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Distribution and determinants of catastrophic and impoverishing health expenditure in Somalia from a calibrated microsimulation

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Research Article

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Abstract

Background. Financial protection is central to universal health coverage (UHC), yet Somalia has no household survey designed to measure it. Out-of-pocket (OOP) payments finance about 45% of current health expenditure and pooled prepayment is negligible. We estimated the incidence, intensity and determinants of catastrophic (CHE) and impoverishing health expenditure (IHE).

Methods. Absent observed microdata, we constructed a reproducible synthetic household dataset (n = 1,350) stratified across the four Somali Health and Demographic Survey (SHDS) 2020 residence domains: urban, rural, nomadic and internally displaced person (IDP) settlements. Household characteristics, consumption and OOP payments were calibrated to SHDS 2020, the WHO Global Health Expenditure Database and World Bank poverty proxies. CHE used 10% and 25% budget-share thresholds and a 40% capacity-to-pay threshold; IHE used a size-adjusted poverty line. Determinants were estimated by multivariable logistic regression. Estimates are model-based projections, not survey observations.

Results. One in four households incurred CHE (CHE10 25.0%; CHE40-CTP 25.6%). OOP payments raised the poverty headcount from 44.4% to 49.0%, impoverishing a further 4.6%. CHE10 rose from 18.5% (urban) to 32.1% (nomadic) and 38.5% (IDP), and from 11.1% (richest quintile) to 35.6% (poorest). Chronic illness was the strongest determinant (adjusted odds ratio 4.05, 95% CI 3.02–5.44); facility delivery, IDP and nomadic residence, female headship and household size were associated with higher odds; the richest wealth quintile was protective, while insurance showed a protective but statistically imprecise association.

Conclusions. Modelled OOP financing behaves as a regressive tax, concentrating hardship among displaced, nomadic, chronically ill, female-headed and poor households. Advancing UHC requires pooled prepayment, strategic purchasing, chronic and maternal exemptions, and subsidised enrolment for the most vulnerable.

1 Introduction

1.1 Financial protection as an objective of universal health coverage

Universal health coverage (UHC) rests on two commitments: that people can use the health services they need, and that using those services does not expose them to financial hardship [1]. The second commitment is the one health systems most often fail to honour. Where prepayment is weak, public financing is fragmented and services are delivered largely by private or other non-state providers, the cost of illness falls on the household at the moment its capacity to absorb that cost is lowest [2, 3].

Out-of-pocket (OOP) payment is, for this reason, among the most regressive ways to finance health care. It is levied on the sick rather than on the healthy; it adjusts poorly, if at all, to ability to pay; and it is

incurred precisely when illness suppresses earning capacity, disrupts employment and adds non-medical costs for transport, accommodation and caregiving [4, 5].

The World Health Organization (WHO) and the World Bank monitor this failure through two complementary indicators. Catastrophic health expenditure (CHE) arises when direct health payments absorb a large share of household resources, displacing spending on food, education, shelter and livelihoods. Impoverishing health expenditure (IHE) arises when health payments push a household below a poverty line, or deepen the deprivation of a household already below it [6, 7]. Read together, the two indicators capture both the intensity of health-related financial stress and its distribution across the population. Both carry particular weight in fragile and conflict-affected settings, where public subsidy is uneven, health markets are weakly regulated, livelihoods are insecure and vulnerable groups are systematically under-protected [8].

1.2 Health financing and financial hardship in Somalia

Somalia presents these conditions in concentrated form. Decades of conflict, state fragmentation, recurrent humanitarian emergencies, mass displacement, climate shocks and sustained underinvestment in public systems have produced a health sector in which care is delivered predominantly by private, charitable, humanitarian and other non-state providers. This plural delivery structure has helped sustain access in the absence of a consolidated public system, but it has also entrenched fragmented financing, variable quality, weak price regulation and heavy reliance on payment at the point of care.

WHO Global Health Expenditure Database estimates place OOP payments at approximately 45% of current health expenditure in Somalia, well above the global average of roughly 18% [9], while formal health insurance remains limited and concentrated in a small, predominantly urban minority. Against a background of widespread poverty, livelihood insecurity, displacement and dependence on informal coping mechanisms, even modest health care costs can become catastrophic [10].

The burden of this financing structure is not evenly distributed. Households managing chronic illness face recurring expenditure on medicines, diagnostics, consultations and follow-up. Women requiring facility-based maternity care encounter user fees, transport costs, informal payments and forgone earnings. Households in internally displaced person (IDP) settlements hold few assets, earn unstably and receive limited social protection. Nomadic and pastoralist households incur substantial geographic and indirect costs when seeking care from facilities designed around settled populations. Female-headed households face overlapping economic and caregiving vulnerabilities. Poor households, though spending less in absolute terms, surrender a larger share of their disposable resources to obtain the same services. Financial protection is therefore not only a health financing question but also a question of equity, poverty reduction and social justice [11, 12].

The Federal Government of Somalia has committed to advancing UHC through three institutional platforms: a national Social Health Insurance Authority (SHIA), the Essential Package of Health Services

(EPHS) [13], and the World Bank-supported Damal Caafimaad programme [14]. Each provides a vehicle for shifting from fragmented point-of-service financing towards pooled prepayment, strategic purchasing and targeted subsidy. Designing these instruments well, however, requires evidence on who is most exposed to financial hardship, which household characteristics drive catastrophic expenditure, and where targeted protection would yield the largest equity gains.

1.3 Measuring financial protection: two complementary traditions

Financial protection measurement has developed along two lines. The budget-share approach classifies a household as experiencing CHE when OOP payments exceed a fixed proportion of total household consumption, conventionally 10% or 25% [4, 8]. It is transparent, easily communicated to policymakers and comparable across countries and over time. Because its denominator is total consumption, however, it can understate hardship among very poor households whose spending is dominated by subsistence needs.

The capacity-to-pay tradition compares OOP payments with resources remaining after essential needs are accounted for [6, 7]. Earlier applications often used food-based subsistence adjustments, while contemporary WHO/Europe monitoring uses a standardised allowance for food, housing and utilities. Capacity-to-pay measures are therefore sensitive to how basic needs are operationalised and should be labelled according to the denominator used. In this study, the 40% sensitivity measure uses total consumption net of actual food expenditure and is reported as a food-adjusted CHE40-CTP indicator rather than as an exact implementation of the current WHO/Europe indicator.

The two approaches are complementary rather than competing. In fragile and low-income settings, reporting both is especially informative: the poorest households may spend little in absolute terms yet suffer substantial welfare loss, reducing food intake, selling productive assets, borrowing informally or forgoing care altogether. A household may cross no budget-share threshold and still be seriously harmed. A complete assessment therefore reports multiple thresholds and interprets them alongside poverty, household composition and vulnerability.

IHE adds a further, policy-relevant dimension. Where CHE asks whether health spending absorbs an excessive share of resources, IHE asks whether that spending pushes the household across a poverty line [6]. The distinction matters: a household can incur catastrophic spending without crossing a poverty threshold, and a household can be impoverished by a payment that appears modest. Where poverty is already widespread, IHE understates the full welfare effect, because many households are poor before they seek care. It nonetheless remains a powerful indicator of the poverty consequences of OOP financing and of the social protection value of financing reform.

1.4 Determinants and consequences in low-income and fragile settings

Empirical work across low- and middle-income countries identifies a consistent set of household-level determinants of catastrophic spending. Chronic illness and non-communicable disease are repeatedly associated with elevated risk, because they require continuous medication, monitoring, diagnostic testing and repeat consultation. Unlike acute episodes, chronic conditions generate recurring expenditure over long periods; without pooled financing or subsidised medicine supply, these repeated payments accumulate into financial toxicity that erodes assets and displaces other essential spending [15].

Socioeconomic position is a second axis. Poor households are more exposed not only because their resources are smaller but because they lack buffers: savings, formal insurance, stable employment and affordable credit. Even where their absolute health spending is lower than that of wealthier households, their relative burden is higher. Large households face elevated risk through greater exposure to illness episodes and higher total consumption needs, while female-headed households may be particularly vulnerable where gendered labour market constraints, caregiving responsibilities and reduced asset ownership limit financial resilience [16].

Geography and residence status form a third. Rural and remote households incur indirect costs invisible in facility fee schedules: transport, accommodation, food during travel and lost income. Nomadic and pastoralist populations face additional barriers because services are typically organised around fixed facilities and settled populations. IDP households confront a distinct cluster of vulnerabilities, including disrupted livelihoods, insecure shelter, minimal assets, weak documentation, exclusion from formal employment and dependence on humanitarian or informal support. Together these can render even low-cost services financially inaccessible.

The consequences extend well beyond the immediate episode of illness. Households sell livestock, tools, land or jewellery; they borrow from relatives, shopkeepers, merchants or moneylenders [17]. In severe cases they withdraw children from school, reduce food consumption, defer rent or postpone other essential spending. Some avoid or delay care entirely for fear of unaffordable cost, producing preventable morbidity, complications, disability or death [5]. This is the mechanism Whitehead and colleagues termed the medical poverty trap: rising OOP costs convert short-term illness into long-term impoverishment, while financial barriers delay care and delayed care raises both clinical severity and eventual cost [18].

Fragile and conflict-affected settings intensify each of these risks. Such systems typically combine weak public financing, dependence on external assistance, fragmented purchasing, shortages of essential medicines, uneven provider distribution and limited regulation of private sector pricing. Households bear not only direct medical costs but also indirect costs arising from insecurity, displacement, restricted road access and distance. Humanitarian programmes may supply partial coverage, but they are commonly project-based, geographically bounded and time-limited, and so lack the stability of a national risk pool. Households consequently depend on informal coping strategies that provide temporary relief but rarely durable protection.

1.5 The Somali evidence gap, study aim and contribution

The available Somali literature is largely system-level: it documents extensive private provision, substantial donor financing, limited public pooling and high OOP expenditure. The SHDS 2020 and related national sources provide essential information on service coverage, maternal and child health, health-seeking behaviour and barriers to care [19], but the survey was not designed to measure household financial shock from care seeking, and Somalia therefore lacks a nationally representative body of household-level financial protection evidence using standard CHE and IHE methods.

This gap has direct policy consequences. Without disaggregated estimates, financial protection reforms risk being designed around an average household that does not resemble those most exposed to hardship. National averages conceal the specific vulnerabilities of IDP settlements, nomadic populations, female-headed households, households affected by chronic illness and the poorest quintiles. Macro-level OOP shares establish that Somali health financing depends structurally on household payments, but they do not reveal which groups cross catastrophic thresholds, how intense the burden is, or which determinants remain material after adjustment for wealth and residence.

Somalia's residence structure sharpens the problem. Urban, rural, nomadic and IDP households differ not only in income but in mobility, access pathways, asset structure, exposure to displacement, reliance on humanitarian assistance and ability to use fixed facilities. An analysis that does not distinguish these domains will understate hardship among mobile and displaced populations: nomadic households may incur substantial indirect costs even where direct fees are modest, while IDP households may have minimal capacity to pay even where absolute payments are small.

This study responds with a methodological bridge rather than a substitute for a national household expenditure survey. We develop a transparent, reproducible, secondary-data-calibrated microsimulation of catastrophic and impoverishing health expenditure in Somalia, and use it to answer a deliberately distributional question: who suffers most from OOP health financing, and what does the answer imply for UHC reform? The contribution is twofold. First, the study provides plausibility-calibrated estimates of how financial hardship is distributed across policy-relevant household groups. Second, it supplies a reproducible analytic pipeline that Somali institutions and their partners can re-estimate on observed microdata as such data become available. In doing so it speaks directly to Sustainable Development Goal target 3.8 on universal health coverage and financial risk protection, and to Goals 1 and 5 on poverty and gender equality [20].

2 Conceptual framework and hypotheses

2.1 Framework

The study adapts established financial protection frameworks [2, 6, 7] to the structural realities of Somalia's fragile, displacement-affected and largely informal economy. In a well-pooled system, the

financial risk of illness is spread across the population through taxation, social health insurance, private insurance or other prepayment. Households do not meet the full cost of care at the point of service; resources are pooled in advance and used to purchase services according to need. In Somalia, formal pooling is minimal, public financing is fragmented and households commonly pay directly when seeking care, creating a short and direct pathway from illness to financial distress (Fig. 1).

The framework proceeds through four stages. The first is structural context: limited pooled prepayment, high reliance on OOP payment, fragmented public and donor financing, a substantial private and non-state delivery sector, weak price regulation and uneven geographic distribution of services. These conditions determine the prices households face, the services available to them and the degree to which they are shielded from financial risk. They also shape whether care is sought from public facilities, private clinics, pharmacies, humanitarian providers, traditional healers or informal channels.

The second stage is household vulnerability. Households enter a health shock with differing resilience, conditioned by residence, wealth, size, sex of head, chronic illness, maternity need, displacement status and insurance coverage, and in Somalia also by livelihood type and asset structure. Urban households may be physically closer to facilities yet still face high private-sector prices; rural households face distance and transport barriers; nomadic households depend on livestock and mobility, which makes facility-based care both difficult and costly; IDP households hold few assets and little income security.

The third stage is the health shock and payment decision. When illness, injury, childbirth or chronic disease occurs, households choose among constrained options: seek care and pay out of pocket; delay care until the condition worsens; substitute cheaper informal care; mobilise remittances; borrow from relatives or merchants; sell livestock or other assets; or forgo treatment. These decisions turn not only on clinical need but on anticipated cost, distance, perceived quality, social networks, gender dynamics and cash availability at the moment of illness.

The fourth stage is economic consequence. Where OOP payments absorb a large share of household resources, the household experiences CHE; where those payments push it below the poverty line, it experiences IHE. Even households that cross no formal threshold may sustain welfare losses through reduced food consumption, school withdrawal, debt accumulation or the sale of productive assets. For pastoralist households, selling livestock to fund care compromises future income. For displaced households, borrowing deepens existing deprivation. For households managing chronic illness, repeated payment sustains a cycle of cumulative impoverishment.

The framework also allows for informal buffers. Somali households draw on diaspora remittances, kinship networks, shop credit, clan-based support, community fundraising and livestock liquidation. These mechanisms can lower the immediate barrier to care, but they are unevenly distributed and unreliable: remittances reach some households and not others; kinship support is strained during covariate shocks; credit postpones rather than prevents hardship; and asset sales finance treatment at the cost of long-term livelihood security. Informal mechanisms are therefore coping strategies, not risk pooling.

Figure 1 Conceptual framework linking structural context, household vulnerability, health shocks, out-of-pocket payment, coping response, and catastrophic (CHE) and impoverishing (IHE) health expenditure

2.2 Working hypotheses

The framework yields five policy-relevant expectations, which the analysis tests:

H1. CHE follows a residence gradient, lowest among urban households and highest among IDP and nomadic households, reflecting differences in income security, service proximity, transport cost, asset ownership and exposure to displacement.

H2. Chronic illness is the strongest household-level driver of catastrophic spending, because chronic conditions require repeated expenditure on medicines, diagnostics, consultations, monitoring and follow-up.

H3. Facility-based maternity care imposes a measurable financial penalty in the absence of effective fee exemption, vouchers or maternal subsidy.

H4. OOP financing is regressive, with poorer households bearing a higher relative burden even where their absolute health expenditure is lower.

H5. Even limited insurance or prepaid coverage confers measurable protection by reducing direct payment at the point of service, although low coverage may limit the precision of the estimated effect.

3 Methods

3.1 Study design and rationale

This is a methodological pilot based on a reproducible, secondary-data-calibrated microsimulation. The analysis did not process data collected from live human participants or individual-level secondary records. Instead, published secondary sources were used as aggregate calibration anchors, and a synthetic household microdataset was generated to approximate the joint distribution of demographic, socioeconomic, health need and expenditure variables relevant to financial protection analysis. The simulation was calibrated to the best available Somali and international secondary sources and analysed using standard WHO and World Bank methods for measuring catastrophic and impoverishing health expenditure [4, 6, 7].

The rationale is both empirical and methodological. Empirically, Somalia requires timely disaggregated evidence to guide the design of social health insurance, strategic purchasing, targeted exemption and demand-side subsidy, yet the absence of observed national household expenditure microdata prevents direct estimation of who is most exposed. Methodologically, a transparent synthetic dataset permits plausibility-calibrated estimation while avoiding any unsupported claim of primary data collection. The

purpose is not to substitute for a nationally representative survey but to provide an interim analytic instrument that can be recalibrated and re-estimated once observed household data exist.

The pilot therefore has two objectives: to estimate the incidence, intensity and distribution of CHE and IHE across policy-relevant Somali household groups; and to demonstrate a reproducible analytic pipeline that Somali institutions, researchers and partners can apply to future household surveys or administrative datasets.

All estimates reported below are model-based projections derived from calibrated synthetic microdata, not direct observations from fielded household interviews.

3.2 Sampling architecture emulated by the simulation

The simulation emulates the multi-stage stratified cluster design used in national household surveys such as the SHDS 2020 [19]. The frame is stratified by Somalia's four residence domains: urban households, rural agro-pastoralist households, nomadic pastoralist households, and households in IDP settlements. This structure is essential because residence in Somalia captures far more than geography; it also encodes livelihood system, mobility, access to fixed facilities, exposure to displacement, asset structure and capacity to absorb financial shock.

The synthetic data-generating process emulates the allocation logic of a multi-stage stratified household survey rather than reproducing an actual field sample. Residence strata and household counts were specified to represent the four SHDS residence domains, and household-level records were then generated algorithmically within those strata. References to sampling architecture therefore describe the structure emulated by the simulation, not recruitment of participants or selection of real primary sampling units. The final analytic dataset comprises 1,350 synthetic households distributed across the four domains.

To preserve compatibility with standard household health-expenditure instruments, the simulation parameterises routine outpatient expenditure on a 30-day equivalent basis and less frequent, higher-cost events on a 12-month equivalent basis. These are modelling windows used to construct synthetic expenditure variables; they are not participant recall periods because no household interviews were conducted.

3.3 Secondary data anchors and calibration

Calibration drew on three categories of anchor. First, the SHDS 2020 informed the demographic and residence structure of the dataset, including residence shares, household size, sex of household head and selected vulnerability indicators [19, 24]. Second, health financing anchors were taken from the WHO Global Health Expenditure Database and World Bank estimates for Somalia [9, 10]; these governed overall reliance on OOP payment, the limited level of prepaid or insurance-based coverage, and the expected magnitude of catastrophic expenditure in a highly OOP-dependent system. Third, household budget and poverty proxies drawn from the Somali High Frequency Survey, Wave 2 [25] shaped total

consumption, food expenditure, non-food expenditure and capacity to pay. Wealth quintiles were constructed from a latent asset index that preserves the expected correlation between residence and poverty: IDP households concentrate in the poorest quintiles, while insured households are confined to a small, predominantly urban minority, consistent with the limited reach of formal coverage in Somalia.

Calibration preserved internal consistency across variables. Residence domain conditioned household size, poverty status, chronic illness probability, insurance coverage and service access. Health need influenced OOP expenditure through chronic illness and facility-based maternity care. Household resources conditioned capacity to pay and, in turn, the likelihood that health spending would cross catastrophic or impoverishing thresholds. This structure allows the synthetic dataset to reproduce plausible relationships among vulnerability, expenditure and hardship rather than independent marginal distributions.

A coping-response module assigned each household a primary financing source for any health payment incurred - current income or savings, insurance or prepayment, informal borrowing, or sale of productive assets - conditional on catastrophic status, wealth quintile and residence domain, with parameters anchored to published evidence on borrowing and asset sales as health financing mechanisms in low- and middle-income countries [17]. This module is the least strongly anchored component of the model and its outputs are reported as indicative only.

3.4 Measurement of catastrophic and impoverishing health expenditure

Standard financial protection indicators were applied to the synthetic dataset. For household i, let Yi denote total monthly household consumption expenditure, Fi food expenditure, and OOPi out-of-pocket health payments net of any reimbursement. OOP payments comprise direct payments for consultations, medicines, diagnostics, inpatient care, delivery care, supplies, care-related transport, and other health payments borne by the household.

Budget-share CHE is the ratio of OOP payments to total household consumption. A household is classified as experiencing CHE when $OOPi / Yi \geq \alpha$, where α takes the two conventional values of 0.10 and 0.25. The 10% threshold captures broad financial stress; the 25% threshold identifies severe burden.

As a complementary food-adjusted capacity-to-pay sensitivity measure, capacity to pay is defined as total consumption net of food expenditure, $CTPi = Yi - Fi$, and a household is classified as experiencing CHE40-CTP when $OOPi / CTPi \geq 0.40$. This specification follows the established capacity-to-pay tradition but should not be interpreted as an exact implementation of the current WHO/Europe food-housing-utilities basic-needs indicator, which uses a standardised basic-needs allowance. The food-adjusted measure is retained here to examine hardship among households with limited non-food resources and is interpreted separately from the 10% and 25% budget-share indicators.

IHE compares household welfare before and after OOP payment. With PLi denoting a household-specific poverty line adjusted for household size, a household is classified as impoverished by health spending when Yi ≥ PLi and Yi - OOPi < PLi. We report the poverty headcount before payment, the headcount after payment, and the additional percentage of households pushed below the line by health expenditure.

3.5 Econometric specification

Determinants of catastrophic expenditure were estimated by multivariable binary logistic regression. The dependent variable is CHE at the 10% budget-share threshold, chosen because it is the measure most widely used in international financial protection monitoring [8] and provides a policy-relevant indicator of exposure to excessive OOP spending. The model takes the form:

$$logit[P(CHEi = 1)] = \beta0 + \beta1\ Residencei + \beta2\ Wealthi + \beta3\ Chronici + \beta4\ FacilityDeliveryi + \beta5\ Insuredi + \beta6\ FemaleHeadi + \beta7\ HHSizei + \varepsilon i$$

Residence denotes residence domain; Wealth denotes wealth quintile; Chronic indicates at least one household member with chronic illness; FacilityDelivery indicates a facility-based birth in the previous year; Insured indicates any health insurance or prepaid coverage; FemaleHead indicates female household headship; and HHSize is household size in members. Urban residence, the poorest wealth quintile, absence of chronic illness, no facility delivery, no insurance and male headship serve as reference categories. Adjusted odds ratios (aORs), 95% confidence intervals and p values are reported. Because the analysis rests on simulated cross-sectional data, coefficients should be read as adjusted associations within the synthetic dataset rather than as causal effects.

3.6 Reproducibility, internal verification and ethics

The data-generating process is deterministic given the random seed 20260626. Household generation, variable construction, financial protection indicator calculation and regression estimation were implemented in reproducible Python scripts, so that the same synthetic microdataset and the same results can be regenerated exactly. The dataset and the complete generating code are openly archived and citable [26]. This reproducibility is central to the study's purpose: the pipeline is designed to be transparent, auditable and adaptable to observed household data.

As an internal verification step, all subgroup estimates were reconciled against the corresponding national figures. Sample-size-weighted CHE10, CHE40-CTP and mean OOP burden computed across residence strata, wealth quintiles, chronic illness status and insurance status each reproduce the reported national values to within rounding, confirming that the disaggregated results in Section 4 are mutually consistent.

The analysis did not use data collected from live human participants. It used published secondary sources only as aggregate calibration anchors and generated fully synthetic, algorithmically generated records; no individual-level human records, identifiable personal data or biological material were processed. Formal ethics committee review was therefore not required for this methodological pilot. No

individual, household or community-level primary data were collected. Any future implementation using observed household data would require approval from a recognised Somali institutional review board, informed participant consent, data protection safeguards, and careful attention to the ethical inclusion of displaced, nomadic and other vulnerable populations.

4 Results

4.1 Sample profile

The calibrated analytic sample comprised 1,350 households across Somalia's four residence domains. Urban households formed the largest group at 595 (44.1%); rural agro-pastoralist households accounted for 338 (25.0%), nomadic pastoralist households for 212 (15.7%) and IDP households for 205 (15.2%). Nomadic and IDP households together represented 30.9% of the sample, ensuring that the model captured two populations of central relevance to equity-oriented health financing in Somalia.

The sample reflects the demographic and vulnerability profile expected in a fragile, displacement-affected setting (Table 1). Household size was high: 70.7% of households contained five to eight members and a further 13.1% more than eight. Female-headed households accounted for 38.7% of the sample. Chronic illness was present in 293 households (21.7%), and 265 households (19.6%) reported a facility-based delivery in the previous year. Any form of health insurance or prepaid coverage reached only 44 households (3.3%). This very low coverage provides the essential context for interpreting the financial protection results: almost every household in the model was exposed to direct payment at the point of care.

Table 1
Sociodemographic profile of the analytic sample (N = 1,350)

Characteristic	Category	n (%)
Residence domain	Urban	595 (44.1)
	Rural (agro-pastoralist)	338 (25.0)
	Nomadic (pastoralist)	212 (15.7)
	IDP settlement	205 (15.2)
Wealth quintile	Q1 (poorest)	270 (20.0)
	Q2	270 (20.0)
	Q3	270 (20.0)
	Q4	270 (20.0)
	Q5 (richest)	270 (20.0)
Household size	1–4 members	219 (16.2)
	5–8 members	954 (70.7)
	> 8 members	177 (13.1)
Chronic illness in household	Present	293 (21.7)
Female-headed household	Yes	522 (38.7)
Facility delivery in previous year	Yes	265 (19.6)
Health insurance or prepaid coverage	Any coverage	44 (3.3)
IDP internally displaced person		

Vulnerability differed markedly across residence strata (Table 2). IDP households were the most socioeconomically exposed group: 62.0% fell in the poorest wealth quintile, 55.1% were female-headed and 29.8% contained at least one member with chronic illness. Nomadic households were also highly vulnerable, combining large average household size (7.0 members), heavy concentration in the poorest quintile (34.0%) and almost no insurance coverage (0.5%). Rural households had similarly large households and no modelled insurance. Urban households showed lower poverty concentration but remained exposed to direct payment through Somalia's largely private and non-state delivery environment. These differences indicate that residence status captures not only geography but livelihood structure, asset security, displacement exposure and the ability to absorb health-related financial shock.

Table 2
Vulnerability indicators by residence stratum. Figures are within-stratum percentages unless otherwise indicated

Residence stratum	Female-headed (%)	Mean household size	In Q1, poorest (%)	Chronic illness (%)	Insured (%)
Urban	39.7	6.1	2.4	23.4	7.2
Rural	32.8	7.0	16.9	15.1	0.0
Nomadic	29.7	7.0	34.0	19.8	0.5
IDP settlement	55.1	5.7	62.0	29.8	0.0

IDP internally displaced person

4.2 Incidence and intensity of catastrophic and impoverishing health expenditure

The model indicates a substantial burden of financial hardship. Nationally, 25.0% of synthetic households crossed the 10% budget-share threshold (CHE10), and 7.8% crossed the 25% threshold (CHE25). Under the complementary food-adjusted capacity-to-pay specification, 25.6% crossed the 40% threshold (CHE40-CTP) (Table 3). These measures are complementary rather than interchangeable: CHE10 and CHE25 assess OOP payments relative to total consumption, whereas CHE40-CTP assesses OOP payments relative to non-food resources. Their broadly similar national incidence indicates substantial modelled financial exposure under different definitions of household ability to pay.

Mean OOP burden was 8.5% of total household consumption, an average that conceals wide variation by residence, wealth, clinical need and insurance status; burden was consistently higher among IDP, nomadic, poorer, chronically ill and uninsured households. OOP payments were also impoverishing: the poverty headcount rose from 44.4% before health spending to 49.0% after it, meaning that health payments pushed an additional 4.6% of households below the poverty line. OOP expenditure therefore functions not only as a barrier to access but as a driver of impoverishment.

A clear residence gradient emerged (Fig. 2). CHE10 rose from 18.5% among urban households to 23.7% among rural, 32.1% among nomadic and 38.5% among IDP households. The capacity-to-pay measure produced a steeper gradient still, from 16.3% among urban to 45.9% among IDP households, indicating that displaced households were especially exposed because they retained very limited non-food resources after meeting subsistence needs. Nomadic households also faced elevated risk, consistent with the combined burden of direct medical costs, transport costs, mobility constraints and distance from fixed facilities. The one departure from strict monotonicity occurs at the 25% threshold, where nomadic households (14.2%) slightly exceed IDP households (12.7%); this reflects the higher absolute expenditure of pastoralist households relative to their consumption, whereas IDP hardship is driven more by the near-absence of discretionary resources, which the capacity-to-pay measure captures.

Figure 2 Catastrophic health expenditure by residence stratum, showing a consistent urban-to-rural-to-nomadic-to-IDP gradient under both the budget-share (CHE10) and capacity-to-pay (CHE40-CTP) definitions

Table 3
Incidence of catastrophic health expenditure and mean out-of-pocket burden, by subgroup

Subgroup	CHE10 (%)	CHE25 (%)	CHE40-CTP (%)	Mean OOP/Y (%)
National	**25.0**	**7.8**	**25.6**	**8.5**
Urban	18.5	3.7	16.3	6.1
Rural	23.7	8.0	23.1	8.9
Nomadic	32.1	14.2	35.8	11.2
IDP settlement	38.5	12.7	45.9	11.8
Q1 (poorest)	35.6	15.9	43.7	11.9
Q2	29.6	9.3	34.1	9.8
Q3	26.7	5.2	24.4	8.2
Q4	21.9	5.9	16.7	7.2
Q5 (richest)	11.1	2.6	8.9	5.1
Chronic illness present	47.4	17.1	45.1	14.1
Chronic illness absent	18.7	5.2	20.2	6.9
Insured	6.8	0.0	2.3	2.3
Uninsured	25.6	8.0	26.3	8.7

CHE10 and CHE25, out-of-pocket payments ≥ 10% and ≥ 25% of total household consumption; CHE40-CTP, out-of-pocket payments ≥ 40% of capacity to pay; OOP/Y, out-of-pocket payments as a share of total consumption; IDP internally displaced person

4.3 Regressivity across wealth quintiles

The distribution of catastrophic expenditure across wealth quintiles confirms the regressive character of OOP financing in the modelled Somali setting (Fig. 3). CHE10 declined steadily from 35.6% in the poorest quintile to 11.1% in the richest. The capacity-to-pay measure showed a larger gradient still, from 43.7% to 8.9%, indicating that poorer households were not only more likely to experience catastrophic spending but also more likely to retain very limited discretionary resources once food and other subsistence needs were met.

Mean OOP burden followed the same pattern, absorbing 11.9% of total consumption in the poorest quintile against 5.1% in the richest. The same financing mechanism therefore produces markedly

different welfare consequences depending on household resources. Wealthier households absorb health payments through savings, regular income or social networks; poorer households reduce essential consumption, borrow informally, sell productive assets or delay care. In this sense OOP financing operates as a regressive tax on illness, imposing the greatest relative burden on those least able to bear it [4, 16].

Figure 3 Regressivity of out-of-pocket financing across wealth quintiles. Both catastrophic expenditure and mean out-of-pocket burden decline as household wealth rises

4.4 Adjusted determinants of catastrophic health expenditure

The multivariable logistic regression identified several independent predictors of catastrophic expenditure at the 10% threshold (Table 4; Fig. 4). The strongest was chronic illness: households with at least one chronically ill member had more than four times the odds of experiencing CHE compared with households without (aOR 4.05, 95% CI 3.02–5.44, $p < 0.001$). This is consistent with the recurrent nature of chronic care costs and underlines the importance of including chronic disease management within financial protection reform and the essential benefit package.

Residence remained independently associated with catastrophic expenditure after adjustment for wealth and other household characteristics. IDP households had significantly higher odds than urban households (aOR 1.90, 95% CI 1.18–3.04, $p = 0.008$), and nomadic households also faced elevated odds (aOR 1.66, 95% CI 1.07–2.58, $p = 0.023$). Displacement and mobility are therefore not merely proxies for poverty; they represent independent axes of vulnerability linked to livelihood disruption, distance from services, limited assets, indirect care-seeking costs and weak access to formal financial protection.

Facility-based delivery in the previous year was also strongly associated with catastrophic expenditure (aOR 1.98, 95% CI 1.42–2.78, $p < 0.001$), indicating a measurable maternity-related financial penalty in the absence of effective fee exemption or demand-side subsidy. The policy significance is direct: households that seek skilled birth attendance should not be financially penalised for using a recommended service.

Female-headed households had higher odds than male-headed households (aOR 1.44, 95% CI 1.10–1.90, $p = 0.009$), suggesting that gendered household vulnerability shapes exposure to health care costs. Household size was independently associated with risk, each additional member raising the odds of CHE by 11% (aOR 1.11, 95% CI 1.03–1.20, $p = 0.004$), consistent with more frequent illness episodes, higher dependency burdens and greater total consumption needs.

Wealth and insurance were protective. Households in the richest quintile had substantially lower odds than those in the poorest (aOR 0.31, 95% CI 0.17–0.54, $p < 0.001$). Any insurance or prepaid coverage was associated with lower odds of CHE (aOR 0.34, 95% CI 0.10–1.17), although the association did not reach conventional statistical significance ($p = 0.086$). The wide confidence interval reflects the very

small number of insured households in the sample; the direction and magnitude of the point estimate are nonetheless consistent with the expected protective role of pooled financing, and hypothesis H5 should be regarded as directionally supported but statistically underpowered rather than confirmed.

Table 4
Multivariable logistic regression for catastrophic health expenditure at the 10% budget-share threshold

Predictor	aOR	95% CI	p value
Rural residence	1.23	0.84–1.80	0.289
Nomadic residence	1.66	1.07–2.58	0.023
IDP settlement	1.90	1.18–3.04	0.008
Q2	0.92	0.61–1.37	0.668
Q3	0.82	0.53–1.27	0.373
Q4	0.66	0.41–1.06	0.086
Q5 (richest)	0.31	0.17–0.54	< 0.001
Chronic illness in household	4.05	3.02–5.44	< 0.001
Facility delivery in previous year	1.98	1.42–2.78	< 0.001
Health insurance or prepaid coverage	0.34	0.10–1.17	0.086
Female-headed household	1.44	1.10–1.90	0.009
Household size, per additional member	1.11	1.03–1.20	0.004

Reference categories: urban residence, poorest wealth quintile (Q1), no chronic illness, no facility delivery, uninsured, male-headed household. Model diagnostics: n = 1,350; McFadden pseudo R^2 = 0.124; likelihood ratio $\chi^2(12) = 187.6$, $p < 0.001$; classification accuracy 76.5%. aOR adjusted odds ratio; CI confidence interval; IDP internally displaced person

Figure 4 Adjusted odds ratios and 95% confidence intervals for catastrophic health expenditure at the 10% budget-share threshold. Points to the right of unity indicate elevated risk; points to the left indicate protective associations

4.5 Impoverishment and distress financing

Beyond catastrophic expenditure, OOP payments generated measurable impoverishment. The modelled poverty headcount rose from 44.4% before health payments to 49.0% after them (Fig. 5). This 4.6 percentage point increase represents households that stood above the poverty line before seeking care and fell below it after paying for it, demonstrating that health payments are not merely an expenditure item but a mechanism that shifts households into poverty.

In the modelled coping-response scenario, approximately 60% of synthetic households experiencing catastrophic expenditure were assigned a distress-financing response rather than savings or insurance,

principally sale of livestock or other productive assets or informal borrowing. This percentage is a scenario output from the least strongly anchored component of the microsimulation and must not be interpreted as an observed population estimate. It is included to illustrate a plausible pathway through which catastrophic payment may translate into longer-term vulnerability, consistent with published evidence on borrowing and asset sales [17, 18].

Taken together, the findings on catastrophe, impoverishment and distress financing indicate that OOP payments in Somalia operate through several distinct pathways of hardship: they suppress current consumption, push some households below the poverty line, and force others to deplete assets or accumulate debt. This strengthens the case for financial protection reform that goes beyond facility expansion and addresses the household cost of seeking care directly.

Figure 5 Poverty headcount before and after out-of-pocket health payments. The increment between pre-payment and post-payment poverty represents households impoverished by paying for care

5 Discussion

This study provides a disaggregated, model-based assessment of how out-of-pocket health financing may be distributed across Somali household groups under a transparent, secondary-data-calibrated microsimulation. The modelled incidence - roughly one synthetic household in four - is consistent with global evidence showing elevated catastrophic spending where risk pooling is weak and OOP reliance high [8, 16]. The contribution lies in demonstrating the plausible structural, social and spatial patterning of financial hardship in a fragile, displacement-affected setting while providing a reproducible framework that can be re-estimated when observed household expenditure microdata become available.

5.1 Somalia in the global financial protection landscape

Global progress on financial protection has been uneven, with many low-income and fragile settings stagnating or regressing [1]. Analyses spanning more than 130 countries show catastrophic spending concentrated where OOP shares are high and prepayment mechanisms limited [8]. Somalia fits this profile closely: OOP financing accounts for approximately 45% of current health expenditure, far above the level generally associated with adequate financial protection [9].

Comparative evidence from sub-Saharan Africa reports substantial variation in CHE incidence according to threshold, data source and method [16]. The modelled Somali estimates fall within a range that warrants policy attention, but they should not be used to rank Somalia against countries with observed household expenditure surveys. Their value is primarily scenario-based: they illustrate how high OOP reliance, limited pooling and socioeconomic vulnerability may combine to produce financial hardship [2].

5.2 An equity reading of the distributional findings

The results can be read through two established equity criteria. Vertical equity requires that households contribute according to ability to pay. The steep wealth gradient observed here - catastrophic spending

more than three times more common in the poorest quintile than in the richest, and mean OOP burden more than twice as large - represents a clear violation of that principle: those with least capacity surrender the largest relative share of their resources [6, 11].

Horizontal equity requires that households with comparable need be treated comparably. Here the findings are equally clear. IDP and nomadic households faced significantly elevated odds of catastrophic expenditure even after adjustment for wealth, indicating that displacement and mobility function as independent structural determinants rather than as proxies for poverty. Households with similar needs and similar resources therefore face systematically different financial risk according to where and how they live - a pattern the Commission on Social Determinants of Health identifies as the signature of structurally produced inequity [21].

This distinction matters for targeting. Displaced populations are widely recognised as facing intersecting vulnerabilities, but financial protection analyses rarely quantify the independent contribution of displacement at household level. Nomadic populations are more often omitted altogether, despite a distinctive exposure: because their wealth is held predominantly in livestock, distress financing takes the form of asset liquidation that directly undermines future income. The implication is that income-based targeting alone will misallocate protection. Effective targeting in Somalia must treat displacement, mobility and marginalisation as primary axes of inequity in their own right.

5.3 Chronic illness and the medical poverty trap

Chronic illness emerged as the single strongest determinant of catastrophic expenditure, quadrupling the odds after adjustment. This aligns with a substantial literature on the household financial burden of non-communicable disease in low-resource settings [15]. Unlike acute episodes, chronic conditions demand sustained expenditure on medication, monitoring and follow-up, which is especially punishing in systems without prepayment.

The dynamic is best understood as the medical poverty trap: illness depletes household resources, and depletion in turn constrains future access to care [18]. In Somalia, the absence of insurance and of subsidised chronic care obliges households to finance continuing treatment out of pocket, producing cumulative rather than episodic financial stress and reinforcing a mutually sustaining cycle of poverty and illness that falls hardest on lower-income groups.

5.4 The maternity penalty and the case for fee exemption

The finding that facility-based delivery nearly doubles the odds of catastrophic expenditure presents a direct policy contradiction. Global maternal health strategy prioritises institutional delivery to reduce maternal and newborn mortality, yet in Somalia the households that comply with that recommendation are financially penalised for doing so.

Evidence from a range of low- and middle-income countries indicates that removing or reducing user fees for maternal services increases utilisation, with the largest gains typically among poorer women

[22]. Where fees persist, the effect operates in two directions at once: some households are deterred from seeking skilled attendance, while those who do seek it absorb a financial shock. Somalia currently sustains both risks simultaneously. Aligning clinical priorities with financial protection instruments - through free or voucher-covered antenatal, delivery and postnatal care - is therefore not a peripheral refinement but a condition for the coherence of maternal health policy. Because 55.1% of IDP households in this sample were female-headed, and female headship independently raised catastrophic risk, maternal fee exemption also carries a direct gender equity dividend.

5.5 Risk pooling as the missing institution

Insurance was protective in direction and magnitude, though imprecisely estimated given that only 3.3% of modelled households held any coverage. That very imprecision is itself the finding: coverage is too thin to measure reliably, which is to say too thin to protect. Countries that have advanced towards UHC have done so by expanding prepayment and spreading financial risk across populations rather than leaving it with the sick [2, 3].

In Somalia, the near-absence of pooling leaves households bearing the full financial consequence of illness. This is a failure of collective financing arrangements rather than of individual behaviour, and it generates both vertical and horizontal inequity simultaneously. Establishing a functioning national pool is accordingly not a technical adjustment but the foundational institutional step on which every subsequent financial protection instrument depends.

5.6 From evidence to instrument: implications for UHC reform in Somalia

Because hardship is concentrated and patterned rather than randomly distributed, it is targetable, and targeted instruments can deliver disproportionate protection per unit of expenditure. Each empirical finding maps onto a concrete financing lever aligned with Somalia's emerging UHC architecture: the Social Health Insurance Authority, the EPHS and Damal Caafimaad (Table 5) [13, 14].

Table 5
From evidence to instrument: priority financing actions for financial protection in Somalia

Finding or challenge	Instrument	Mechanism and delivery vehicle
No risk pooling; regressive OOP financing	Mandatory, subsidised social health insurance	Operationalise the Social Health Insurance Authority as a single national pool; fully subsidise premiums for IDP, nomadic and poorest households; purchase EPHS services on their behalf
Chronic illness is the leading determinant	Continuity-of-care exemptions	Zero co-payment for essential chronic disease medicines and monitoring within the EPHS benefit package; pre-authorised refill protocols
Maternity-related financial penalty	Demand-side maternal subsidy	Free or voucher-covered antenatal, delivery and postnatal care; deliver subsidies over mobile money rails for unbanked and mobile households
Displacement raises risk independent of wealth	Residence-targeted enrolment and outreach	Auto-enrol IDP settlement and pastoralist households; finance mobile and outreach service delivery
Opaque private pricing	Strategic purchasing and price regulation	Contract accredited private providers at negotiated tariffs; publish standard prices; tie reimbursement to quality and price transparency
Distress financing and asset depletion	Catastrophic cost ceiling and emergency fund	Annual OOP cap per household within benefit design; pooled fund for high-cost episodes to prevent asset depletion

EPHS Essential Package of Health Services; IDP internally displaced person; OOP out-of-pocket

Sequencing matters, because protection is bought most cheaply where risk is most concentrated. The highest-return first moves are full premium subsidy for the poorest and displaced, chronic disease exemption, and maternal vouchers. Each targets a determinant this analysis identifies as both high-impact and tractable, and each can be delivered through institutions Somalia is already building. This is the logic of progressive universalism: ensuring that poorer groups gain at least as much as better-off groups at every stage of coverage expansion, rather than waiting to catch up as universality is approached [23].

5.7 Contribution to the Sustainable Development Goals

The findings speak directly to three Sustainable Development Goals [20]. For Goal 3 and target 3.8 in particular, the study supplies disaggregated estimates of financial risk protection, the coverage dimension for which Somalia currently has the weakest evidence. For Goal 1, the demonstration that health payments push an additional 4.6% of households below the poverty line establishes health financing reform as a poverty reduction instrument and not solely a health sector concern. For Goal 5, the independent association between female headship and catastrophic expenditure, alongside the maternity-related penalty, identifies health financing as a gendered domain in which apparently neutral payment arrangements produce systematically unequal outcomes for women.

5.8 Strengths and limitations

The central limitation is foundational and should govern the reading of every estimate reported here: the analysis rests on a reproducible, secondary-data-calibrated simulation rather than a fielded primary survey. Household records are algorithmically generated and anchored to published macro indicators, so the estimates are model-based projections whose validity depends on the calibration assumptions. Magnitudes should be read as plausibility-bounded planning figures rather than as precise population parameters, and they should not be cited as observed national statistics.

Several specific constraints follow. The small insured subsample limits precision and leaves the protective effect of coverage underpowered. The synthetic design cannot capture all regional security variation, remittance flows or unmodelled heterogeneity. The coping and distress financing module is the most weakly anchored element of the model. The cross-sectional structure precludes causal inference, and the analysis does not observe households that forwent care entirely, which means the true welfare burden is understated: households deterred by cost register no expenditure and therefore no catastrophe.

Against these constraints, the study has real strengths. The pipeline is transparent and deterministic: every figure can be regenerated from a single random seed, and the framework can be re-estimated once observed microdata become available. It applies internationally standard financial protection definitions, reports both budget-share and capacity-to-pay measures, and disaggregates by Somalia's four-domain residence structure, including the nomadic and IDP populations that national averages routinely obscure. Subgroup estimates reconcile to national totals, confirming internal consistency. Above all, the framing is deliberate about what these numbers are and are not, which is a precondition for their responsible use in policy.

Future work should re-estimate the framework on observed household expenditure microdata, integrate longitudinal data to examine causal pathways, model regional and conflict-related heterogeneity, and incorporate qualitative evidence on coping strategies and the decision to forgo care.

6 Conclusion

The calibrated microsimulation suggests that heavy reliance on out-of-pocket payment can generate regressive financial hardship, with modelled burden concentrated among displaced, nomadic, chronically ill, female-headed and poorer household groups. These findings should be interpreted as planning scenarios rather than observed national estimates. They nevertheless identify policy-relevant vulnerabilities that can inform the design and future empirical evaluation of pooled prepayment, strategic purchasing and targeted financial protection through Somalia's emerging UHC architecture, including the Social Health Insurance Authority, the EPHS and Damal Caafimaad. Confirmation of the magnitude and distribution of these effects requires nationally representative household expenditure microdata.

Declarations

Funding. This work received no specific grant from any funding agency in the public, commercial or not-for-profit sectors. It was undertaken by the author as part of independent scholarly and institutional work.

Competing interests. The author declares no competing financial or non-financial interests. The author holds a national health financing institutional role in Somalia; the analysis and views expressed here are scholarly and do not represent the official position of any institution.

Ethical Approval and accordance

Not applicable. The study did not involve live human participants, human biological material or individual-level human data. Published secondary sources were used only as aggregate calibration anchors, and the analytic dataset was fully synthetic. No ethics committee or institutional review board approval was required. The analysis was conducted in accordance with responsible research practices and the usage conditions of the cited sources.

Consent to participate

Not applicable. No live human participants were recruited or enrolled, and no participant-level data were collected or processed; informed consent to participate was therefore not required.

Consent to publish

Not applicable. The manuscript contains no identifiable individual data or personal images.

Data Availability Statement

The datasets generated during and/or analysed during the current study are available in the Zenodo repository, https://doi.org/10.5281/zenodo.22802394.

Third party material

Not applicable. All figures, tables and supplementary materials in this manuscript were created by the author from the fully synthetic dataset and published secondary sources; no copyrighted third-party material has been reproduced.

Code availability. The deterministic Python code used to generate the synthetic household dataset, construct the financial-protection indicators and reproduce the statistical analyses is archived with the dataset in the Zenodo repository cited in reference 26.

Author contributions. The sole author conceived the study, designed the analytic framework, generated and calibrated the synthetic dataset, conducted the analysis, prepared all figures and tables, and wrote and approved the manuscript.

Use of generative artificial intelligence. Generative artificial intelligence tools were used to assist with language editing and manuscript formatting. They were not used to generate data, conduct analyses or draw conclusions. The author reviewed and verified all content and takes full responsibility for the integrity of the work.

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Figures

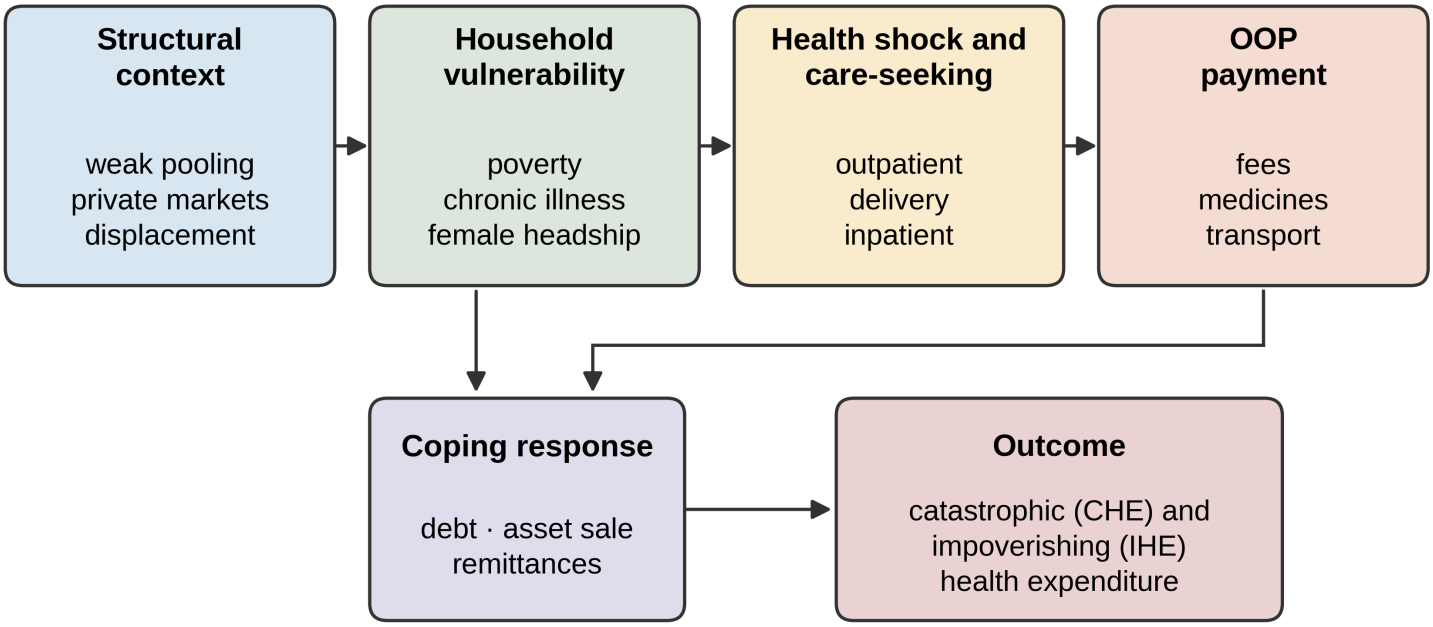


Figure 1

Conceptual framework linking structural context, household vulnerability, health shocks, out-of-pocket payment, coping response, and catastrophic (CHE) and impoverishing (IHE) health expenditure

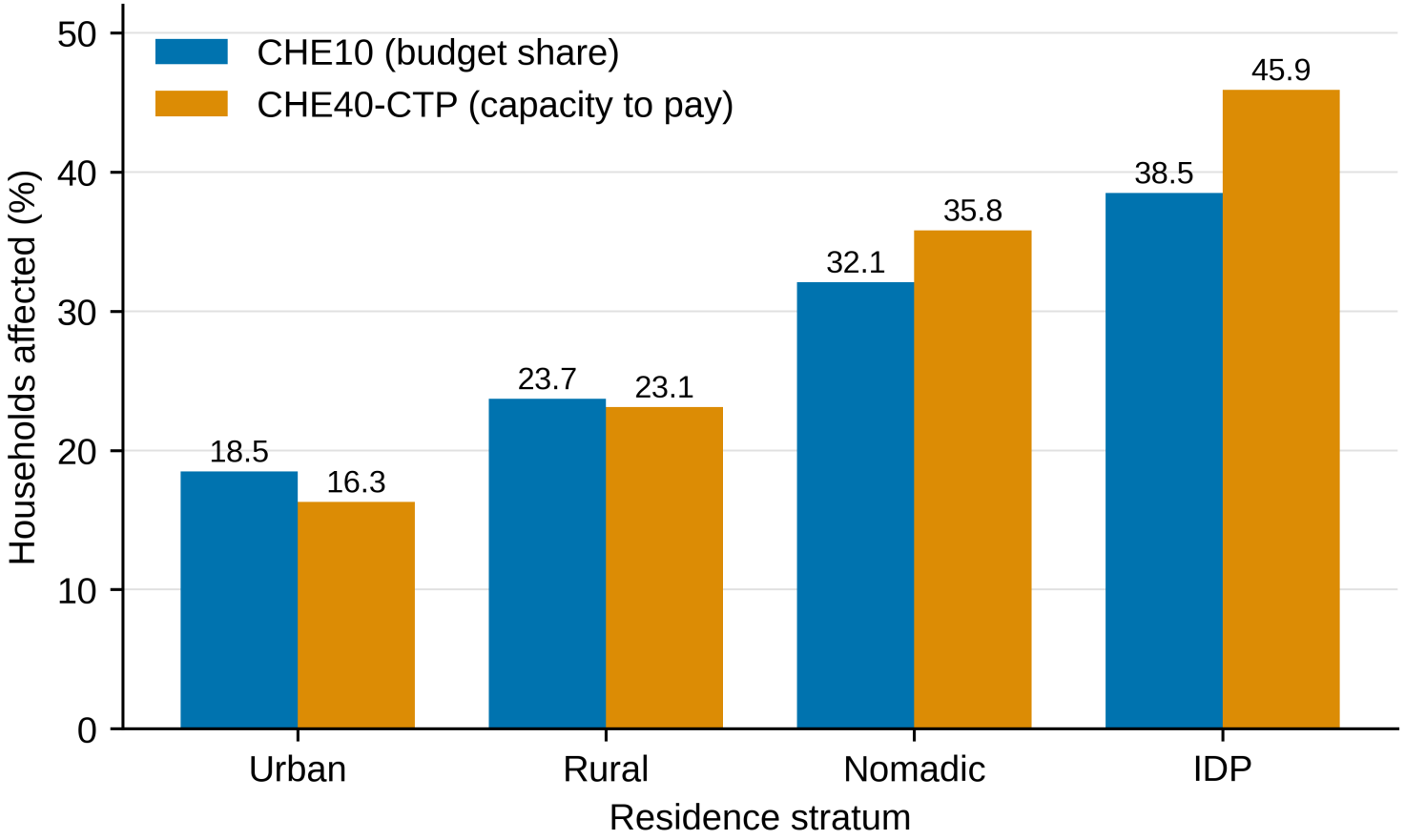


Figure 2

Catastrophic health expenditure by residence stratum, showing a consistent urban-to-rural-to-nomadic-to-IDP gradient under both the budget-share (CHE10) and capacity-to-pay (CHE40-CTP) definitions

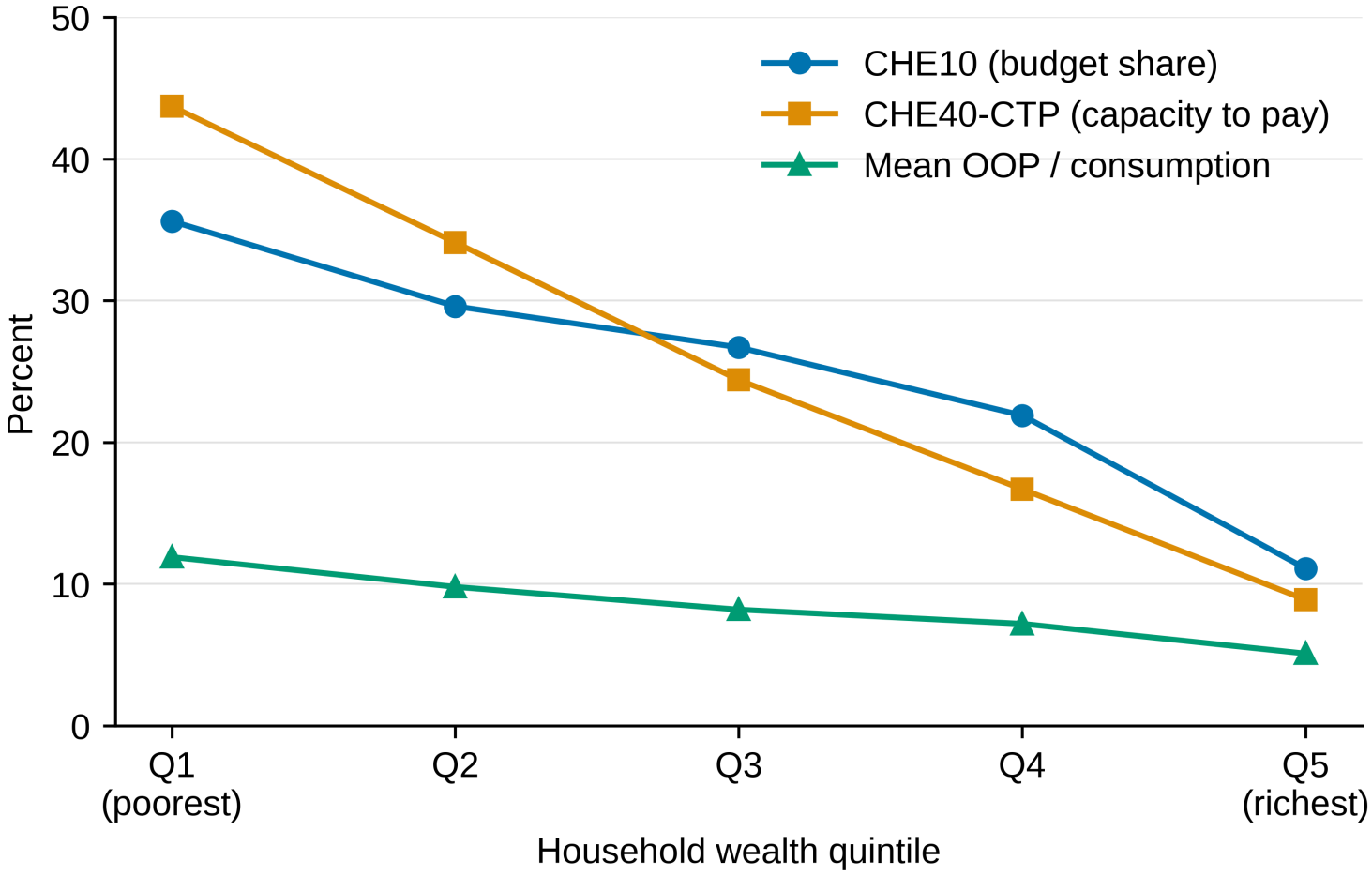


Figure 3

Regressivity of out-of-pocket financing across wealth quintiles. Both catastrophic expenditure and mean out-of-pocket burden decline as household wealth rises

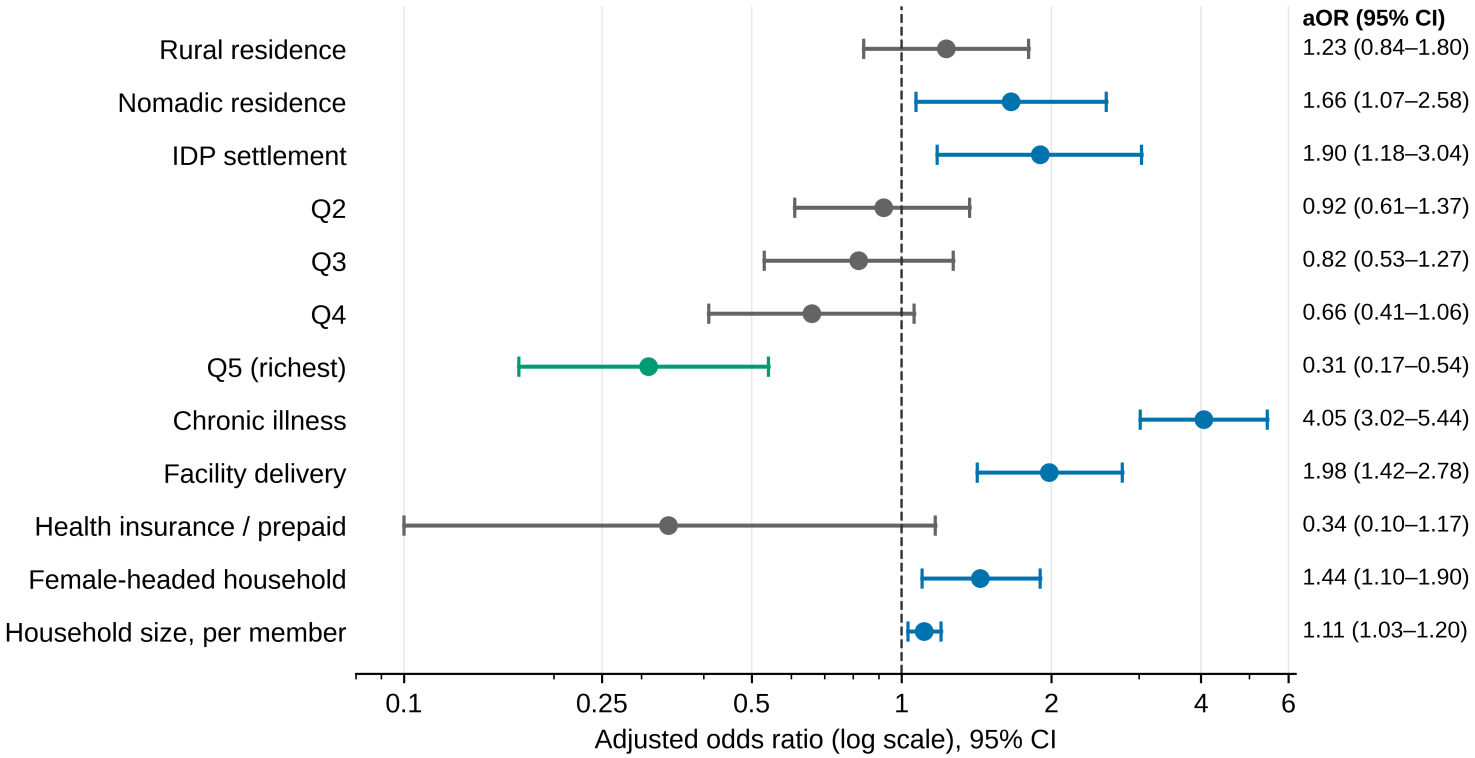


Figure 4

Adjusted odds ratios and 95% confidence intervals for catastrophic health expenditure at the 10% budget-share threshold. Points to the right of unity indicate elevated risk; points to the left indicate protective associations

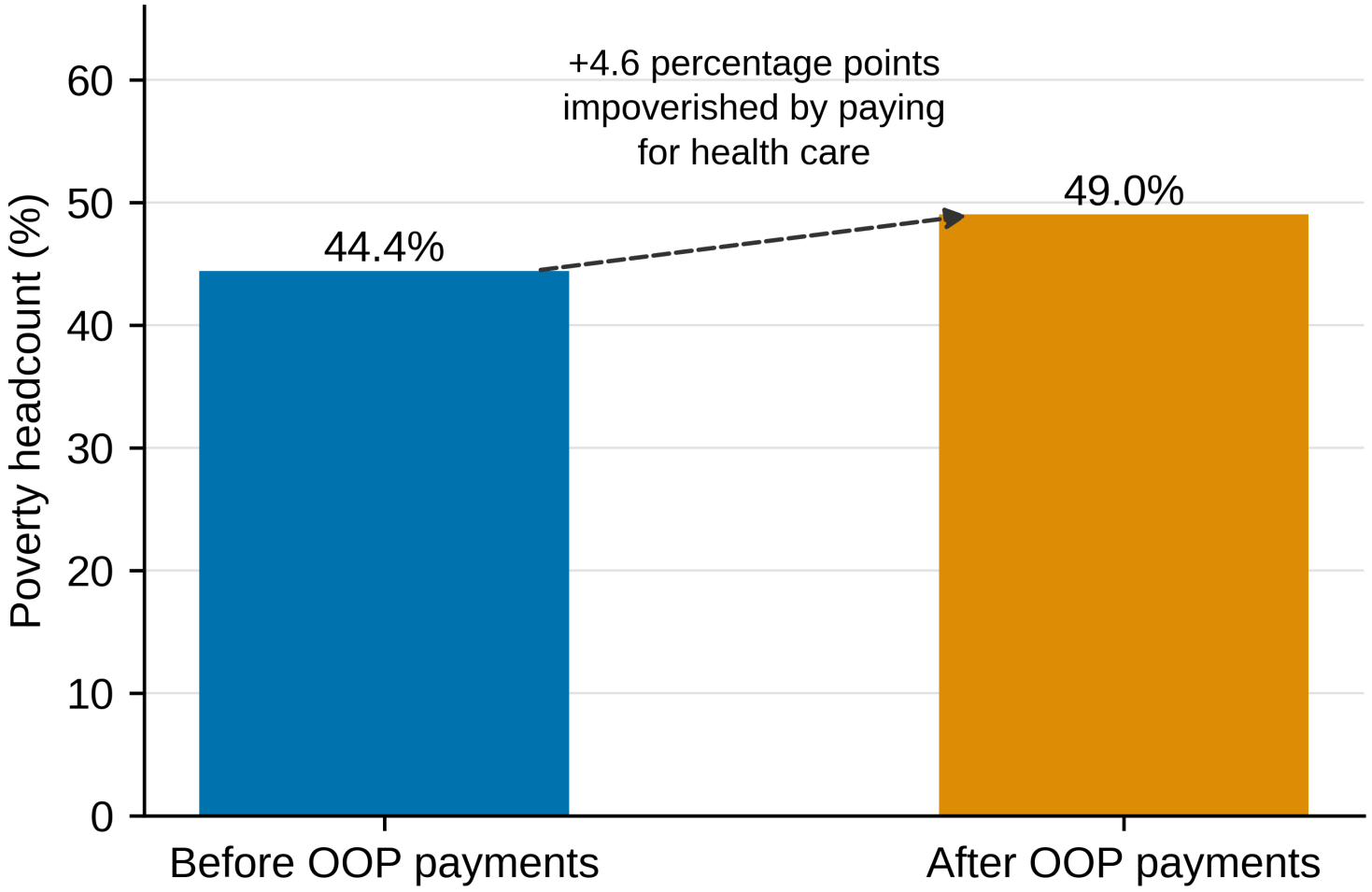


Figure 5

Poverty headcount before and after out-of-pocket health payments. The increment between pre-payment and post-payment poverty represents households impoverished by paying for care

Supplementary Files

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- SupplementaryInformationforCatastrophicHealthExpenditureinSomalia.docx