



# What contributes to out-of-pocket health expenditure in Cambodia's uncovered population? A distributional and decomposition analysis using survey data

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## ABSTRACT

**Introduction:** Out-of-pocket health expenditures (OOPE) are an inefficient and inequitable means of health financing. Identifying the factors driving these expenditures is crucial to design effective prepayment schemes. This study uses Cambodia—a country with high OOPE and prevalent informal employment—as a case study to analyse the relative contributions of *healthcare*, *health*, and *social* factors to OOPE and the OOPE budget share (OOPE as a proportion of total annual household expenditure) across different points in their distribution.

**Methods:** We used data from a 2023 cross-sectional survey among 3254 households engaged in informal employment with no access to prepayment schemes (uncovered households). We employed unconditional quantile regression to investigate the distributional effects of *healthcare*, *health*, and *social* factors on OOPE and the OOPE budget share. To examine the heterogeneity in the contributions of these factors to the explained variance in OOPE and the OOPE budget share at different quantiles, we combined unconditional quantile regression with Shapley decomposition.

**Results:** Uncovered households incurred high OOPE, leading to elevated incidences of financial hardship. *Healthcare* factors, including levels of care, private providers, medications, and visits were the largest contributors to the explained variance in OOPE and the OOPE budget share. *Health* factors, including severity, days lost to illness/injury, noncommunicable diseases, and injuries, also contributed substantially. *Social* factors contributed less overall, with wealth being the primary driver. Contributions of these factors varied across different points in the outcome distributions.

**Conclusion:** These findings underscore the need to improve financial protection for uncovered households. The Cambodian government should consider expanding prepayment schemes that directly address the main healthcare drivers identified in this study. Schemes should provide effective access to comprehensive outpatient care and essential medications, and necessary services at higher care levels, including in the private sector. Addressing the rising burden of noncommunicable diseases alongside multisectoral efforts to reduce injuries may also be important.

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## 1. Introduction

Since the inclusion of universal health coverage (UHC) within the United Nations sustainable development goals, there has been an intensified focus on out-of-pocket health expenditures (OOPE) and financial protection in health policy and practice. OOPE have long been recognized as an inequitable and inefficient source of health financing, with recent evidence also illustrating how reliance on OOPE impedes inclusive social and economic progress (World Bank Group, 2019). Alongside global financial protection monitoring efforts by the World Health Organization and the World Bank, a substantial body of academic literature has assessed financial protection, with a particular emphasis on catastrophic and impoverishing health expenditures. While tracking progress in financial protection is essential, it is equally important to understand the determinants of OOPE to inform the design of effective health financing and social health protection (SHP) schemes that reduce the financial risks patients and households face when seeking necessary care. Therefore, this study uses a large cross-sectional dataset from 2023 in Cambodia to analyse the relative contributions of *healthcare*, *health*, and *social* factors to OOPE and the OOPE budget share across different points in their distribution. Our research makes several contributions to the literature.

First, while numerous studies have investigated the determinants of OOPE in low- and middle-income countries (LMICs), most have focused on mean effects. However, the effects of determinants can vary across the OOPE distribution, making it crucial to understand such variations to inform effective financial protection policy. We contribute to the existing evidence by employing unconditional quantile regression (UQR) to analyse the determinants at different quantiles of the OOPE distribution. Although several studies have applied conditional quantile regression in the context of OOPE, only two have utilized UQR, with only (Zewde et al., 2023) analysing the determinants of OOPE. In addition to OOPE, we examine the OOPE budget share, an important financial protection indicator that serves as the continuous construct underlying catastrophic spending, which has received little attention in the literature.

Second, building on recent advancements in research on health inequalities (Davillas and Jones, 2020; Sinha et al., 2021), we combine Shapley decomposition with UQR. This approach allows us to quantify the relative contributions of various factors to the explained variance in OOPE and the OOPE budget share across different quantiles. This is the first study to apply these combined methods in the context of OOPE and financial protection. This methodology enables the identification of factors that disproportionately affect households at higher or lower OOPE and budget share levels, informing policy measures targeted to different population segments.

Third, our study specifically focuses on nonpoor informal workers and their dependents, a demographic often left behind in health financing and SHP reforms in LMICs owing to the challenges of extending coverage to this group (A. Kaiser et al., 2023; Kutzin et al., 2016) that is also underrepresented in the scientific literature.

Our findings showed that *healthcare* factors, including private providers, higher levels of care, medications, inpatient nights, and outpatient visits, are the largest contributors to OOPE and the OOPE budget share in Cambodia, followed by *health* factors such as illness severity, days lost to illness/injury, and noncommunicable diseases (NCDs). We recommend expanding noncontributory prepayment schemes to nonpoor informal workers and their dependents, with scheme design targeting these key *healthcare* and *health* contributors.

### 1.1. Study context

Our analyses focus on Cambodia, a lower middle-income country in Southeast Asia with a population of approximately 15.6 million people (National Institute of Statistics, 2019). Over the past two decades, Cambodia has achieved significant economic growth and poverty

reduction. However, many Cambodians remain at the lower end of the wealth distribution, leaving them vulnerable to economic shocks and life-cycle risks (World Bank Group, 2022). Additionally, 88.3% of Cambodian workers are engaged in informal employment, limiting their access to social protection schemes and reducing government revenue capacity (International Labour Organization, 2023).

The Cambodian SHP system includes the National Social Security Fund (NSSF) and the Health Equity Fund (HEF). The NSSF provides coverage for formal workers, civil servants, and dependents, financed through mandatory employee contributions. The HEF provides free access to public healthcare for poor and vulnerable households, supported by general government expenditure and development partner contributions. In 2023, the NSSF introduced voluntary contributory enrolment for own-account workers. While uptake has exceeded expectations, the scheme faces challenges common to voluntary health insurance, such as adverse selection (Mathauer and Kutzin, 2018). As of 2024, these schemes cover approximately 41% of the population (National Social Protection Council, 2024). This leaves a substantial segment of the population, primarily nonpoor workers in informal employment and their dependents (referred to as uncovered households) without SHP coverage.

Cambodia's health spending is relatively high, averaging 7.53% of gross domestic product on current health expenditure (CHE) in 2021, the highest among Southeast Asian LMICs and above the global LMIC average of 5.44%. However, general government health expenditure accounted for only 26.58% of CHE, far below the global LMIC average of 51.71%, and is the second lowest in Southeast Asia after Myanmar (World Bank, 2024). This translates into a heavy reliance on OOPE, which comprises approximately 54.94% of CHE (World Bank, 2024), leaving especially uncovered households at substantial risk of financial hardship (Kaiser et al., 2023). Beyond insufficient public financing, Cambodia's health system faces supply-side challenges, including shortages of trained healthcare workers, inadequate equipment and medical supplies, and service delivery issues, resulting in limited availability, accessibility, and quality of health services. A comprehensive overview of Cambodia's health system and its challenges is available in (World Health Organization, 2015).

In May 2024, the Cambodian government reaffirmed its commitment to UHC by launching the UHC Roadmap 2024–2035. This roadmap aims to increase population coverage to 80% and reduce OOPE to 35% of CHE (National Social Protection Council, 2024). Our study provides timely insights to support these efforts and offers lessons for other LMICs facing similar challenges with informal employment and SHP expansion.

## 2. Materials and methods

### 2.1. Data

Our study utilized data from a cross-sectional survey conducted between June and July 2023, involving 3,254 households (15,421 individuals) not covered by Cambodia's SHP mechanisms or other prepayment schemes. We employed a multistage clustered approach across seven provinces. These were purposively selected to represent the five geographic zones of Cambodia and collectively represent approximately 46.28% of the Cambodian population. All districts within these provinces were included and a total of 102 communes were randomly selected from these districts to serve as primary clustering units. In each commune, all villages were visited. Households were selected via a systematic random walk method, targeting homes with at least one member who accessed preventive or outpatient services within the last 30 days and/or inpatient care in the past 12 months. A structured questionnaire was administered to the head of the selected households to gather detailed information on household demographic, socioeconomic, and health characteristics, as well as household consumption. The questionnaire also gathered detailed data on outpatient, inpatient, and preventive service utilization for all household members. Data

collection was carried out by a Cambodian research firm. The National Ethics Committee for Health Research of the Ministry of Health Cambodia granted ethical approval for this study in May 2023 (Ref. no. 142).

2.2. Outcome measures

We focused on two continuous outcome measures: total OOPE and the OOPE budget share. Total OOPE was defined as the aggregate annual household medical expenditure on healthcare incurred at the point of service for both outpatient and inpatient care, based on the 5,243 outpatient and 714 inpatient care-episodes captured in our data. The OOPE budget share was determined as the share of total annual household consumption expenditure (THCE) allocated to total OOPE (A. H. Kaiser et al., 2023; Mancini and Vecchi, 2022). Additionally, we conducted separate analyses for outpatient and inpatient OOPE. To address the skewness displayed by our outcome measures, we applied a natural logarithm transformation to all outcome variables in our regression and decomposition analyses.

All measures were assessed at the household level, involving the aggregation of individual visit-level data on healthcare utilization and OOPE to a household aggregate. To ensure consistency across time-frames, we annualized the data for a 12-month period. Both adjustments align with commonly employed methodologies in the measurement of financial protection in health (O'Donnell et al., 2008; Wagstaff et al., 2020). Furthermore, all monetary values were converted into 2023 US-dollars, utilizing an average exchange rate of 4100 Khmer Riel to 1 US-dollar for that year.

2.3. Explanatory variables

We selected explanatory variables based on established health economics theories and a literature review on the determinants of OOPE and financial protection. Variables were categorized into three groups on the basis of their potential modifiability through public policy following (Haakenstad et al., 2022).

- **Healthcare** factors included the sector of care (public, private, overseas, nonmedical), level of care (pharmacy, primary, secondary, tertiary), and intensity of healthcare utilization within the household (annualized number of outpatient visits, inpatient nights and medications). Sectors and levels were categorized according to the Cambodian Ministry of Health's framework (Ministry of Health Cambodia, 2023).
- **Health** factors included the share of household members with chronic illnesses, disabilities, and self-reported health rated as less than good and the severity of conditions and productive days lost to illness/injury (both transformed using a natural log to address skewness). The causes of illness were categorized into communicable diseases, NCDs, maternal, neonatal, and nutritional diseases (MNNDs), and injuries, violence, self-harm, and accidents (injuries), following the Global Burden of Disease framework (Roser et al., 2021).
- **Social** factors included demographic factors such as household size, head of household characteristics, employment ratio, share of household members under five and over 60 years of age, and socioeconomic variables such as the consumption-based wealth quintile, outstanding debt, and geographic domain.

Table 1 presents the values of the included factors alongside their standard errors (SEs). Tables S1–S4 in the Supplementary information illustrate the values of these factors across selected quantiles for all outcomes.

2.4. Quantile regression and decomposition methods

To investigate the distributional effects of the *healthcare, health, and*

**Table 1**  
*Healthcare, health, and social factors at the household level.*

	Value	Standard error
<b>Healthcare factors</b>		
<i>Sector of care</i>		
Public outpatient	3.90%	0.01
Public inpatient	2.51%	0.01
Private outpatient	80.26%	0.01
Private inpatient	11.84%	0.01
Nonmedical	0.11%	0.00
Overseas	1.38%	0.00
<i>Highest level of care</i>		
Ancillary (pharmacy)	58.92%	0.21
Primary	28.51%	0.18
Secondary	34.95%	0.15
Tertiary	4.30%	0.06
Mean (median) inpatient nights (12 months) *	4.41 (3.00)	2.84
Mean (median) outpatient visits (30 days)#	1.72 (1.00)	0.37
Mean (median) outpatient medications (30 days)#	5.03 (4.00)	0.14
<b>Health factors</b>		
Share HHMs with chronic illness	18.30%	0.95
Share HHMs with disability	9.83%	0.68
Share HHMs in self-reported health < good	52.32%	1.52
Mean days lost to illness/injury	8.65	0.76
<i>Cause of illness</i>		
Maternal, neonatal, and nutritional diseases	8.98%	0.73
Communicable diseases	67.46%	1.90
Noncommunicable diseases	47.72%	1.53
Injuries	4.50%	0.41
<b>Social factors</b>		
Mean household size	3.95	0.08
Mean head of household age	46.75	0.63
Share female head of household	35.56%	4.06
Share HHMs under 5	9.93%	0.62
Share HHMs over 60	11.36%	0.79
Employment ratio	46.46%	0.81
Total indebtedness	\$2829	422
<i>Geographical domain</i>		
Capital	34.72%	0.99
Other urban	2.93%	0.21
Rural	62.35%	0.96

**Abbreviations:** HHM = household member.

**Notes:** \* For households who sought inpatient care. # For households who sought outpatient care.

*social* factors on the outcome measures, we applied UQR. Unlike conditional quantile regression—which assesses the influence of explanatory variables at different quantiles of an outcome's distribution conditional on the levels of other explanatory variables—UQR examines associations across the entire distribution without conditioning on other variables. This enables the estimation of unconditional partial effects (Davillas and Jones, 2020; Firpo et al., 2009; Sinha et al., 2021). UQR was implemented using recentred influence functions (RIF) through several steps. Initially, we estimated the sample quantiles  $q_\tau$  of our outcomes at the 10th, 25th, 50th, 75th, and 90th quantiles (Q10 to Q90). We then determined the density  $f_Y(q_\tau)$  of the distribution of our outcomes at these quantiles via kernel density estimation methods (Davillas and Jones, 2020; Firpo et al., 2009; Sinha et al., 2021) and computed the RIF for each quantile  $q_\tau$  as:

$$RIF(Y, q_\tau) = q_\tau + \frac{\tau - 1(Y \leq q_\tau)}{f_Y(q_\tau)} \tag{1}$$

where  $q_\tau$  denotes the quantile;  $\tau$  the quantile level;  $1(Y \leq q_\tau)$  is an indicator function equal to 1 if  $Y$  is less than or equal to the quantile  $q_\tau$  and 0 otherwise; and  $f_Y(q_\tau)$  is the estimated density of  $Y$  at  $q_\tau$  (Firpo et al., 2009).

We then regressed the RIFs for each quantile on our *healthcare, health, and social* factors using ordinary least squares regression (Firpo et al., 2009).

Building on recent advancements in health inequality research, we then combined UQR with Shapley decomposition to analyse the heterogeneity in contributions of explanatory variables to the explained variance ( $R^2$ ) across quantiles of our OOOPE outcomes and the OOOPE budget share (Davillas and Jones, 2020; Huettner and Sunder, 2012; Shorrocks, 2013; Sinha et al., 2021). Analogous to the decomposition of means, the decomposition of the RIFs calculates each explanatory variable's contribution to the total explained variance by considering all possible permutations of explanatory variables and averaging their marginal effects (Shorrocks, 2013). Shapley decomposition ensures order (path) independence, ensuring that contributions are unaffected by the order in which variables are entered or removed from the model, and additivity, meaning that contributions sum precisely to the total explained variance (Huettner and Sunder, 2012; Shorrocks, 2013). Further methodological details are available in (Israeli, 2007). Contributions were quantified as proportions of the total explained variance (Davillas and Jones, 2020; Huettner and Sunder, 2012) for our three groups and individual variables. To estimate uncertainty, we employed bootstrapping with 1000 replications to calculate confidence intervals for the contributions of individual variables and groups.

We conducted all the statistical analyses in Stata 18.0. Our descriptive statistics and the UQR analysis were weighted using household-level sampling weights to ensure representativeness of the findings for the uncovered population in the selected provinces. For the decomposition analysis, we applied clustered standard errors to correct for within-cluster correlation. While we present a succinct summary of the UQR analyses, our detailed focus in the results section lies in the Shapley decomposition results to illustrate the varying contributions of our explanatory variables and groups across specified quantiles.

### 3. Results

An overwhelming majority of households, 99.25% (SE 0.20), reported incurring inpatient and outpatient OOOPE. The mean total OOOPE was \$475.30 (SE 31.70), with annual outpatient and inpatient OOOPE averaging \$372.76 (SE 26.45) and \$517.18 (SE 54.95), respectively. The median values for total, outpatient, and inpatient OOOPE were \$148.37, \$118.70, and \$128.05, respectively. The mean OOOPE budget share was 7.84% (SE 0.49), with a median of 3.73%. This resulted in an average incidence of catastrophic health expenditure of 24.24% (SE 1.53) at the threshold of 10% of THCE and 5.98% (SE 1.04) at the 25% threshold, and an incidence of impoverishment of 6.67% of households using Cambodia's national poverty line. Although not primary outcome measures in this study, these indicators of financial protection provide important context to the financial burdens faced by households due to OOOPE.

#### 3.1. Quantile regression results

*Healthcare* factors consistently showed that higher levels of care and opting for private care significantly increased all measured outcomes across nearly all quantiles. The number of medications significantly elevated total OOOPE, outpatient OOOPE, and the OOOPE budget share throughout the distribution. Inpatient nights were a significant factor in increasing inpatient OOOPE from Q25 onward. Among *health* factors, severity significantly increased total and outpatient OOOPE and the OOOPE budget share across all quantiles, though it was significant only at Q10 for inpatient OOOPE. Days lost to illness/injury increased outpatient OOOPE significantly across quantiles and was significant at median and higher quantiles for total OOOPE, inpatient OOOPE, and the budget share. NCDs significantly raised total and outpatient OOOPE, as well as the budget share, from the lower to median quantiles. Injuries significantly increased these outcomes from the median to higher quantiles. Specifically for inpatient OOOPE, injuries were a significant driver from Q25 to Q90, unlike NCDs, which had a nonsignificant negative effect. Chronic illnesses and disabilities generally led to significantly higher OOOPE

outcomes and the budget share at median and higher quantiles. Concerning the *social* factors, we observed a significant wealth gradient across all outcomes. For total, outpatient, and inpatient OOOPE, households in higher wealth quintiles experienced increased expenditures across all quantiles. Conversely, this gradient reversed for the OOOPE budget share, indicating that lower quintiles faced a greater financial burden, with significant effects up to the median (Q50). Other *social* factors, including household size, head of household age and gender, employment ratio, the presence of young children under 5, and geographic location influenced outcomes at certain quantiles, although effects varied in direction, magnitude, and significance across quantiles. Detailed tables describing these findings are available in [Supplementary Tables S5–S8](#).

#### 3.2. Shapley decomposition results

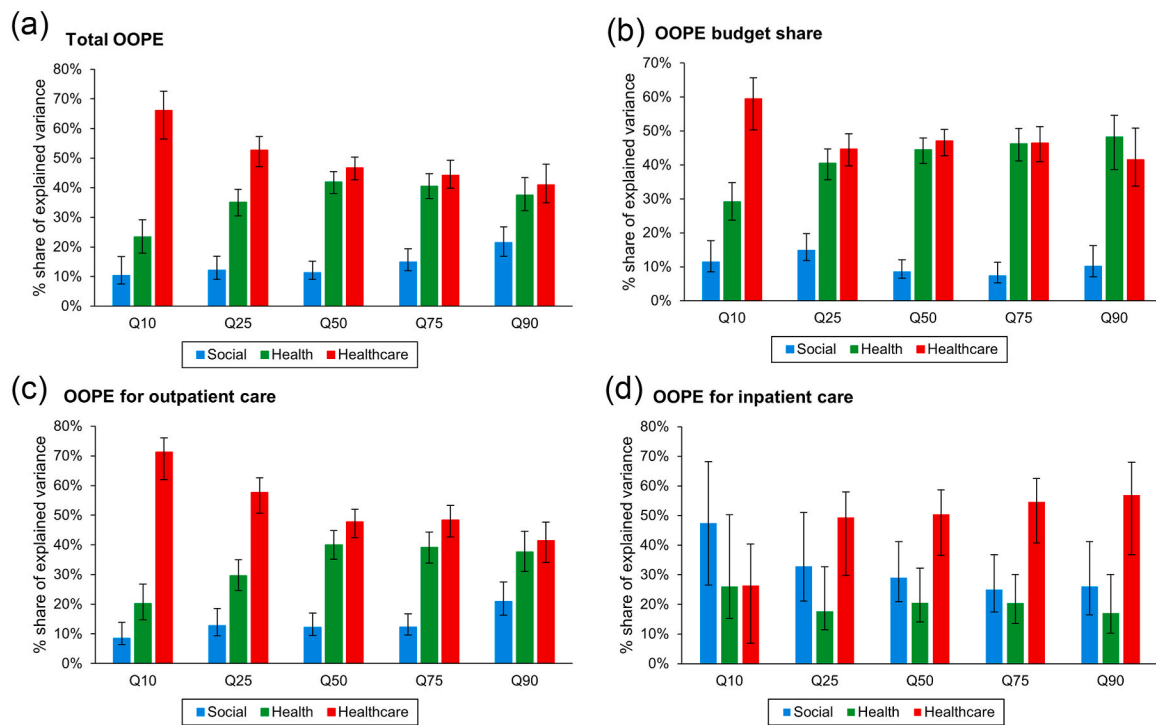
[Fig. 1a–d](#) illustrate the *healthcare*, *health*, and *social* contributions to the explained variance in our outcomes across specified quantiles. For numerical data, see [Supplementary Table S9](#). For total OOOPE, *healthcare* factors emerged as the largest contributors to the explained variance across all quantiles, although their relative importance decreased in magnitude from 66.14% at Q10 to 41.00% at Q90. *Health* factors increased from 23.44% at Q10 to a peak of 41.91% at the median, before slightly receding to 37.55% at Q90. *Social* factors strongly increased across the distribution, doubling their contribution from 10.41% at Q10 to 21.45% at Q90.

Similar patterns were observed in the OOOPE budget share, although *health* factors' contributions consistently increased across quantiles, peaking at 48.19% at Q90 and surpassing *healthcare* factors, which accounted for 41.59% of the explained variance at this quantile. However, *social* factors remained relatively less important across the OOOPE budget share distribution, even showing a decrease in higher quantiles.

For outpatient OOOPE, the contributions from *healthcare* factors were particularly pronounced at Q10, accounting for 71.30% of the explained variance, but decreased to 41.41% by Q90. Conversely, contributions from *health* factors rose substantially, starting at 20.24% at Q10, peaking at 40.04% at the median, and remaining high through Q90. Mirroring the trend observed in total OOOPE, contributions from *social* factors increased consistently across the distribution, reaching a peak of 20.97% of the explained variance at Q90.

OOPE for inpatient care exhibited a distinct pattern. While *healthcare* contributions were initially moderate at 26.43% at Q10, they became the predominant contributors by Q90, accounting for 56.91% of the explained variance. Conversely, *social* factors' contributions started high at 47.51% at Q10 but decreased to 26.03% by Q90. *Health* factors maintained moderate and relatively stable contributions across the distribution, ranging from 26.07% at Q10 to 17.06% at Q90—which are consistently lower than for the other outcomes. The smaller sample size for inpatient care introduced greater uncertainties in the group contributions to inpatient OOOPE, as indicated by the wide confidence intervals.

For total OOOPE, among the *healthcare* factors, private outpatient and inpatient care made substantial contributions at lower quantiles but their relative importance decreased at higher quantiles. Contributions from secondary care were notable, increasing sharply from 5.06% at Q10 to 16.59% at the median, before reducing to 6.95% at Q90. Tertiary care contributions gradually rose, reaching 6.60% at Q90. Both the number of inpatient nights and outpatient visits increased their contributions toward higher quantiles, notably ranking among the top three contributors at Q90. Medications were consistently important, peaking between Q25 and Q75 at close to 8%. Among *health* factors, the severity score was the largest contributor, starting at 14.56% at Q10, peaking at 24.13% at the median, and then decreasing to 16.52% at Q90. Days lost to illness/injury contributed up to 6.38% at Q75, before slightly declining to 5.39% at Q90. NCDs followed a similar pattern, rising to 6.14% at Q50 and tapering off to 4.67% at Q90. In contrast,



**Fig. 1a.** Fig. 1a. Group contributions to the explained variance of total OoPE  
**Fig. 1b.** Group contributions to the explained variance of the OoPE budget share  
**Fig. 1c.** Group contributions to the explained variance of outpatient OoPE  
**Fig. 1d.** Group contributions to the explained variance of inpatient OoPE.

contributions from injuries grew across quintiles, beginning at a modest 0.54% at Q10 and climbing to 6.89% at Q90. The wealth quintile emerged as the primary *social* factor, with its contribution to the explained variance increasing steadily from 4.22% at Q10 to 16.04% at Q90. Other *social* factors generally contributed less than 1% or 2% of the variance.

The patterns observed for outpatient OoPE largely mirrored those for total OoPE across the three groups, with some distinct differences. Among *healthcare* factors, private outpatient care exhibited a greater decline in its contribution than total OoPE did, falling sharply from 44.51% at Q10 to just 0.31% at Q90. Conversely, the contributions from secondary care increased markedly across the distribution, peaking at 22.40% at Q75 and remaining elevated at 17.12% up to Q90. Tertiary care contributions were less pronounced compared to total OoPE. Contributions from outpatient visits and medications were consistently greater across all quintiles for outpatient OoPE, with medications peaking at 12.18% at Q25 and declining slightly to 10.55% at Q90. Among the *health* factors, days lost to illness/injury made more pronounced contributions to the variance in outpatient OoPE than total OoPE, peaking at 9.62% at Q90. NCDs were also more influential in outpatient OoPE, peaking at 8.91% at the median and remaining influential at 5.88% through Q90. In contrast, injuries contributed less, peaking at a modest 2.31% at Q90. Concerning the *social* factors, the wealth quintile again played an important role, showing progressively large contributions to the explained variance across the distribution.

The OoPE budget share findings were largely consistent with the two OoPE outcomes, with some exceptions. Chronic illnesses held greater relative importance for the budget share, with their peak contribution at 5.28% at Q25 and remaining at approximately 4% up until Q90. Notably, the contribution from the wealth quintile peaked at 7.38% at Q25, then decreased strongly to 0.84% by Q90, contrasting with its consistent increase in total and outpatient OoPE. The contributions of all other variables remained within the ranges observed for total OoPE, with some percentage variations.

For comprehensive numerical results across these three outcomes, refer to Table 2. Additional details, including confidence intervals, are available in Supplementary Tables S10–S12. Given the small sample size and consequently high uncertainty, we do not elaborate on individual contributors to inpatient OoPE (see Supplementary information, Table S13).

#### 4. Discussion

Nearly all households incurred OoPE, with a mean of \$475.30 and an OoPE budget share of 7.84%. This translated into high incidences of financial hardship. Notably, while wealthier households spent more in absolute terms, poorer households bore a larger relative financial burden on OoPE. In the Shapley decomposition analysis, *healthcare* factors were the largest contributors to the explained variance in all outcomes, followed by *health* factors. *Social* factors contributed less, with contributions largely driven by wealth quintile across the distribution. Key *healthcare* contributors included higher levels of care, the private sector, medications, outpatient visits, and inpatient nights. *Health* contributions were influenced primarily by the severity score, days lost to illness/injury, NCDs, and injuries. The contributions of these factors varied across the distribution of our outcomes, underscoring the importance of analysing the entire distribution of OoPE and the OoPE budget share; such variations would be masked if analyses were based solely on the mean.

##### 4.1. Interpretations of findings

Studies applying UQR and Shapley decomposition to analyse health expenditures are scarce. An Ethiopian study, which applied UQR to examine the determinants of OoPE, targeted different quintiles (Q20, Q50, Q80), but similarly found significantly greater OoPE among wealthier households and observed that utilizing private providers significantly increased OoPE across all quintiles, both of which accord

**Table 2**  
Shapley decomposition results: contributions to the explained variance in total OOPE, OOPE budget share, and outpatient OOPE.

	Total OOPE					OOPE budget share					Outpatient OOPE				
	Q10	Q25	Q50	Q75	Q90	Q10	Q25	Q50	Q75	Q90	Q10	Q25	Q50	Q75	Q90
<b>Healthcare factors</b>	<b>66.14</b>	<b>52.77</b>	<b>46.71</b>	<b>44.19</b>	<b>41</b>	<b>59.51</b>	<b>44.67</b>	<b>47.09</b>	<b>46.42</b>	<b>41.59</b>	<b>71.3</b>	<b>57.64</b>	<b>47.76</b>	<b>48.42</b>	<b>41.41</b>
<i>Sector of care (Ref: Public outpatient)</i>															
Public inpatient	5.58	1.56	0.98	0.65	0.38	3.00	1.07	0.86	1.09	0.26					
Private outpatient	23.09	9.67	2.59	1.04	1.19	17.93	7.3	2.36	1.54	1.02	44.51	19.74	6.2	0.90	0.31
Private inpatient	9.91	6.34	4.61	3.3	4.11	8.44	6.11	4.08	5.00	2.99					
Overseas	0.53	0.13	0.02	0.17	1.19	0.51	0.09	0.02	0.25	1.70	0.53	0.07	0.04	0.03	0.26
Nonmedical	5.26	4.27	1.26	0.34	0.24	5.96	2.52	1.21	0.52	0.29	3.99	3.32	1.27	0.50	0.27
<i>Level of care (Ref: Ancillary/Pharmacy)</i>															
Primary	5.6	2.07	1.18	0.78	0.52	3.02	1.35	1.21	0.91	0.67	4.12	2.28	0.95	0.98	0.95
Secondary	5.06	11.41	16.59	13.28	6.95	6.10	9.6	18.86	12.95	9.25	3.14	8.86	16.03	22.4	17.12
Tertiary	0.48	1.79	3.58	5.78	6.60	0.47	2.08	3.85	6.33	6.85	0.28	0.55	1.18	3.90	2.91
Number of inpatient nights	0.84	1.49	2.77	4.72	6.82	1.03	1.77	2.42	5.45	8.14					
Number of outpatient visits	4.07	6.08	6.29	6.33	7.04	5.47	6.00	5.62	5.56	4.62	5.67	10.64	10.61	8.71	9.03
Number of medications	5.72	7.96	6.86	7.8	5.95	7.56	6.77	6.59	6.82	5.8	9.07	12.18	11.48	11.00	10.55
<b>Health factors</b>	<b>23.44</b>	<b>35.11</b>	<b>41.91</b>	<b>40.48</b>	<b>37.55</b>	<b>29.11</b>	<b>40.46</b>	<b>44.42</b>	<b>46.25</b>	<b>48.19</b>	<b>20.24</b>	<b>29.61</b>	<b>40.04</b>	<b>39.21</b>	<b>37.62</b>
Share HHMs with chronic illness	2.82	2.33	2.05	1.02	1.38	2.72	5.28	4.11	2.74	3.76	3.44	2.27	2.41	1.69	1.3
Share HHMs with disability	0.15	0.19	0.15	0.73	1.56	0.16	0.41	0.76	0.99	2.19	0.09	0.14	0.43	1.24	2.26
Share HHMs in SRH < good	1.44	1.05	1.05	0.70	0.46	3.22	2.57	1.94	0.98	0.61	2.08	1.23	0.8	1.05	0.47
Severity score (log)	14.56	22.03	24.13	22.78	16.52	18.61	22.52	23.38	24	21.16	10.11	15.68	20.82	17.13	15.07
Days lost to illness/injury (log)	1.50	2.57	5.47	6.38	5.39	1.06	2.55	6.12	6.51	8.3	0.51	2.38	5.69	9.55	9.62
<i>Number of HHMs with disease (Ref: Communicable diseases)</i>															
NCDs	1.96	5.33	6.14	4.97	4.67	2.34	4.5	5.05	5.19	4.46	2.56	6.5	8.91	6.66	5.88
MNNDs	0.48	0.48	1.11	1.01	0.68	0.43	1.45	1.1	0.8	1.33	0.91	1.14	0.50	1.43	0.70
Injuries	0.54	1.13	1.82	3.25	6.89	0.57	1.18	1.97	5.05	6.36	0.53	0.27	0.47	0.44	2.31
<b>Social factors</b>	<b>10.41</b>	<b>12.12</b>	<b>11.38</b>	<b>14.98</b>	<b>21.45</b>	<b>11.38</b>	<b>14.87</b>	<b>8.49</b>	<b>7.32</b>	<b>10.22</b>	<b>8.46</b>	<b>12.75</b>	<b>12.21</b>	<b>12.38</b>	<b>20.97</b>
Household size	0.78	1.58	1.5	1.29	1.23	0.68	0.77	0.61	1.93	2.09	0.55	1.12	1.57	0.92	1.74
HoHH age	0.69	0.84	0.09	0.36	0.62	0.76	1.15	0.74	1.06	1.06	0.65	0.74	0.36	0.39	0.47
HoHH gender	0.38	0.39	0.04	0.36	0.29	0.09	0.07	0.11	0.29	1.25	1.3	0.81	0.08	0.11	0.28
HoHH education	0.37	0.05	0.06	0.07	0.07	0.11	0.31	0.18	0.38	0.1	0.11	0.12	0.12	0.11	0.18
Employment ratio	0.62	0.27	0.24	0.16	0.23	0.12	0.2	0.39	0.27	0.34	0.09	0.26	0.17	0.11	0.12
Share HHMs over 60	0.56	0.74	0.55	0.41	0.42	1.23	1.67	2.35	1.36	0.96	0.73	1.38	1.17	0.68	0.61
Share HHMs under 5	1.49	0.98	0.25	0.4	0.73	1.82	1.91	0.65	0.31	0.9	0.11	0.53	0.32	0.14	0.55
Wealth quintile	4.22	7.00	8.29	11.38	16.04	6.14	7.38	2.63	0.93	0.84	3.28	7.29	8.18	9.36	14.29
Total indebtedness	0.25	0.13	0.18	0.42	1.46	0.2	0.83	0.33	0.23	0.35	0.05	0.12	0.16	0.41	0.55
Geographic domain	1.06	0.14	0.19	0.12	0.35	0.23	0.58	0.49	0.55	2.32	1.59	0.38	0.09	0.16	2.17

**Abbreviations:** HHM = household member; HoHH = head of household; MNNDs = maternal, neonatal, and nutritional diseases; NCDs = noncommunicable diseases; OOPE = out-of-pocket health expenditure; Q10-Q90 = quantiles 10–90; SRH = self-reported health.

with our findings (Zewde et al., 2023). Only one Indian study applied Shapley decomposition to analyse the explained variance in the OOPE budget share at the mean (Haakenstad et al., 2022). While our use of decomposition across the distributions of outcomes is not directly comparable, we draw parallels where relevant.

Concerning the *healthcare* factors, the increasing contributions from the number of inpatient nights and outpatient visits across the distribution of total OOPE and the budget share are unsurprising given their direct financial implications. More outpatient visits and hospital nights drive higher costs, especially for inpatient care, which often requires intensive medical interventions and is commonly charged per night in Cambodia. Notably, at most quantiles for total OOPE, outpatient OOPE, and the budget share, medications contributed more strongly to the explained variance. While neither inpatient nights nor outpatient visits were significant in the UQR analyses for total OOPE and the budget share, medications consistently showed significance across the distribution for these outcomes. This highlights the importance of considering not only the quantity of healthcare visits but also the specific treatments and procedures received, which can significantly impact OOPE and financial burdens. Cambodia's 3,747 private pharmacies play an essential role in the health system, with most patients utilizing them during their care-seeking journey. In private pharmacies, virtually any type of medication is accessible without a prescription, incentivizing self-medication and increasing medication volumes (Bureau-Point et al., 2020; Gryseels et al., 2013). Cambodian medication prices are often

considerably higher than international reference prices (World Health Organization Regional Office for the Western Pacific, 2022). For uncovered households, this situation directly contributes to increased OOPE and budget shares. In the Indian decomposition analysis, private sector medicines explained a striking 35.3% of variation in the OOPE budget share (Haakenstad et al., 2022).

The private sector's significance in the UQR analysis and strong contributions in the Shapley decomposition were noteworthy. In Cambodia, 76.7% of OOPE were directed towards private healthcare in 2016, with studies indicating an increasing trend since then (World Health Organization, 2019). Cambodia has 16,185 private healthcare providers, far outnumbering the 1,474 public health facilities (Ministry of Health Cambodia, 2023). Compared with public facilities, private providers are perceived as more accessible and responsive, despite variable quality and higher prices. Given that uncovered households must pay out-of-pocket in both sectors, the lower costs in public facilities may not offset the inconveniences of longer travel distances, waiting times, and shortages of doctors, equipment, and essential medicines (World Health Organization, 2015). Substantial contributions of secondary care were also noteworthy, partially reflecting the high rate of private care-seeking in our study; over 90% of outpatient visits to secondary care in our study were to private hospitals or clinics. Patients often consult these providers for serious illnesses. Additionally, without a referral or gatekeeping system, patients are not incentivized to seek primary healthcare first, potentially leading to unwarranted utilization

of higher care levels (World Health Organization, 2015). The combined private sector and secondary care contributions overshadowed those of the severity score for total OPE, outpatient OPE, and the budget share. However, the decline in contributions from these variables at higher quantiles was notable. This does not imply that these variables are unimportant but reflects the nature of the data and Shapley decomposition. At higher quantiles, care-seeking behaviour was relatively homogeneous, with nearly all high OPE spenders and those with high budget shares opting for private care and an increasing portion seeking secondary care (Supplementary Tables S1–S4). Thus, Shapley decomposition's ability to differentiate spending and budget share levels within private and secondary care diminishes, resulting in lower explained variation attributed to these variables. This occurs when much of the data exhibit similar behaviour, reducing the relative contribution of these variables to explaining the greater decrease in OPE and budget share levels, as the model cannot discern further differences between them (Garin, 2014).

Moreover, the growing importance of tertiary care levels especially in total OPE and the budget share up to Q90 points to tertiary care's role in treating inpatient cases as well as serious or complex health conditions that require specialized and thus more costly healthcare services. For all outcomes, the proportion of households seeking tertiary care increases at higher quantiles (Supplementary Tables S1–S4).

Notably, among *social* factors, the wealth quintile's influence differed between total OPE, outpatient OPE and the OPE budget share. As indicated by the UQR analysis, total and outpatient OPE increased significantly with wealth. Supplementary Table S1 confirms this trend, showing a decline in the proportion of households in the lowest quintile at higher quantiles of total and outpatient OPE. While this trend may reflect wealthier households having more discretion in allocating funds to health-related needs, it also likely indicates foregone care among poorer households due to financial barriers. Foregone care is an important yet under-researched indicator of financial protection (Grépin et al., 2020; Rahman et al., 2022). Foregone care among poorer households is particularly concerning since they often have larger (unmet) healthcare needs and have also been shown to underreport illnesses in other LMICs, either due to low health literacy or a failure to recognize health needs due to opportunity costs or normalization of poor health (Mcintyre et al., 1998; Sauerborn et al., 1996). These patterns are consistent with other LMICs, where wealthier households generally have better healthcare access and can afford more preventive, specialist, and advanced care, increasing their absolute OPE (Braveman and Gottlieb, 2014). Conversely, poorer households tend to limit healthcare spending predominantly to medications (Bredenkamp and Buisman, 2016; World Health Organization and World Bank Group, 2023). Consequently, the wealth quintile's importance increased across the distribution for total OPE. However, despite higher absolute OPE, it constituted a smaller proportion of THCE for wealthier households compared to poorer ones, explaining the wealth quintile's decreasing contributions across the distribution of the OPE budget share and aligning with its lack of significance in higher quantiles in the UQR analysis. The Indian mean-based decompositions also found that the wealth quintile made small contributions to the OPE budget share (Haakenstad et al., 2022). The minor contributions of other *social* variables across all quantiles and outcomes suggest their lesser influence compared to wealth in influencing variance in OPE outcomes and the budget share.

Among the *health* factors, the severity score's significance in the UQR analyses and its strong contributions in Shapley decomposition likely indicate that diseases perceived as more severe necessitate more resource-intensive healthcare, including advanced procedures, which may increase costs (Raghupathi and Raghupathi, 2023). The slight decrease in severity score's contributions at higher quantiles may indicate that at higher quantiles, many households may have already reached the severity threshold necessitating costly interventions. Further increases in severity may not proportionally increase OPE and the budget share, reducing its explanatory power. Notably, poorer

households reported significantly lower severity scores compared to richer ones. This discrepancy may be attributed to poorer households normalizing or downplaying symptoms and illnesses after chronic exposure to poor health conditions (Mcintyre et al., 1998), which can lead to lower self-reported severity.

Days lost to illness/injury reflect indirect cost associated with health conditions through productivity losses. Their increasing relative importance at higher quantiles, particularly in the OPE budget share, suggests that productivity losses increasingly strain household budgets. These losses may not only influence OPE but also reduce the denominator in the budget share—THCE—by decreasing household resources. This impact is particularly severe for workers in informal employment, who typically lack paid sick days and face a choice between working sick or losing income or even jobs (OECD/ILO, 2019; Scheil-Adlung and Sandner, 2019). In the Indian decomposition analysis, productive days missed contributed 9.30% to the explained variance at the mean of the OPE budget share—close to our findings (Haakenstad et al., 2022).

NCDs strongly contributed to the explained variance in total OPE, outpatient OPE, and the budget share between Q25 and Q50, reflecting the financial burden of managing these conditions. This aligns with global evidence (Kankeu et al., 2013; NCD Alliance, 2023) and prior Cambodian evidence (Jacobs et al., 2016). NCDs are major causes of morbidity and premature mortality in Cambodia (Institute for Health Metrics and Evaluation (IHME), 2024) and disproportionately affect lower socioeconomic groups, including informal workers (Kankeu et al., 2013; Sommer et al., 2015). Limited public sector readiness for treating prevalent NCDs in Cambodia such as diabetes and hypertension leads most patients to seek private care, where medications and care are more available. However, recent studies have demonstrated inferior treatment outcomes for NCD patients visiting private facilities (Chham et al., 2023). NCD contributions declined at higher quantiles, suggesting a reduced relative importance at the highest spending and budget share levels, possibly owing to the onset of more acute or severe conditions overshadowing NCD-related costs. Both our UQR and Shapley decomposition analyses support this, showing significant and increasing contributions from injuries at higher quantiles. This is further corroborated by Supplementary Tables S1–S4, showing an increasing proportion of households seeking care for injuries at higher quantiles. In Cambodia, injuries are largely driven by road accidents, often necessitating intensive and costly emergency treatment (United Nations Development Program, 2021). Informal workers commonly face heightened workplace safety risks, contributing to the burden of injuries (Panneer et al., 2019).

The greater contribution of chronic illnesses and disabilities to the OPE budget share may reflect their economic burden, including indirect costs such as lost income or reduced productivity, diminishing household resources as measured in the denominator of the budget share (Kankeu et al., 2013; Murphy et al., 2019). These findings align with the Indian study's results (Haakenstad et al., 2022).

Concerning future research, additional studies should apply the methods used in this study—combining UQR and Shapley decomposition—to other demographic groups in Cambodia and other country contexts to broaden the evidence base on the drivers of OPE and budget shares across the distribution. Additionally, since our study focused solely on households where at least one member sought care during the recall periods, future research should investigate the prevalence and reasons for foregone care, especially among lower wealth quintiles. Studies should also examine factors contributing to the severity of illnesses and days lost to illness/injury, as well as the necessity and appropriateness of secondary and tertiary care utilization, particularly in outpatient settings. Research is also needed to explore strategies for modifying health characteristics such as severity and days lost to illness/injury and investigate factors driving high medication usage and costs in Cambodia.

There are several limitations to our study. All data were based on retrospective self-reports by household heads, potentially introducing

recall bias. Our decomposition analysis of inpatient OOPE was limited by the small sample size of inpatient care-seekers. Additionally, data on the number of medications were only collected for outpatient care, potentially underestimating the relationships with total OOPE and the budget share. The primary objective of our decomposition analysis was to illustrate the relative importance of the explanatory variables and groups. Although our models did not exhibit significant multicollinearity, several variables demonstrated moderate correlations of approximately 0.50, which could have affected the accuracy of attributing specific contributions. Thus, our results should not be interpreted causally. Moreover, unmeasured confounding variables may have influenced both the factors and our outcomes, leading to potential bias. Finally, Shapley decomposition is limited in attributing explained variation to variables where data behave similarly, such as private care-seeking or secondary care utilization.

## 5. Conclusions

Using the novel combination of Shapley decomposition and UQR, we analysed *healthcare*, *health*, and *social* factors across the distribution of OOPE and the OOPE budget share in Cambodia among non-poor households engaged in informal employment and lacking coverage under SHP or other prepayment coverage. Our findings revealed heterogeneous patterns in the significance and contributions of these factors across different quantiles, which may be obscured in mean-based analyses. Nevertheless, a consistent trend emerged: *healthcare* factors were the largest contributors to the explained variance, followed by *health* and *social* factors, with wealth quintile being the primary driver of the latter. Key *healthcare* contributors included private providers, higher levels of care, medications, inpatient nights, and outpatient visits, while *health*-related contributions were predominantly influenced by illness severity and days lost to illness/injury, followed by NCDs and injuries.

Our study highlights the need to reduce OOPE and enhance financial protection for uncovered households. The finding that *healthcare* factors consistently emerged as the largest contributors to the explained variance across all outcomes is relevant for policymakers, as these factors are directly modifiable through public policy. However, it is equally important to consider the broader public health and social context when designing strategies to reduce OOPE and improve financial protection.

The Cambodian government should consider expanding SHP or other prepayment schemes to uncovered households, prioritizing poorer households who currently bear higher OOPE budget shares. Global evidence suggests mandatory schemes financed through compulsory sources, such as direct and indirect taxes, are more effective for expanding coverage and advancing UHC in contexts with high informal employment (A. Kaiser et al., 2023; Kutzin et al., 2016). In Cambodia's fiscal context, with informal employment comprising 88.3% of total employment, schemes may need to be predominantly financed through general revenues sourced from indirect taxes (Kutzin et al., 2016). Cambodia introduced voluntary contributory enrolment under the NSSF for own-account workers in 2023. While voluntary health insurance (VHI) can sometimes serve as transitional mechanisms towards UHC and have been successfully employed as complementary insurance in some contexts, evidence indicates VHI generally plays a negligible role for UHC. VHI often fails to provide sufficient financial protection to lower-income groups, as it predominantly benefits wealthier populations (Mathauer and Kutzin, 2018). Moreover, VHI funds are frequently pooled separately from broader SHP schemes, as seen in Cambodia, exacerbating system fragmentation. Overall, its risks often outweigh its benefits, particularly in settings with high informality (Mathauer and Kutzin, 2018). Therefore, the Cambodian government should consider transitioning Cambodia's VHI into a mandatory coverage scheme, financed through indirect taxes or other compulsory sources (Kutzin et al., 2016), before extending coverage to uncovered households. Two examples of countries that have successfully introduced non-contributory schemes funded through general revenues,

gradually increasing subsidies to expand coverage, are Thailand and Mexico (Knaul et al., 2012; Prakongsai et al., 2009). Additionally, with external financing accounting for a substantial 14.39% of CHE in 2021 (World Health Organization, 2021), exploring mechanisms for increasingly channelling these funds 'on-budget' may be important, as evidence suggests this approach can improve financial protection (Gabani et al., 2024). Moreover, such reforms need to address key challenges in extending prepayment coverage to informal workers, including effective identification and enrolment, overcoming administrative barriers, managing mobility, addressing low awareness and trust, and ensuring sustainable financing (Bitran, 2014; A. Kaiser et al., 2023).

The design of these schemes should directly address the main *healthcare* and *health* determinants of OOPE and the OOPE budget share identified in this study—reflecting the specific health needs and healthcare preferences of uncovered households. To offer effective coverage, schemes should provide access to comprehensive outpatient care grounded in strengthened primary care, affordable essential medications, inpatient care, and necessary services at secondary and tertiary care levels. Our findings highlighted that certain factors, such as inpatient nights and tertiary care, became increasingly important for higher spenders and households with high OOPE budget shares, while other factors, like medications, contributed substantially across all quantiles. This suggests that targeted policy interventions could be developed to address the distinct factors driving the explained variance among low and high spenders, as well as households with low and high budget shares. For instance, strategies for low spenders may require providing access to basic outpatient services and affordable essential medications, while strategies for higher spenders may need to focus on reducing costs associated with inpatient and tertiary care, while still providing access to affordable medications. Further research is needed to validate and refine such targeted approaches.

Given the strong preference for private care among uncovered households, strategically engaging private provider in prepayment schemes may be necessary as strengthening the public sector alone is unlikely to sufficiently improve financial protection in this context. However, designing effective and contextually relevant private sector engagement will be critical, as global evidence indicates that private sector engagement does not always align with UHC goals (Sriram et al., 2024). Importantly, any engagement may need to be accompanied by implementing effective regulation of private sector quality and practices, including medicine pricing, as envisioned in the Cambodian government's UHC Roadmap 2024–2035.

Strengthening the health system to address the rising burden of NCDs and adopting multisectoral approaches to reduce the incidence and severity of injuries may also be important. By adopting such a comprehensive approach, the government can not improve financial protection for uncovered households and advance towards the goals of Cambodia's UHC Roadmap and the country's broader social and economic development objectives.

## CRedit authorship contribution statement

**Andrea Hannah Kaiser:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Searivoth Vorn:** Writing – review & editing. **Björn Ekman:** Writing – review & editing, Supervision, Conceptualization. **Marlaina Ross:** Writing – review & editing, Formal analysis. **Sovathiro Mao:** Writing – review & editing. **Sokunthea Koy:** Writing – review & editing, Funding acquisition. **Pichenda Koet:** Writing – review & editing, Supervision. **Jesper Sundewall:** Writing – review & editing, Supervision, Conceptualization.

## Ethics approval

This study received ethical approval from the National Ethics



Committee for Health Research of the Ministry of Health, Cambodia, on May 2, 2023 (Reference number 142). All procedures were performed in compliance with relevant laws and institutional guidelines. All respondents were provided with detailed verbal information and a study information sheet explaining the study's purpose, methods, and the voluntary nature of their participation. Informed consent was obtained from all participants prior to data collection. To ensure privacy and confidentiality, all collected data were de-identified, and final datasets were fully anonymized, retaining only non-identifiable household and individual codes. Publicly available data, including those shared in this study, are presented solely in aggregate form.

### Declaration of competing interest

The authors declare that they have no competing interests.

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### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.socscimed.2025.117783>.

### Data availability

The authors do not have permission to share data.

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