results include both states with refundable tax credits and non-refundable tax credits. While we know which states offer refundable or non-refundable credits, we simply don't know enough about individual household deductions or eligibility for other credits to know when non-refundability is a constraining limit or not, or how large a portion of the credit is retained by the state (on average) when there are non-refundability rules. What we do know is that non-refundable credits mean that our calculated benefits represent the top-level estimate of state EITC receipts, so that our test for a significant effect (possibly from a smaller number of state EITC benefit dollars) is conservative (that is, less likely to produce a low p-value). Finally, in a related limitation, we only observe EITC receipt in the year that the participant was interviewed, but record deaths no matter which state they occurred in. To the extent that a participant moved from a state with benefits to one without (or vice versa), the signal in our estimate is weakened, again rendering the estimate more conservative.

Conclusions

While the EITC is an effective anti-poverty program, it tends to provide fairly modest income support [8]. These modest program effects may be offset by the fact that the vast majority of people who apply for EITC remain on EITC for many years [47]. The cumulative effects the income support provided by EITC over the years may therefore add

up to survival benefits over time. Nevertheless, a recent RCT showed that just three years of exposure to supplemental income from EITC can produce measurable impacts on health-related quality of life, at least among females.[26]

Our findings are important from a policy perspective. There is now reasonable evidence that America's declining health and life expectancy are related to the declining fortunes of lower- and middle-class families.[48] While some of the decline must be addressed with structural changes to the health system[3] and other anti-poverty policies,[25 49] we find encouraging evidence that expanding the EITC could produce significant benefits for health.

Contributorship statement

The paper topic and analytical approach were conceived of by PM. PM led the final drafting of the paper and helped guide the analysis. JH conducted the statistical analyses, and made major contributions to the revisions of the manuscript. DV drafted much of the first version of the paper, particularly the methods and results, and helped guide the analysis in collaboration with JH. All authors made substantial efforts in responding to reviewer comments.

Competing interests

The authors have no competing interests to disclose.

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Data sharing statement

The National Longitudinal Mortality Survey (NLMS) is maintained by the United States Bureau of the Census and contains identified data. These data can be accessed only by certified personnel.

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Table 1. The Supplemental Earned Income Tax Credit (EITC) benefit by state and the year enacted.*

State	Year Enacted	Percent Addition to Federal EITC
California	2015†	85
Colorado	1999, 2013†	10
Connecticut	2011	30
Delaware	2005	20
District of Columbia	2000	40
Illinois	2000	10
Indiana	1999	9
Iowa	1989	15
Kansas	1998	17
Louisiana	2007	3.5
Maine	2000	5
Maryland	1987	25.5
Massachusetts	1997	23
Michigan	2006	6
Minnesota	1991	35
Nebraska	2006	10
New Jersey	2000	30
New Mexico	2007	10
New York	1994	30
Ohio	2013†	10
Oklahoma	2002	5
Oregon	1997	8
Rhode Island	1986	12.5
Vermont	1988	32
Virginia	2004	20
Washington	2000	10
Wisconsin	1989	11

*Details of implementation and variability by family size and year available from TAXSIM[24-25]

†Not included in analysis as having supplemental EITC because program implementation was after the period of our mortality follow-up.

Table 2: Descriptive statistics for lower-income adult person-years (ages 18-64 at initial interview) in the National Longitudinal Mortality Survey (NLMS), 1986-2011. (United States Bureau of the Census approval DRB approval number CBDRB-FY19-366.)

	Maximum follow up[1]		10-year follow up[1]		5-year follow-up[1]	
Variable	Mean	(SD(x)) SE(p)	Mean	(SD(x)) SE(p)	Mean	(SD(x)) SE(p)
Age at person-year	43.2	(13.5)	41.6	(13.2)	40.5	(13.2)
Female (%)	52.5	0.03	52.2	0.03	52.0	0.05
Married at interview (%)	47.5	0.03	46.5	0.03	45.8	0.04
Race/ethnicity:						
Hispanic (%)	15.1	0.02	15.9	0.02	16.5	0.03
White (%)	65.5	0.03	64.3	0.03	63.5	0.04
Black (%)	15.1	0.02	15.2	0.02	15.3	0.03
Native American (%)	0.87	0.004	0.88	0.005	0.86	0.007
Asian/ Pacific Islander (%)	3.5	0.010	3.7	0.013	3.8	0.016
Highest educational attainment at time of interview:						
No high school diploma (%)	20.1	0.02	19.8	0.03	19.3	0.03
High school diploma (%)	37.7	0.03	37.0	0.03	36.5	0.04
Some college education (%)	26.6	0.03	27.3	0.03	27.7	0.04
College degree or higher (%)	15.6	0.02	16.0	0.03	16.4	0.03
Family income at time of interview $2015; (mean, SD)	40,500	(22,500)	40,000	(22,500)	39,500	(22,500)
Family income, $2015 (as natural log. of income at time of interview; mean, (SD))	10.2	(1.8)	10.1	(1.8)	10.1	(1.9)
Employment status at time of interview:						
Employed	68.0	0.03	67.6	0.03	66.9	0.04
Unemployed	11.2	0.02	11.9	0.03	12.7	0.03
Not in labor force	20.8	0.02	20.5	0.03	20.4	0.04
Receiving State EITC (%)[1]	27.8	0.03	27.2	0.03	27.3	0.04
Federal EITC receipts (in $100 units; mean, (SD))[1]	14.8	(13.0)	15.9	(14.1)	16.3	(14.5)
State EITC receipts (in $100 units; mean (SD))[1]	3.26	(4.06)	3.29	(4.13)	3.32	(4.18)
Sample size (person-years) [2]	8,820,000		5,960,000		3,530,000	
Sample size (respondents) [2]	793,000		793,000		793,000	

Number of deaths [2]	48,000	24,000	12,000

Note: results weighted to be representative of the 0-64 U.S. population in 2015.
[1]SD = standard deviation; SE = standard error; EITC = Earned Income Tax Credit.

For Tmax: Conditional means for <fed_eitc> on 2.250,000 PY (206,000 persons), conditional means for <st_eitc> on 281,000 PY (42,500 persons). [Correlation is 0.285 among Fed. EITC recipients.]

For T10: Conditional means for <fed_eitc> on 1,540,000 PY (206,000 persons), conditional means for <st_eitc> on 246,000 PY (42,500 persons). [Correlation is 0.291 among <fed_eitc> recipients.]

For T05: Conditional means for <fed_eitc> on 912,000 PY (206,000 persons), conditional means for <st_eitc> on168,000 PY (42,500 persons). [Correlation is 0.301 among <fed_eitc> recipients.]

[2]Sample counts are rounded according to the U.S. Census Bureau Disclosure Review Board Disclosure Avoidance Guidelines.
Note: The statistics in this table have been cleared by the Census Bureau's Disclosure Review Board with release authorization number CBDRB-FY19-366.

Table 3: Cox proportional hazard models of supplemental EITC's impact on mortality risk for lower-income adults for adult person-years (ages 18-64) in the NLMS, 1986-2011. (United States Bureau of the Census approval DRB approval number CBDRB-FY19-366.)

	Maximum follow-up		10-year follow-up		5-year follow-up	
Variable	Hazard ratio	95% CI	Hazard ratio	95% CI	Hazard ratio	95% CI
Age at person-year (years)	1.071***	1.070-1.073	1.067***	1.066-1.069	1.064***	1.062-1.066
Female	0.595***	0.576-0.614	0.593***	0.571-0.616	0.586***	0.559-0.614
Married at time of interview	0.692***	0.669-0.715	0.685***	0.658-0.712	0.686***	0.653-0.720
Race/ethnicity (White, non-Hispanic is referent):						
Hispanic	0.588***	0.550-0.629	0.590***	0.546-0.638	0.600***	0.547-0.659
Black	1.086**	1.039-1.135	1.091***	1.037-1.149	1.085*	1.019-1.156
Native American	1.26***	1.10-1.45	1.28**	1.10-1.49	1.30**	1.08-1.56
Asian/ Pacific Islander	0.578***	0.509-0.657	0.579***	0.500-0.670	0.580***	0.486-0.691
Highest educational attainment at time of interview (High school diploma is referent):						
No high school diploma	1.111***	1.070-1.154	1.087***	1.039-1.137	1.072*	1.013-1.134
Some college education	0.889***	0.850-0.929	0.887***	0.842-0.934	0.884***	0.829-0.941
College degree or higher	0.701***	0.659-0.746	0.713***	0.663-0.767	0.729***	0.667-0.796
Family income, 2015 dollars (as natural log. of income at time of interview)	0.986***	0.977-0.995	0.988*	0.978-0.998	0.989^{NS}	0.977-1.001
Employment status at time of interview (Employed is referent):						
Unemployed	3.20***	3.06-3.34	3.47***	3.30-3.6	3.78***	3.56-4.01
Not in labor force	1.79***	1.72-1.86	1.91***	1.82-2.00	2.03***	1.91-2.15
Earned Income Tax Credit (EITC) in $100 units of 2015$						

Federal EITC	1.003*	1.001-1005	1.002[NS]	1.000-1.005	1.002[NS]	0.999-1.005
State EITC	0.979*	0.959-0.999	0.973*	0.951-0.996	0.968*	0.941-0.995
Sample size (N=person-years) [1]	8,820,000		5,960,000		3,530,000	

All three Cox proportional hazard models include state fixed-effects corrections (state HRs not shown), and time-trends based on the year of the respondent's ACS interview.

* p<0.05, ** p<0.01, *** p<0.001

[1] Sample counts are rounded according to the U.S. Census Bureau Disclosure Review Board Disclosure Avoidance Guidelines. All models included N=793,000 respondents.

[NS] Not statistically significant at p <= 0.05.

Note: The statistics in this table have been cleared by the Census Bureau's Disclosure Review Board with release authorization number CBDRB-FY19-366.

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7
Bias	9	Describe any efforts to address potential sources of bias	11
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	NA
		(*c*) Explain how missing data were addressed	4
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	6
		(*e*) Describe any sensitivity analyses	

Continued on next page

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	4
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6
		(b) Indicate number of participants with missing data for each variable of interest	NA
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	7
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	*10*
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	*NA*
		Cross-sectional study—Report numbers of outcome events or summary measures	*NA*
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10
		(*b*) Report category boundaries when continuous variables were categorized	NA
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13
Generalisability	21	Discuss the generalisability (external validity) of the study results	11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.