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Socioeconomic Inequalities in the Economic Burden of Chronic Diseases: Evidence from NHANES 2011–2018

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Abstract:

Chronic noncommunicable diseases impose substantial and unequally distributed financial pressure on households, yet evidence on how income scarcity interacts with chronic disease complexity to shape the economic burden remains limited. This study analyzes nationally representative data to quantify whether the financial burden borne by adults with multimorbidity rises disproportionately at the lower end of the income distribution. Leveraging NHANES 2011–2018 for sociodemographic and clinical profiles and MEPS for annual medical spending, we estimate a survey-weighted log-expenditure model in MEPS that includes an income × disease interaction and then map the coefficients to NHANES individuals to obtain predicted annual expenditure; we compute the expenditure-to-income ratio (EIR), catastrophic spending at 10% and 20% of income, EIR quantiles, and Gini coefficients to profile affordability and concentration. Results show a clear two-dimensional gradient: within each disease stratum, EIRs are systematically higher in lower-income groups, and within each income stratum, EIRs increase from no chronic disease to single condition and then to multimorbidity; the lowest-income adults with multimorbidity exhibit the highest catastrophic-spending prevalence and the most unequal expenditure distributions. The interaction terms are jointly significant, indicating compounding disadvantage at the intersection of low income and multimorbidity. These findings underscore the need to pair integrated multimorbidity management with income-linked financial protection so that recurrent out-of-pocket outlays do not translate into unsustainable household burdens.

Keywords: Chronic disease; Multimorbidity; Health expenditure; Expenditure-to-income ratio; Inequality

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1. Introduction

Chronic non-communicable diseases (NCDs), including hypertension, diabetes, cardiovascular disease, chronic kidney disease, and chronic respiratory conditions, represent the leading contributors to morbidity, disability, and mortality worldwide. According to the World Health Organization, NCDs are responsible for approximately 71% of global deaths, and their burden continues to rise in both developed and developing countries [1]. Beyond their clinical consequences, NCDs generate considerable economic strain on health systems, households, and societies. In high-income countries such as the United States, nearly half of all adults are diagnosed with at least one chronic condition, and an increasing proportion live with multimorbidity, defined as the coexistence of two or more chronic diseases [2]. The presence of multimorbidity compounds healthcare needs, elevates medical expenditures, and challenges existing health financing mechanisms [3].

The economic burden of NCDs is substantial and unevenly distributed. A recent report from the Centers for Disease Control and Prevention (CDC) estimated that 90% of the United States' annual healthcare spending is attributable to individuals with chronic and mental health conditions [4]. Such costs arise from long-term medication use, outpatient visits, frequent hospitalizations, and post-acute rehabilitation services. However, not all households bear this burden equally. Evidence shows that lower-income populations face higher relative financial stress, with out-of-pocket costs consuming a disproportionately larger share of limited income [5]. Consequently, socioeconomic inequalities exacerbate health disparities, and vulnerable groups are more likely to face catastrophic healthcare expenditures and forego necessary treatments.

The link between multimorbidity and financial burden has been well documented in prior studies. Salive emphasized that older adults with multiple chronic conditions have elevated risks of hospitalization, functional decline, and long-term care use, all of which substantially raise healthcare costs [6]. Wong and colleagues demonstrated that patients with multimorbidity incur significantly higher healthcare expenditures compared with those managing a single chronic disease [7]. More recent work has further suggested that multimorbidity not only increases absolute costs but also disproportionately affects economically disadvantaged households, magnifying inequality [8]. Yet relatively few studies have explored the joint effects of multimorbidity and household income on financial burden in nationally representative datasets, leaving an important gap in the literature.

Several large-scale surveys, such as the Medical Expenditure Panel Survey (MEPS) and the National Health Interview Survey (NHIS), have been widely used to study the costs of chronic disease and socioeconomic disparities. While these datasets provide valuable information on expenditures, they often lack comprehensive biomarker data and detailed clinical information that allow for precise classification of chronic disease status. The National Health and Nutrition Examination Survey (NHANES), in contrast, integrates demographic, socioeconomic, self-reported, and laboratory-based health measures, providing a unique opportunity to assess how multimorbidity interacts with income levels in shaping healthcare expenditures [9]. By combining clinical indicators with expenditure and income data, NHANES allows for a more nuanced analysis of health and economic inequality.

The motivation for this study is twofold. First, while the absolute costs of chronic disease management are well documented, there is insufficient evidence on the relative burden borne by different income groups, particularly among adults living with multimorbidity. Second, understanding the intersection of socioeconomic status and chronic disease burden is crucial for designing equitable health financing strategies. To address this gap, we analyze nationally representative NHANES data from 2011–2020 to evaluate the economic burden of chronic diseases among U.S. adults. Specifically, this study seeks to determine: (1) whether multimorbidity significantly increases healthcare expenditures; (2) whether lower-income adults with multimorbidity face disproportionately higher expenditure-to-income ratios compared with higher-income counterparts; and (3) the extent to which socioeconomic inequality moderates the relationship between chronic disease status and healthcare costs.

In summary, this research contributes to the global discussion on health equity by providing empirical evidence from the U.S. context. While the study is based on U.S. data, the findings are relevant for other high-income countries confronting similar challenges of rising chronic disease prevalence and widening socioeconomic disparities. By highlighting the combined influence of multimorbidity and income inequality, this study provides insights for policymakers, researchers, and healthcare providers seeking to mitigate disparities and enhance financial protection for vulnerable populations.

2. Methods

2.1 Data source

Data for this study were assembled from two complementary, nationally representative surveys so that the covariates, the income construct, and the expenditure outcomes could be aligned in a coherent analytic framework.

The National Health and Nutrition Examination Survey (NHANES) 2011–2018, which comprises four two-year cycles covering the civilian, non-institutionalized United States population, provided person level sociodemographic information, self-reported health and chronic condition indicators, and insurance status gathered under a multistage stratified probability design. Adults aged eighteen years or older with interview data were included, and, following the NHANES analytic guidance, all descriptive estimation incorporated the design variables SDMVSTRA and SDMVPSU together with a pooled interview weight defined as WTINT2YR divided by four so that inference reflects the average adult population over the pooled period rather than any single cycle [9]. Because NHANES does not collect annual total medical expenditure, we complemented it with the Medical Expenditure Panel Survey Household Component Full Year Consolidated files for 2011 through 2018, which supply annual total expenditure, insurance, income, and region along with the design variables VARSTR and VARPSU and the person weights PERWTyyF, and we then fit an expenditure model on MEPS and applied the estimated coefficients to matched NHANES covariate profiles, thereby generating an individual level predicted annual expenditure for every NHANES adult. Household income used to form the expenditure to income ratio was derived inside NHANES from the family poverty income ratio INDFMPIR and the U.S. Department of Health and Human Services poverty guidelines for the forty-eight contiguous states plus the District of Columbia, matched by interview year and household size to preserve temporal comparability [10].

2.2 Data Preprocessing

Within NHANES, the Demographics, Medical Conditions, Health Insurance, and Health care Utilization or Access components were merged by respondent identifier to form a consistent adult analytic file, after which we constructed family size, assigned pooled interview weights as WTINT2YR divided by four, and created the income groups from INDFMPIR combined with the appropriate year specific poverty guideline for the observed household size. Records that lacked key covariates required for expenditure mapping or burden construction, such as age, sex, race or ethnicity, education, insurance, income or PIR, or the chronic disease indicators, were excluded from the corresponding analysis step, while descriptive tables used available case weighting so that sample size would remain maximized under the complex design. For MEPS, all adult records from the 2011–2018 Full Year Consolidated files were stacked and harmonized to mirror the NHANES covariates including age, sex, race or ethnicity, education, insurance, census region, and poverty level, and the dependent variable for modeling was the annual total medical expenditure, denoted TOTEXPyy. Given the well-known right skew of medical spending, subsequent regression used the natural logarithm of total expenditure, a specification that stabilizes variance and improves interpretability of multiplicative contrasts in line with standard recommendations [11].

2.3 Variable Definitions

Chronic disease status was summarized into three mutually exclusive categories to reflect the increasing complexity of long-term conditions in a parsimonious way, namely no chronic disease when none of the priority conditions was present, a single condition when exactly one was present, and multimorbidity when two or more were present. The priority set included hypertension, diabetes, coronary heart disease or myocardial infarction or other heart disease, stroke, asthma, emphysema or chronic obstructive pulmonary disease, hypercholesterolemia, cancer, and arthritis, and these indicators were constructed to be comparable across MEPS and NHANES so that the mapped model would retain clinical meaning. Income groups were defined as less than two hundred percent, two hundred to three hundred and ninety nine percent, and at least four hundred percent of the federal poverty line; in MEPS the grouping followed the percent of the poverty line variable POVLEV, whereas in NHANES we used the product of INDFMPIR and the year and household size specific poverty guideline to assign the same three level construct. Because annual total medical expenditure is not observed in NHANES, we treated expenditure as a predicted outcome: coefficients from the MEPS log expenditure model were applied to matched NHANES covariate profiles so that each adult received a predicted annual expenditure on the dollar scale after back transformation, while all covariates used as controls in regression and in descriptive summaries included age, sex, race or ethnicity, education, insurance coverage classified as any private, public only, or uninsured, and census region.

By defining disease complexity and income consistently across data sources and by treating expenditure as a mapped prediction, the analysis isolates the socioeconomic gradient while holding covariate definitions constant across surveys.

2.4 Statistical Analysis

The analysis proceeded in an integrated sequence that connected design-based description, model-based prediction, and distributional assessment into a single narrative that addresses both absolute levels and affordability. First,

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using NHANES pooled weights together with SDMVSTRA and SDMVPSU, we produced design-based summaries of demographics, insurance coverage, and initial burden indicators by the cross classification of income group and disease complexity, and we assessed differences with design appropriate t tests and Rao–Scott chi square tests so that inferences respected the multistage design. Second, on the pooled MEPS adult sample we estimated an ordinary least squares model for the logarithm of annual total expenditure, which included an explicit income by disease interaction and controls for age, sex, race or ethnicity, education, insurance, census region, and year fixed effects; estimation incorporated PERWTyyF together with robust standard errors that were consistent with the MEPS design defined by VARSTR and VARPSU, and the fitted coefficients were then applied to NHANES covariate profiles to obtain predicted annual expenditure for every NHANES adult with complete information. Third, on NHANES we computed the expenditure to income ratio as predicted annual expenditure divided by estimated household income with zero or negative income excluded, we summarized the prevalence of catastrophic spending at the conventional thresholds of at least ten percent and at least twenty percent of income, we reported weighted quantiles of the ratio including the median and the upper quartile within income by disease cells, and we characterized overall concentration of spending by the weighted Gini coefficient calculated for the full adult population and within income groups. Two sided tests with a nominal significance level of five percent and ninety five percent confidence intervals were used throughout, and the log specification for medical spending followed standard practice for skewed costs to aid interpretation in terms of percentage differences and to limit the influence of extreme values.

3. Results

3.1 Descriptive profile and the initial burden gradient

Considering adults pooled across years and applying the complex-survey design, the profile of socioeconomic and clinical risk factors aligns with the equity concerns motivating this study: low-income adults (<200% FPL) display markedly weaker financial protection, and once chronic illness emerges—especially multimorbidity—both annual outlays and the expenditure-to-income ratio (EIR) rise steeply; by contrast, high-income adults (≥400% FPL) combine near-universal insurance with low EIRs even when absolute spending is material. Baseline indicators in Table 1 summarize these gradients and motivate the interaction models below.

Table 1. Baseline characteristics and average burden (adults; weighted)

Income	Disease	Age mean (y)	Female (%)
200–399%	Multimorbidity	60.69	54.17
200–399%	No chronic	34.83	48.81
200–399%	Single	44.04	51.52
<200%	Multimorbidity	60.46	60.31
<200%	No chronic	33.32	52.85
<200%	Single	42.45	56.61
≥400%	Multimorbidity	60.62	46.63
≥400%	No chronic	38.12	50.44
≥400%	Single	47.77	48.99

Two regularities stand out and will recur in model-based estimates: for a given disease category, EIRs are systematically higher at lower income; and for a given income category, EIRs increase from no chronic disease to single condition and then to multimorbidity, with the steepest rises concentrated among low-income adults, foreshadowing compounding disadvantage.

3.2 Annual expenditure, EIR medians, and catastrophic thresholds

Because the social meaning of financial burden lies in affordability rather than nominal spending, this study reports the median annual total expenditure alongside median EIR values and the prevalence of catastrophic health spending at conventional thresholds (≥10% and ≥20% of income) [12]. Table 2 presents a consistent two-dimensional gradient: within each disease stratum, financial burden increases as income declines, whereas within each income stratum, burden intensifies with disease complexity. Notably,

among adults below 200% of the Federal Poverty Level (FPL) with multimorbidity, the median EIR reaches 0.26, and the catastrophic shares climb to 64.85% (≥10%) and 52.35% (≥20%), far exceeding the corresponding values among those above 400% FPL (0.04; 23.80%; 11.63%).

Table 2. Annual expenditure & EIR medians, and catastrophic shares (adults; weighted)

Income	Disease	Median expenditure ($)	EIR median
200–399%	Multimorbidity	3582	0.08
200–399%	No chronic	294	0.01
200–399%	Single	912	0.02
<200%	Multimorbidity	4208	0.26
<200%	No chronic	140	0.01
<200%	Single	666	0.04
≥400%	Multimorbidity	4072	0.04
≥400%	No chronic	575	0.00
≥400%	Single	1456	0.01

These cross-stratified medians and catastrophic shares reveal that income interacts strongly with disease complexity in shaping the economic burden of chronic illness. The disproportionate rise in EIR among low-income adults with multimorbidity indicates not only higher absolute costs but also lower capacity to absorb them, a hallmark of health financing inequity.

Together with Table 1, these medians illustrate how similar or modest differences in dollars convert into much larger shares of household resources at the bottom of the distribution, which is central to the equity interpretation of burden in chronic disease [13].

3.3 Adjusted associations: log-expenditure models with an income × disease interaction

We estimated survey-weighted ordinary least squares (OLS) models of log (total expenditure) including an income × disease interaction term, controlling for age, sex, race/ethnicity, education, insurance status, and region. Robust standard errors and survey weights were applied, following established procedures for nationally representative microdata (Table 3).

Table 3. OLS log (total expenditure): main effects and interactions (percent change, p-value)

Term	Percent change (%)	p	Term
disease_status_Multimorbidity	260.1	0	disease_status_Multimorbidity
disease_status_Single	45.1	1.022e-29	disease_status_Single
inc_grp_200–399%	-0.0	0.9886	inc_grp_200–399%
inc_grp_200–399%: disease_status_Multimorbidity	-13.8	3.707e-05	inc_grp_200–399%: disease_status_Multimorbidity
inc_grp_200–399%: disease_status_Single	-2.3	0.6031	inc_grp_200–399%: disease_status_Single
inc_grp_≥400%	14.6	6.715e-07	inc_grp_≥400%
inc_grp_≥400%: disease_status_Multimorbidity	-16.4	9.402e-08	inc_grp_≥400%: disease_status_Multimorbidity
inc_grp_≥400%: disease_status_Single	4.2	0.3244	inc_grp_≥400%: disease_status_Single

Three findings are salient. First, disease complexity dominates spending: relative to no chronic disease, single disease increases total expenditure by ≈45% and multimorbidity by around 260% (both $p<0.001$), consistent with prior work on multimorbidity and resource use. Second, the interaction terms are jointly significant and negative, indicating that the income-related spending differences widen far less at high income when complexity rises; substantively, multimorbidity carries smaller incremental penalties among high-income than low-income adults, reinforcing the compounding-disadvantage interpretation. Third, controls behave as expected—older age, coverage,

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education and regional/racial patterns each shift expenditures—echoing prior utilization–cost evidence.

To translate coefficients into levels, marginal predictions under a common covariate profile show a widening gradient as complexity rises: in no chronic disease, predicted dollars differ modestly across income; in single disease, the contrast grows; and under multimorbidity, low-income adults record the highest predicted dollars and, crucially, the highest EIR once income is accounted for, matching the catastrophic-spending patterns in Table 2.

3.4 Distribution of the burden: EIR quantiles and inequality metrics

To make affordability differences transparent, Table 4 presents weighted EIR quantiles. In < 200% FPL with multimorbidity, the median EIR is 0.26 and the 75th percentile reaches 0.85, meaning one quarter of individuals devote at least 85% of annual income to medical outlays; in ≥ 400% FPL with multimorbidity, the median is 0.04 and p75 = 0.09, illustrating a far flatter gradient among high-income adults. Complementing quantiles, inequality metrics show heavy concentration of outlays: the weighted Gini for total expenditure is 0.769 overall and higher in lower-income strata (Table 5), consistent with the episodic intensity of chronic care among financially fragile households.

Table 4. Weighted EIR quantiles by income × disease

Income	Disease	EIR p25	EIR p50
200–399%	Multimorbidity	0.02	0.08
200–399%	No chronic	0	0.01
200–399%	Single	0	0.02
<200%	Multimorbidity	0.07	0.26
<200%	No chronic	0	0.01
<200%	Single	0	0.04
≥400%	Multimorbidity	0.01	0.04
≥400%	No chronic	0	0
≥400%	Single	0	0.01

Table 5. Gini coefficients for annual total expenditure (adults; weighted)

Income group	Gini (TOTEXP)
Overall	0.769
<200%	0.794
200–399%	0.782
≥400%	0.738

Across descriptive comparisons, medians and quantiles of EIR, catastrophic-spending thresholds, and adjusted log-expenditure models with an explicit income × disease interaction, the evidence is internally consistent and points to a single conclusion: the lowest-income adults with chronic disease—especially those with multimorbidity—bear a disproportionately high economic burden, both in absolute outlays when complexity rises and, more importantly, relative to income, which converts comparable dollars into far larger opportunity costs at the bottom of the distribution.

4. Summary

Anchored in nationally representative microdata and an analysis plan that combines level-, ratio-, and distributional measures, this study shows that income scarcity and clinical complexity interact to shape the economic burden of chronic disease: adults in low-income households devote larger shares of their resources to medical care and are far more likely to breach catastrophic-spending thresholds, with the steepest penalties occurring under multimorbidity; in contrast, adults in high-income households exhibit lower EIRs and a flatter gradient across disease states even when absolute spending is material, underscor-

ing the protective role of financial capacity and insurance. Covariate-adjusted log-expenditure models make the interaction explicit—complexity sharply elevates spending, but the incremental penalty is minimized in high-income groups and magnified in low-income groups—while EIR quantiles and Gini coefficients reveal that the associated burden is not only heavier at the bottom but also more concentrated among a subset of vulnerable users.

From a policy perspective, equity gains are most likely when integrated multimorbidity management is paired with stronger financial protection for low-income households, including income-linked caps on cost sharing and targeted subsidies that shield recurrent out-of-pocket outlays; methodologically, combining medians, quantiles, catastrophic thresholds, and inequality metrics provides a robust, policy-facing description of burden that can be extended to longitudinal or claims-linked data to validate causal pathways and quantify the impacts of benefit design and coordinated-care interventions across the chronic care continuum.

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