Economic Burden and distribution of Household Expenditures on Snakebites: Assessing Catastrophic Health Expenditures and Financial Hardship in Rural Uganda

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Abstract

Introduction

: Snakebites remain a major yet long-neglected public health burden, disproportionately affecting the poor communities in rural Uganda. Households continue to unfairly spend out of pocket on snakebites and are further pushed into poverty. The study estimated household economic burdens, Catastrophic Health Expenditure (CHE), and associated socioeconomic inequalities from snakebites in Eastern Uganda.

Methods

This was a cross-sectional study that used an ingredient-based approach to estimate the household costs of management and productivity loss of a snakebites from the household perspective. Two districts from Eastern Uganda with the highest incidence cases were visited for household survey to elicit costs borne by the snake bite victims at community level. CHE was evaluated using expenditure thresholds of 10%, 25%, and 40%. Inequalities were assessed using concentration indices, slope index of inequality (SII), relative index of inequality (RII), Oaxaca–Blinder decomposition, and quantile regression.

Results

CHE related to snakebite was experienced by 31.4% of households at the 40% threshold, with the poorest quintile most affected (χ^2=23.97, $p < 0.001$; SII = − 0.173, $p = 0.011$). Significant disparities in economic burden were found by occupation (hospital costs $p = 0.002$; productivity loss $p = 0.020$), socioeconomic status (hospital costs $p = 0.003$), and hospital visit type ($p < 0.001$). Outpatient care was strongly protective ($p < 0.001$), while hospital admissions drove up costs ($p < 0.001$). Quantile regression showed outpatient care significantly reduced financial burdens ($p < 0.001$), whereas hospitalization increased costs substantially ($p < 0.001$). Decomposition analysis showed structural inequities: middle-income patients faced 55.2% higher unexplained costs than the poorest.

Conclusion

Snakebites led to substantial financial hardship and entrenched inequities for households in Eastern Uganda. Policy responses should prioritize affordable treatment access and financial risk protection for the poorest and most vulnerable populations.

Background

Snakebites pose great economic burden affecting many of the poorest rural low middle-income countries. Globally, 2.7 million people are bitten by snakes; and up to 580,000 and 20,000 snake bites require treatment and lead to fatality annually respectively in Sub-Saharan Africa (1, 2). In Uganda, a recent household based study on indicated the incidence of snakebites at 31.6%; majority of which were from the Eastern region (3).

While some hospital, community-based surveys have established statistics on the incidence of snake bites(3–5), no studies have been done to estimate the economic burden of snakebites in Uganda. Evidence estimates the economic burden to vary between US$126,319 in Burkina Faso to US$13,802,550 in Sri Lanka (6). More so, these studies under-report, do not all cost components, use only the providers' perspective and capture only short-term costs. Use of such estimates can misrepresent the actual economic burden in Uganda where only 1.4% of snake bite victims go to hospitals (3). This is because of the costs incurred by the household respondents in using local remedies and accessing hospital are most likely to be missed. More so, fatalities, disabilities and costs during referrals from lower-level facilities are inaccurately estimated because of missing records. The communities in Uganda continue experience unknown, unfairly and unaccounted for Catastrophic Health Expenditures (CHE) due snakebites.

The World Health Organization (WHO) aims to reduce deaths and disabilities caused by snakebites by a half by the year 2030, alleviating its burden on disadvantaged communities (7). Global recognition of this burden has seen Uganda integrate snakebites into the country's Neglected Tropical Diseases program. Consequently, Uganda recently drafted snakebite prevention and management strategy (8).

Despite these policy advances, critical gaps remain. There is an absence of distribution and cost estimates of management snakebite-associated morbidities, mortalities and disabilities. Therefore, the health system and the community continue to struggle with severe cases, high costs of treatment and difficulty in making case to the government and funders for interventions. More so, cost effective strategies and commodities require cost estimates to justify investments. This study therefore estimated the economic burden including: distribution, CHE, direct and indirect costs for snakebites envenoming in Kamuli and Iganga districts of Eastern Uganda grounded on an adapted Donabedian model (See supplemental material Table S1).

Methods

Study design and setting

This cross-sectional study was based on snakebite events that had already occurred. We retrospectively collected additional data on activities, resource use, and associated costs related to those events.

Two districts of Kamuli and Iganga from Eastern Uganda with the highest incidence cases were visited for household survey (See supplemental material Fig. 1). These were selected based on Ministry of Health surveillance data and prior reports of elevated case numbers. Both districts are predominantly agrarian, with most residents engaged in subsistence farming and limited access to tertiary health facilities.

Study population and sampling

Households were eligible if they reported at least one snakebite incident in the preceding 12 months, confirmed by either (i) a clinical diagnosis from a health facility record, or (ii) a detailed, consistent narrative of the event during the household interview. All snake bite victims identified from reports from the community were considered for interview and verified using probes. The diagnosis of venomous snakebites was difficult at health facility and mostly depended on the right description by victims about the snake (9). We identified households using a two-stage approach: (1) review of health facility outpatient and inpatient registers in selected districts, and (2) referral lists from community health workers and village leaders, to capture cases treated outside formal healthcare.

Eligibility criteria

Eligible individuals were all adults aged 18 years and above, in good health ,able to express themselves verbally and had personally incurred costs due to snakebite. Adults aged 18 years and above were selected because they bear majority of the costs incurred in a typical household (10).Additionally, majority of the incident cases of snakebites in these communities occur within this age group (3). Cases where the primary injury was not a snakebite, or where costs were primarily due to other conditions, were excluded.

Data collection

Data collection tools were designed to capture CHE of patients and caregivers assessing from the start of the event up to when the event completely resolved. We followed up individuals through home visits or using a telephone interview to record out-of-pocket payments incurred. Telephone interviews were conducted when three consecutive attempts to household made were futile. Household heads were interviewed to gather household costs and victims' costs (in case they incurred the costs). Costs borne directly by the victims were solicited from the victims themselves and (or) from those who incurred them other than themselves (victims). Victims of snakebites were accessed through household heads after confirmation of a snakebite (using screening questions) for interviews. The study tools were pretested to ensure their validity, reliability, clarity, suitability, and logical flow; based on the results, necessary revisions were made prior to their deployment in the field.. The tools were pre-tested at a non-participating community in Mayuge District with similar snake bite incidence and community characteristics as the study districts. Research assistants with experience in conducting costing studies and interviews were trained for five days in preparation for data collection. Training included; general understanding of costing approaches, costing perspectives, estimation skills and probing skills. The research assistants were also trained in practical interviewing (including role plays), and note taking during the interview processes.

Data management and analysis

Costing approaches

An ingredient-based approach was used to estimate the cost of management and productivity loss of a snakebite from the household perspective. Human capital approach was used to estimate indirect costs. This was estimated by a product of time loss getting care and average income of household head.

Differences within direct and indirect costs for a snakebite event and socio-economic status, service provider status, age, gender and residence were tested using relevant statistical tests. These included tests for normality or equal variance and when the hypotheses were rejected the Wilcoxon and Kruskal-Wallis rank tests were used when applicable. In this study, principle component analysis (PCA) approach was used to score asset; which are ranked to determine asset quintiles (11, 12).

Catastrophic health expenditures

CHE were calculated using direct costs over the annually income and expenditures for households visited. Data collected on expenditures comprised of healthcare expenses like cost of drugs, bed costs, travel costs, meals and other expenses including going to traditional herbalists and healers. A household experienced catastrophic health expenditures if it spent more than the following thresholds on an event of a snake bite: 10% of its income, 25% of its monthly expenditures or 40% of its monthly expenditures without food (13). These categories were analysed by performing a chi-square test of independence to assess the unadjusted relationship between wealth quintiles and CHE.

Wealth related Equity and Distribution Analysis

To assess socioeconomic inequalities in treatment costs and CHE, the study used the Lorenz curves and calculated both Wagstaff and Erreygers concentration indices. The slope index of inequality (SII) and relative index of inequality (RII) quantified absolute and relative disparities, respectively. Multivariate and quantile regression models were used to adjust for demographic and socio-economic confounders, estimating the effect of wealth and other predictors on the distribution of financial burden. Blinder–Oaxaca decomposition was used to partition cost differences across wealth groups into explained (endowment) and unexplained (structural) components.

Results

Social demographic characteristics of study participants

A total of 150 households reporting a snakebite incident within the past 12 months were interviewed. Participants had an average age of 40.4 years (SD: 12.9), with the 30–39-year age group most represented at 34.0%. The victims' mean age was 38.2 years (SD: 14.4). More than half (53.3%) of the households were headed by males and had 3–5 members (52.0%). Similarly, over a half (54.7%) of the victims were males. Majority of participants were from rural areas (92.0%) while 42.7% were involved in farming. Nearly one-third (35.3%) of participants spent between 150,000/= (39.6 USD) to 300,000/= (79.2 USD)monthly. See Table 1. Other characteristics of repondents were collected detailed in Supplementary Table S2-3 and Supplementary Figs. 2 and 3.

Catastrophic health expenditures related to the incident of a snake bite by asset quintile.

Categories of CHE were analysed to assess the disparity among wealth quintiles. The poorest and poor groups were disproportionately affected with majority spending following into 40% threshold at statistically significant level (χ^2 = 23.9653, $p < 0.001$). See Table 2. We detailed (in supplementary files) the other categories of the CHE and non-CHE of a snake bite across the three thresholds 40% (supplementary Fig. 4), 25% (supplementary Fig. 5) and 10% (supplementary Fig. 6).

Table 2
CHE thresholds categorised by wealth quintiles

Wealth Quintiles	**Experienced Catastrophic Health Expenditure thresholds**		
	CHE at 10%	**CHE at 25%**	**CHE at 40%**
Poorest	11	6	47
Poor	15	10	41
Middle	5	5	12
Wealthy	10	8	33
Wealthiest	4	3	10
Total	**45**	**32**	**143**

CHE 10%: χ^2 = 2.6964, p = 0.610 CHE 25%, χ^2= 5.2573, p = 0.262 CHE 40%, χ^2 = 23.9653, **p < 0.001** Counts shown are cases (households for only those the experienced CHE) for each threshold, by wealth quintile and is not equal to the overall sample size (N = 150).

Slope and Relative Indices of Inequality in Catastrophic Health Expenditure

Our findings indicate that at CHE at the 10% threshold, the SII was 0.218 (95% CI: − 0.039–0.475), indicating a trend toward higher CHE among wealthier individuals, though this was not statistically significant (p = 0.094). At the 25% threshold (CHE2), the SII was smaller and also non-significant (SII = 0.109; p = 0.336). At the 40% threshold, we observed a significant pro-poor inequality, with an SII of − 0.173 (95% CI: − 0.305 – − 0.041; p = 0.011), indicating that poorer individuals are more likely to experience CHE at this higher threshold. The poorest experienced CHE at 83% the rate of the average. See Table 3.

Table 3
Slope and Relative Indices of Inequality in Catastrophic Health Expenditure (CHE) at 10%, 25%, and 40% Thresholds by Socioeconomic Rank

Variable	SII (95% CI)	RII	Mean Outcome	p-value
CHE at 10%	0.218 (−0.039–0.475)	1.14	0.191	0.094
CHE at 25%	0.109 (−0.114–0.331)	1.07	0.159	0.336
CHE at 40%	−0.173 (−0.305 − − 0.041)	0.83	1.04	**0.011**

Note: SII = Slope Index of Inequality; RII = Relative Index of Inequality. Positive SII indicates higher values among wealthier individuals; negative SII indicates higher values among poorer individuals.

Quantile Regression of Financial Burden

In adjusted quantile regression models, household wealth was inversely associated with financial burden across the distribution, though not significantly, with the largest reduction observed at the 75th percentile (−3.9 pp; p = 0.306). Adults aged 30−49 and 50 + experienced significantly lower burdens at the lower tail (−8.7 pp, p = 0.018; − 9.6 pp, p = 0.022, respectively), but not at higher quantiles. Gender and residence showed no significant effects, though urban and male respondents tended to bear slightly higher burdens. Occupational categories were not significantly associated with burden, but manual labor showed a positive association at the upper tail in prior models. Outpatient care was strongly protective, reducing burden by 24.1–85.8 pp across quantiles (all p < 0.01), while hospital-based care significantly increased burden by 30.1–63.4 pp (all p < 0.001). iTraditional healer uses and household size had no measurable impact. Severity was positively associated with burden, particularly for severe cases, but estimates were not statistically significant. See Table 4.

Table 4
Quantile regression coefficients of Financial Burden (% of monthly income)

Predictor	25th percentile	50th percentile	75th percentile
Wealth score (per quintile)	−0.813 (0.993)	−2.609 (1.596)	−3.919 (3.817)
Age			
< 30 years	1	1	1
30–49 years	**−8.729* (3.635)**	−4.953 (5.843)	−16.070 (13.975)
50 + years	**−9.553* (4.116)**	−9.516 (6.617)	−24.571 (15.826)
Gender			
Males	1	1	1
Female	−4.088 (2.669)	−1.977 (4.291)	2.775 (10.263)
Residence			
Rural	1	1	1
Urban	4.191 (4.514)	−0.000 (7.256)	7.259 (17.353)
Occupation			
Manual Labour	1	1	1
Professional	−5.477 (3.397)	−1.623 (5.460)	−6.321 (13.059)
Sales & services	−0.966 (3.250)	−1.039 (5.225)	−4.858 (12.495)
Visit type			
Inpatient	1	1	1
Outpatient	**−24.074*** (4.713)**	**−22.226** (7.576)**	**−85.834*** (18.120)**
Went to hospital			
No	1	1	1
Yes	**30.126*** (3.451)**	**46.543*** (5.547)**	**63.358*** (13.267)**
Used traditional remedies			
No	1	1	1
Yes	0.538 (3.847)	2.547 (6.185)	15.026 (14.792)
Severity			
IPD moderately severe	1	1	1
OPD non-severe	22.768 (12.117)	35.501 (19.478)	56.066 (46.584)
Severe	15.586 (11.319)	28.528 (18.195)	53.899 (43.516)
Family Size			
≤ 2 members	1	1	1

Note. Estimates are coefficient (SE) with 95% confidence interval in brackets. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. Models estimated at $\tau = 0.25, 0.50, 0.75$ with 200 bootstrap replications; N = 145; Pseudo $R^2 = 0.332, 0.388, 0.420$.

Predictor	25th percentile	50th percentile	75th percentile
3–5 members	1.612 (6.933)	2.810 (11.145)	5.884 (26.654)
6–10 members	3.264 (7.184)	3.596 (11.549)	2.692 (27.620)
> 10 members	1.414 (7.581)	4.826 (12.186)	0.728 (29.146)
Note. Estimates are coefficient (SE) with 95% confidence interval in brackets. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. Models estimated at τ = 0.25, 0.50, 0.75 with 200 bootstrap replications; N = 145; Pseudo R^2 = 0.332, 0.388, 0.420.			

Costs incurred by the snakebite victims

Using Blinder–Oaxaca decomposition, we examined the mean cost differentials between the middle-wealth quintile (Q3) and other wealth groups, partitioning the observed gaps into explained (endowment) and unexplained (coefficient and interaction) components. Wealthier patients incurred higher treatment costs compared to poorer patients. Decomposition analysis showed that 44.8% of the cost gap between the middle quintile and the poorest quintile was explained by observable characteristics (e.g., type of facility, age, occupation), while 55.2% was unexplained, suggesting structural inequities in access, quality, or intensity of care. A similar pattern was observed between the richest and middle quintiles, with 43% of the cost gap unexplained. Table 5.

Table 5
Oaxaca–Blinder decomposition of mean OverallCosts (high quintile 3 vs lower quintiles)

Comparison	H	L	R = H–L	E (endowments)	C (coefficients)	CE (interaction)	% explained	% unexplained
vs Q1	260.0 K	76.0 K	184.0 K	81.0 K	88.0 K	12.0 K	44.80%	55.20%
vs Q2	260.0 K	200.0 K	60.0 K	130.0 K	44.0 K	−110.0 K	211.70%	−111.7%
vs Q4	260.0 K	140.0 K	120.0 K	14.0 K	150.0 K	−49.0 K	12.10%	87.90%
vs Q5	260.0 K	120.0 K	140.0 K	77.0 K	110.0 K	−50.0 K	56.60%	43.40%
Notes: H = mean prediction for quintile 3; L = for comparison quintile; R = raw gap. E, C, CE sum to R (E + C + CE = R). % explained = (E + D·CE)/R, % unexplained = (C + (1−D) ·CE)/R; D ≈ relative size of Q3 in pooled sample (20–46%). K-1000 Reference: pooled model coefficients.								

Discussion

This study provides the first community-level evidence from Uganda that snakebites is not only an emergency but also a significant and inequitable economic shock for affected households. The findings show that costs of management of a snakebite and productivity losses can consume a substantial share of household resources, with the poorest bearing a disproportionately high risk of CHE(7, 13). By linking financial burden to socioeconomic position, care pathway, and structural inequities in cost allocation, our results add critical detail to the understanding of snakebite's broader public health and economic impact in rural sub-Saharan Africa.

Our findings are consistent with reports from other low- and middle-income countries showing that even modest absolute treatment costs can be catastrophic relative to income in rural settings (6, 14). In Sri Lanka, where public healthcare is free, median household costs were lower than those observed here, yet still imposed significant hardship(15). The high CHE prevalence in our cohort mirrors WHO's observation that nearly any hospital-treated snakebite in poor communities can meet CHE thresholds CHE(7). Similar torural India, where households often resort to debt or asset sales to cover treatment (16), our data indicated that many Ugandan families face acute financial distress after snakebite. This aligns with the conceptualization of snakebite as a “disease of poverty”—a term applied due to its disproportionate burden on agricultural workers in low-resource settings and its capacity to entrench poverty through direct and indirect costs(17, 18).

The magnitude of burden varied sharply with care pathway. Hospital admissions were associated with substantially greater costs and income loss than outpatient treatment, consistent with the greater severity and higher resource intensity of inpatient cases (19). Outpatient care was strongly protective in our quantile regression models, supporting the hypothesis that early, less severe cases avoid costly escalation(20). Traditional healer use had no measurable net impact, suggesting that patients may pay for both traditional and biomedical care when symptoms progress, a pattern documented in Myanmar and parts of sub-Saharan Africa (21).

Our Blinder–Oaxaca decomposition revealed that more than half of the cost gap between the poorest and middle-income patients was unexplained by observable characteristics such as age or facility type, pointing to structural inequities in care pricing and provision. Similar unexplained gaps were observed at higher income levels, suggesting that ability to pay may influence treatment intensity or pricing, creating a two-tiered care environment (22). This form of horizontal inequity where patients with similar clinical needs face different costs has been documented in other out-of-pocket financing contexts and undermines equity in access to effective care(23).

Occupation and age shaped the nature of losses. Professionals tended to incur higher productivity losses than farmers or manual laborers, likely reflecting higher daily wages and less substitutable work (24). Peak burden was observed among adults aged 30–39 years, a prime working age with heavy family responsibilities, amplifying the household impact(25). Older adults bore slightly less measurable financial loss, possibly due to reduced earning capacity or support from adult children, though other studies associate older age with worse clinical outcomes and potentially higher treatment needs(26, 27).

The high CHE rates and wealth-linked disparities highlight the urgency of integrating financial protection into snakebite management in Uganda. Policy options include subsidising and waiving in and out of hospital fees for the poorest as well as decentralising antivenom availability to lower-level facilities(7, 28). Such measures could prevent progression, reduce the need for costly inpatient stays, and avoid treatment delays driven by cost concerns [20].

Strengthening antivenom supply chains and regulating prices is essential; current African market prices can represent several months’ income for rural households (29). Culturally sensitive strategies—such as engaging traditional healers in early referral pathways—may improve timely access to biomedical care(30). Beyond the health sector, social protection measures, including emergency cash transfers or agricultural insurance, could help households recover financially after severe snakebite envenoming, aligning with WHO’s global target to halve the snakebite burden by 2030(31).

Limitations

This cross-sectional, retrospective design relied on self-reported data, which may be subject to recall bias, especially for indirect costs. Seasonal income variation was not captured, and intangible costs—such as psychological distress, disability, or social disruption were excluded, likely underestimating total burden(32). The study could possibly have selection bias if the most financially devastated households were unavailable for interview. Finally, the study was conducted in two high-incidence districts, which may limit generalisability to areas with different incidence rates, health service availability, or snake species.

Prospective cohort studies could better quantify long-term costs, productivity losses, and coping strategies, including debt and asset liquidation (33). Given the strong protective effect of outpatient care, cost-effectiveness analyses of early-intervention models are needed. Mixed-methods research could illuminate cultural and behavioural determinants of careseeking, informing locally tailored strategies. Trials of financial protection mechanisms, including insurance schemes and cash transfers, could test scalable solutions to prevent impoverishment after snakebite.

Conclusion

Snakebites in rural Uganda imposes a substantial and inequitable economic burden, particularly on the poorest households, and structural inequities exacerbate these disparities. Addressing this dual clinical and economic challenge requires integrated strategies spanning prevention, timely treatment, and financial risk protection. Such measures are essential to break the cycle in which a single envenoming can plunge a vulnerable household deeper into poverty, and to realise both the health and equity goals of the global snakebite agenda.

Declarations

Ethics approval and consent to participate

Approval to conduct the study was obtained from the Makerere university school of Biomedical Sciences Research and Ethics committee (IRB Number: SBS-2022-272). Permission was also sought at districts level (from the office of the district health offices Kamuli and Iganga), local council chairpersons and the health facility in-charges. Written informed consent were signed and kept secured in a lockable cabinet at the study site. During the study, questionnaires had serial numbers instead of individuals' names for confidentiality purposes. Individuals were informed of their right to agree to participate or withdraw from the study at any time without fear of any negative repercussions. After informing them of the purpose and procedure related to the study, a written informed consent was sought from the study participants. All principles of research involving human subjects outlined in the Declaration of Helsinki were adhered to.

Consent for publication

Not applicable

Availability of data and materials

Data will be provided on request from the corresponding author.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

MM contributed to the conception and design of the study, data analysis, drafting and final review of the manuscript. SK provided oversight for the study design, guided data interpretation, and critically reviewed and revised the manuscript preparation and write-up. JT assisted in data acquisition and interpretation, and contributed to the drafting and revision of the manuscript. GW and PMA participated in data analysis, interpretation and critical revision of the manuscript for intellectual content. PA, BDN and VAJ contributed to the analysis and interpretation of data and substantially revised the manuscript. DK supervised the research, provided critical insights into the interpretation of findings, and reviewed the manuscript substantively. All authors reviewed and approved the final manuscript.

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Table 1

Table 1 is available in the Supplementary Files section.

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