Research article

Estimation of household health cost and climate adaptation cost with its health related determinants: empirical evidences from western Nepal

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A B S T R A C T

Limited evidence is available concerning the household-level costs of prevailing diseases and the potential cost of climate adaptation in Nepal. This study estimates these costs and assesses the relationships between prevalent diseases and climate adaptation at the household level using survey data from 420 households. An ingredients-based approach was used to estimate the cost of health and adaptation, and a Probit regression model was used to analyze the relationship between prevalent diseases and climate adaptation costs. Household direct curative costs are the highest among health cost components. Two-thirds of total health costs are direct costs for households. On average, 15.90% of household income is used for direct cost of health care. The climate hazard cost among afflicted households is estimated to be high. In addition, diseases like malaria, typhoid and jaundice, their costs, climate awareness program, droughts, family size and loss of per capita income are more likely to raise the cost of climate adaptation. The occurrence of gastritis, prevalence of diarrhea and cold waves are less likely to affect the cost. Policymakers should implement health financing schemes and adaptation strategies to prevent the loss of human health in western Nepal.

1. Introduction

The economic burdens of incremental health costs in developing countries threaten the sustainability of universal health coverage (UHC) (Stenberg et al., 2018; Chatterjee et al., 2013; Kim et al., 2011). Health costs affect household social, economic, and alternative welfare and are indicative of a lower funding potential for other prosperity alternatives (Puteh and Almualm, 2017). Literatures are most commonly focused on cost calculations and evaluations for individual diseases, for instance; cardiovascular diseases (McDonald et al., 2015; O'Sullivan et al., 2011), tuberculosis (Rupert et al., 2017), visual impairments (Gordois et al., 2012), thyroid disorder (Kahaly and Dietlein, 2002), gastrointestinal cancer (Ashtari and Vahedi, 2014) and injuries (Nguyen et al., 2015). However, evidences are rarely available on the community-based total healthcare expenses to reflect the real aggregate health costs of households triggered by various diseases at different times and severity rates.

Recent studies have asserted that health costs have been the key cause of generating impoverishment and inequity among the poor in developing countries (Love-Koh et al., 2020; Feng et al., 2020, Nguyen et al., 2015). Adam et al. (2003) have reported hospital-based curative costs relying on the unit cost of each individual item that directly affected the healthcare payment rate. Similarly, Chatterjee et al. (2013) have estimated hospital costs to make the outcomes more effective and useful for the administrator of the health facility, trying to reflect the hospital cost with ability to pay of people for existing health services across developing countries. And several of these studies have focused on the development of method or theory on how to estimate health costs (Ashtari and Vahedi, 2014) and forecast potential health costs (Chang et al., 2019). These studies have emphasized the cost of supply-side safety, but the major concern about household demand for healthcare remains a low priority. Demand side health cost estimation and the relationship between diseases and the cost of climate adaptation are new research areas in Nepal. This study has tried to reflect the hospital cost with ability to pay of people for existing health services across developing countries.

Some evidences have proven that climate change is responsible for emerging and reemerging disease burdens in developing countries

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(Bosello et al., 2006) including Nepal (Bhandari et al., 2012; Shrestha et al., 2017), and others have suggested that the global health costs due to prevalence of diseases could be USD 12 billion by 2030 (Ebi, 2008; Yoon et al., 2014). A climate adaptation cost analysis estimated that actual adaptation costs in low and middle income countries could be higher than half of gross domestic product (IPCC, 2007b; Chapagain et al., 2020). These studies are, however, limited to some meta-analysis and comparison exploration which ignore the demand side adaptation cost estimates based on the climate-related sensitivity analysis. To this end, community-based data at the local and regional level can be helpful in drawing the real situational costs of climate hazards and household adaptation cost, and their ties to diseases that contribute to the region's heath cost (IPCC, 2014). Such cost figures and the relationship of major diseases to climate change are not readily available across western Nepal.

This study therefore first estimates and analyzes the household level health costs, adaptation costs and natural hazard costs based on the survey data collected from western Nepal. Second, this study reports the cost of climate adaptation relationship with most prevalent diseases to explore how prevalence of the diseases and the related costs influence the community level adaptation costs. This estimate and the relationship could be useful for policymakers to frame the priority of disease-specific health financing strategy, making it integrated with climate adaptation measures.

2. Methods and materials

2.1. Research design

This was a cross-sectional economic cost estimation study using survey data. An estimation of health cost and climate cost is followed by assessment of the relationship between major disease prevalence and cost of adaptation, controlling for household and environment variables. Simple random sampling was used to identify 420 sample households (using Epi-INFO software) in western Nepal, after obtaining a sampling frame from a pilot survey. Data were collected by means of record reviews, focus group discussions, in-depth interviews with community people and health professionals, and by administering semi-structured questionnaires that include both qualitative and quantitative elements as followed by Paudel et al. (2020) and Dror et al. (2008). Data were entered into SPSS and transformed into STATA for the analysis. Probit regression is used to establish disease–climate adaptation relationships as demonstrated in Figure 1. A theoretical framework was developed, followed by econometric models, with reference to some literatures. The rationale behind the use of the methods in the research was detailed in the methodology section of a previous paper (Paudel and Pant, 2020a).

2.2. Study area

Jajarkot and Banke districts were chosen as the study areas for data collection because they are considered the most climate sensitive areas of western Nepal (Bhandari et al., 2009). Detailed information of the study areas are detailed in previous paper (Paudel and Pant, 2020a). However, figure for demonstrating the location of the study areas is included as *Supplementary Materials-Appendix 1* for this study. Of the total 420 sample households, 200 were from hill side and 220 from Terai (plain) region. To address the heterogeneity of the sample households, rural, semi-urban and urban areas in the two districts are purposively included in the sample. Similarly, consecutive sample households were chosen at a distance of 500 m for the sake of maintaining the climatic and socio-economic differences. The detail of study setting and designs are also explained in Paudel et al. (2020).

2.3. Aggregate hypothesized variables measured

The study explores the relationship between prevalent diseases and climate adaptation cost by using cross-sectional data; controlling for health system variables, environmental variables, and socio-economic and behavioral variables. Consequently, the factors that are hypothesized to be associated with climate adaptation cost to prevalent diseases are:

1) Dependent variable: adaptation cost
2) Independent variables: health system variables, environmental variables, and household socioeconomic and behavioral variables.

The health system variables include the most common illnesses and medication costs. The environmental variables include knowledge and perception about climate change, natural disasters due to environmental change (drought, forest fire, flood, windstorm, thunderstorm, heavy rain, sporadic rain, landslide, snowstorm, erosion, heat waves, cold waves, biodiversity change, air pollution, water pollution and solid waste disposal (CBS, 2016) and change in water resources.

Similarly, the household-based socioeconomic and behavioral variables include sex, age, education, marital status, income and current occupation of household head, ownership of the residence, source of drinking water, main source of energy for cooking and lighting, types of toilets, habit of hand-wash, disposal practices of solid waste, preferences of food, access to health facilities, distance from the road, saving habit in microfinance and involvement in awareness program (WHO, 2017).

Of the total variables, the literature-based limited relevant variables are used in the regression model to prevent the irrelevance and crowding of excessive variables in the regression model.

2.4. Theoretical framework

Climate change leads to changes in disease costs at household level that can result to changes in the cost of adaptation (UNFCCC, 2009). It seems worth contemplating the evolving actions of humanity due to the climate change, after the estimation of the cost of adaptation of households; and how the past disease costs push the population into adopting adaptation steps. It is commonly believed that people take proactive steps to reduce future disease costs. The aim of this particular study is to adopt a utility approach as defined by Paudel et al. (2020) for the purpose of finding the impact of diseases on adaptation cost (marginal cost). Suppose u_1 be the utility of an individual from a health status (H) and income (Y) with other non-health factors (X), subject to disease cost (DC).

$$u_1 = f(H, Y, X) s.t. DC \tag{1}$$

Similarly, let u_2 be the utility of an individual due to adaptation (A) and other than adaptation activities (X_1) for the climate hazards, subject to adaptation cost (AC)

$$u_2 = f(A, Y, X_1) s.t. AC \tag{2}$$

Then, total utility (u) from the health recovery and adaptation as obtained from the effect of of health status (H), income (Y) and adaptation benefit (A) is subject to disease cost (DC). Accordingly, from the combination of (1)(1) and (2)(2), u reforms as,

$$u = f(H, Y, A) s.t. DC \tag{3}$$

Alternatively,

Based on Grossman's (1972) and Cropper's (1981) approaches, let us consider an individual whose decision on climate adaptation related to disease cost is optimal choice of time paths for both his health capital and for consumable non-health goods. The decision problem of individual can be expressed by an inter-temporal utility function U, given by,

$$u = \sum_{t=0}^{n} w_t u_t, where\ u_t = u(s_t, z_t, Y_t) \tag{4}$$

where,

w_t = Weights determined by individual's rate of preferences.

u_t = Utility in period t.

s_t = Services of health capital.

z_t = Non-health products consumed by the individuals.

Y_t = Income of the individual during the time t.

Modification of Killingworth's (1983) functional approach in the optimization problem can be inferred as the health capital stock as measured in units of healthy time,

$$s_t = s(H_t), \frac{\partial s}{\partial H_t} > 0 \tag{5}$$

and non-health consumable goods as,

$$z_t = z(S_t, Y_t), \tag{6}$$

where, S denotes human capital (e.g. education), Y_t as income.

The marginal shift in health capital stock over time with investment I_t(as an adjustment proxy) with depreciation of the existing stocks is defined as,

$$\Delta H_{t+1} = H_{t+1} - H_t = I_t - \delta H_{t+1} H_t \tag{7}$$

where, δ is rate of depreciation.

At the same time, the individual tries to recover his health capital through investment in adaptation (A_t), on medication (M_t), income (Y_t) and time inputs (TH_t) and other non-health exogenous parameters (X_t).

$$I_t = I(A_t, M_t, .Y_t, TH_t, X_t) \tag{8}$$

The inter-temporal optimization problem of the individual deals with the problem of discrete optimal control (Leonard &Van Long, 1992). Now, the objective is to maximize u of Eq. (4).

$u = \sum_{t=0}^{n} m_t u[h(H_t, Z_t, Y_t)]$, subject to Eqs. (6), (7), and (8); considering other additional restrictions on work, income and expenditure on M_t and X_t.

As stated by Ried (1994), Eq. (7) can be rewritten as,

$\Delta H_{t+1} = \left(\frac{\partial A_t^I}{\partial P_t^M} \right)^{-1} M_t - \delta_t H_t$, where $A_t^I(A_t)^z$ is marginal cost of gross investment for adaptation; and $P_t^M(P_t)$is price of medication for period t.

The optimality condition for the stock of health capital in this particular case can be written as,

$R_t \frac{\partial h}{\partial H_t} = A_{t-1}^t(1+r) - A_t^I(1 - \delta_t)$, where, R_t is wage rate, r is rate of interest.

In order to achieve estimable household adaptation equation based on higher disease prevalence, the logarithmic function can then be written as, $LnA_t = \frac{\partial A_t^I}{\partial P_t^M} + Ln\delta_t H_t + \Delta H_{t+1} \Big)$ and the logistic regression model can be expressed with assumption of a binary random variable A_t (constant variance and non-zero mean) with value 1 for the probability p_h and 0 with probability ($1-p_h$).

$$p_h = p(A|_{H=h}) = \frac{1}{1 + e^{(-a+bh)}} \tag{9}$$

Furthermore, if the log odds of adaptation cost changes linearly with change in h, the log likelihood of changes in disease cost can be shown as,

$$Log\left(\frac{p_h}{1 - p_h}\right) = Log\left(oddsforp\left(A|_{H=h}\right)\right) = a + bh \tag{10}$$

where, a and b are parameters, and $p(A|_{H=h}) = p_h$ = Risk for high or low health cost.

2.5. Econometric model

Skewed continuous cost data being problematic to fit to the model they were converted into a categorical variable with the help of the median (NPR 11,000), making <11,000 as less prevalence (coded-0) and ≥11,000 as high prevalence (coded-1). Jewell (2004) suggests that probit model is better utilized for dichotomous response of environmental exposures as of binary dependent variables 0 or 1, meaning that non-negative and not greater than 1; rather than Logit model. Therefore, to identify the determinants of the adaptation cost at i^{th} household within t time period, the probit regression equation for this study takes the form,

$$A_{it} = \beta_0 + \beta_j H_{ijt} + \beta_k X_{ikt} + \beta_l Y_{ilt} + e_{it} \tag{11}$$

Following the procedure suggested by McDonald et al. (2015), the specific form for the Probit regression equation for the relationship between adaptation cost and disease prevalence/cost along with other control variables is given as follows:

$$Adaptation \, Cos \, t = \beta_0 + \beta_1 Malaria + \beta_2 Typhoid + \beta_3 Jaundice + \beta_4 Gastric$$
$$+ \beta_5 Diarrhea + \beta_6 Disease \, Cos \, t + \beta_7 PerCapitaIncome + \beta_8 Occupation$$
$$+ \beta_9 FamilySize + \beta_{10} AwarenessProgram + \beta_{11} Draught + \beta_{12} ColdWaves$$
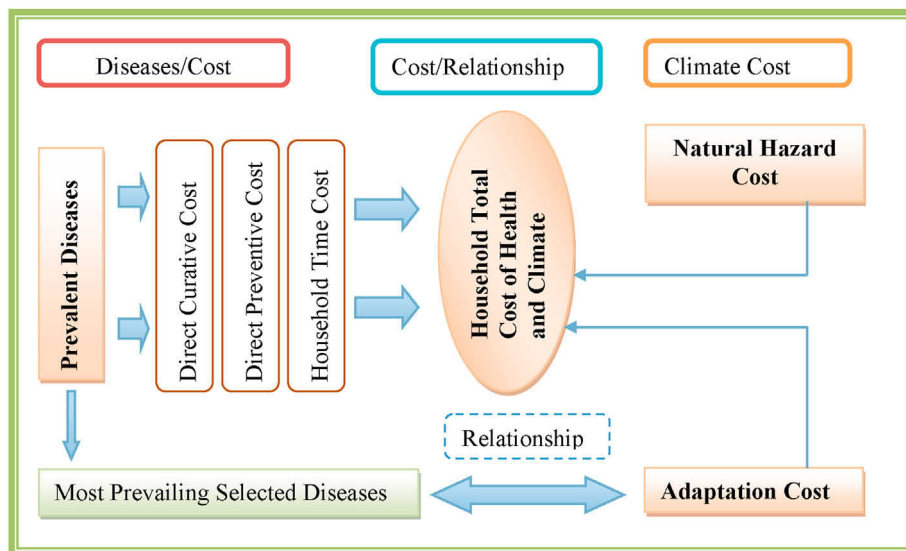

Figure 1. Conceptual Framework: Relationship of disease prevalence costs and adaptation costs.

2.6. Description of hypothesized variables

Table 1 presents descriptive analysis of the major hypothesized variables which are likely to affect adaptation costs. The hypothesized variables are based on literature and their relevancy to affect the dependent variable.

2.7. Cost estimation techniques

The cost specifies inputs foregone to recover damage instigated by health loss, climate change or other changes. In general, the household cost may be the sum of out-of-pocket (OOP) spending on health, adaptation cost and natural hazard costs; where diseases prevalence is high due to climate change. The health cost was individually estimated right after listing prevailing diseases across the target population. As explicated in the National Climate Change Report-2016 (CBS, 2016), the questions for household cost estimation were asked for the last five years, minimizing recall bias. All the cost estimates are converted to annual cost estimates while presenting the results.

2.7.1. Household health cost estimation

Health cost relates to the inputs required for improving health outputs. The ingredients-based method (Paudel and Pant, 2020b) was used to estimate both direct and indirect health costs of households using the data obtained through the review of existing published and unpublished literature, direct interviews and focus group discussion.

1) Direct Costs: The direct costs for the treatment of diseases embrace both curative and preventive costs as household OOP payment. Direct curative cost (A_1) comprises travel, medication, food and water, renting of equipment and health registration fees. Direct preventive cost (A_2) involves household's OOP payments for preventive activities such as payment for mosquito nets, window and door netting, toilet cleaners, water treatment devices, skin care products and family safety insecticides at home.

2) Indirect costs: The indirect costs comprise time costs of the households for disease cure and disease prevention. Curative time costs (B_1) of patient and caregiver include time costs for bed rest days, hospitalized days and time to get to the health facilities in order to recover and to take care during this process. Preventive time costs (B_2) often include the time spent for fitting net on the bed, time spent for solid waste management etc. Curative as well as preventive indirect costs were estimated by converting the time lost in monetary terms with the government minimum wage rate NPR 385 per working day of 8 h (MoLESS, 2018).

2.7.2. Adaptation cost

Household adaptation cost in general is simply understood as preventive healthcare cost and other costs, but here the household adaptation costs (C_1) are not overlapping with preventive healthcare cost. The major household costs for the climate adaptation includes home rebuilding, household infrastructure, buying fans, refrigerator and air-conditioning, seasonal clothing, water reservation tank for long periods of drought, heavy rain drainage and lightning prevention measures. The estimates of costs are based on the cost figures derived from direct in-depth interviews with respondents in the study area.

2.7.3. Natural disaster cost

In Nepal, many climate-related disasters, such as drought, heavy rainfall, floods, thunderstorm and heat waves cause household property damage. Household property loss includes the cost on home structure, crops and livestock, and treatment cost of disaster related injuries. With this reality, the natural disaster costs (D_1) were estimated by the loss incurred by the households due to various natural disasters; being based on data from each sample household in the study area via direct interview response.

The sum of health inaction cost, adaptation cost and cost of natural hazards is the overall cost for households. Mathematically, household cost induced by environmental degradation = $(A_1 + A_2 + B_1 + B_2) + C_1 + D_1$.

It is important to further assess the impact of health cost on household economy by finding the average share of households' overall income on health.

2.8. Ethical protocol

Ethical protocol was obtained from Nepal Health Research Council, an autonomous government body. Ethical issues were adequately considered by researchers and enumerators during the data collection as per the data collection guidelines of the Council.

3. Results

Almost 76 percent of the patients who were healed for different diseases were females. This indicates that women are more vulnerable to climate hazards. Two-thirds of the families had a growing pattern of sickness. Diarrhea, Asthma, Pneumonia, Typhoid, Kidney Stone, Diabetes, Cholera and Gastritis are the major diseases that are growing in the study area's northern hill and mountain region, while heart diseases, malnutrition, uric acid, typhoid and asthma are prevalent in southern

Table 1. Hypothesized independent variables with description.

Variables name	Description	Hypothesized sign	Mean	Standard Deviation
Asthma	Asthma occurrence (Yes-1, 0 otherwise)	+ve (D'Amato et al., 2015)	0.306	0.457
Malaria	Malaria occurrence (Yes-1, 0 otherwise)	+ve (Ebi, 2008)	0.323	0.468
Typhoid	Typhoid occurrence (Yes-1, 0 otherwise)	+ve (Ebi, 2008)	0.435	0.496
Jaundice	Jaundice occurrence (Yes-1, 0 otherwise)	+ve (Slusher et al., 2017)	0.055	0.287
Gastric	Gastritis occurrence (Yes-1, 0 otherwise)	+ve	0.254	0.436
Dysentery	Dysentery occurrence (Yes-1, 0 otherwise)	+ve	0.111	0.315
Diarrhea	Diarrhea occurrence (Yes-1, 0 otherwise)	+ve (Ebi, 2008)	0.471	0.499
Family size	Number of family members	+ve (Cohen et al., 2017)	6.551	3.412
Per capita income	Household per capita income (NPR in thousand)	+ve (Cohen et al., 2017)	51.278	2.590
Occupation	Agriculture Occupation (Yes-1, 0 otherwise)	+ve	0.681	0.365
Awareness Program	No participation in awareness program (Yes-1, 0 otherwise)	+ve (Wamsler et al., 2012)	0.821	0.287
Disease Cost	Household Treatment cost (NPR in thousand)	Undetermined	48.199	83.666
Draught	Increasing draught (Yes-1, 0 otherwise)	+ve (Udmale et al., 2014)	0.610	0.371
Cold waves	Increasing cold waves (Yes-1, 0 otherwise)	+ve	0.571	0.461

Source: Field Survey, 2018

plain of western Nepal. Cost figures for households are also based on the episode of cure for diseases.

3.1. Direct household health cost

3.1.1. Household direct curative cost

The household's average annual direct curative costs are NPR 26,814, with the largest share (81%) relating to medication cost (Figure 2). The average annual visits to hospitals per patient are 8 times (ranging from no visit to 21 visits for disease treatment). The amount for the travel cost indicated that health facilities are not treated equitably.

Households were more likely to use health facilities in India because of easy access to Indian border towns and uncertainty about the availability of medicines and human resource in health facilities in western Nepal. Households both in hilly and Terai regions are paying a significant sum for the medication. To disaggregate the distribution of regional cost, the percentage medicine costs tend to be higher for hilly area relative to Terai region (Supplementary Materials-Appendix 2). Likewise, household average total costs are found to be substantially higher in the hilly affected region (NPR 42,452) compared to western Nepal's Terai (NPR 15,772). This gigantic cost of households to treat the diseases may have a detrimental impact on community's economic development in western Nepal.

3.1.2. Household curative time cost

Almost 6.6 h (range: 1 to 7) is the average time spent for reaching the nearest hospital. The average hospitalized days are 6 (range: 0 to 37) days. Importantly, restriction on patient's work ability after the sickness is around 34% at least for a month. This loss of work capability is significant for the loss of productivity in the national economy. A care giver spent 6 days in average for the recovery of the diseases (Supplementary Materials- Appendix 3).

The estimated average annual curative time cost for each household is quite high at Rs 12,486 (Table 2) which includes patient's rest days and caretaker's time. The average time to reach health facility is nearly 6 h from the home. Long period of employment missed by the patients and caregivers due to sickness, including time taken for several follow-up visits, accounts significant household losses in western Nepal. Such huge losses often include financial loss, morbidity increment, poor quality of life, low productivity, often disability and premature mortality (Yabroff et al., 2004).

Comparatively, households in the hilly region (Supplementary Materials-Appendix 4), have higher time cost due to higher travel cost to distant health facilities and long rest days at home than that in the Terai areas. The restricted work performance of patients living in the hilly region is 14% higher than that in the Terai region. Higher workability restriction due to the illness has contributed to lower productivity in household economies. In the hilly area, due to high relative poverty, the

further impoverishment may result in high work-life sickness restriction. In comparison, household time costs for disease cure across the hilly region are around 67% higher than that in the Terai region.

3.2. Household preventive health cost

3.2.1. Household direct preventive cost

Households have paid for their own safety from different unanticipated climate and non-climatic hazards. The average annual payment for the nets that are used in window and doors is NPR 2,862. Similarly, the household's average direct preventive cost was for mosquito net, pesticide, skin care products and others (Table 3), and was estimated to be NPR 8,130.

3.2.2. Household indirect preventive cost

The average total preventive time cost (Table 4) is estimated as NPR 11,144 which appeared less compared to the curative time cost, but this cost could be for all the households which aggravate a large community cost of infected areas. Regarding the time cost, the households are compelled to stay inside their home because of extreme heat or cold or other weather events which raise the household cost in terms of time loss. Net fitting average time is 5 min per day (range: 2 to 8) which is converted into days for a year. Similarly, average time for solid waste management (20.06 min per week) is also converted into days in a year. In average, households stay inside home for 3.13 h per day (range: 0–4 h) to be protected from extreme heat and cold waves during day-time reducing the working hours at least for 2 months in a year.

To analyze the regional cases, the time cost across Terai region (NPR 13,263) is almost double to the hilly region (NPR 7,669). Within the cost components of Terai region, more than 97% share of cost is attributed to time loss staying inside the house to protect them (Supplementary Materials-Appendix 5). The large time cost in Terai region compared to hilly region is due to spending long time inside at home to be protective from extreme weather events (summer heat waves and winter cold waves) and possible health hazards in this region. It is normal to be increasing long summer heat waves as well as the extreme cold waves in the winter season across Terai region, but such extreme weather events increasingly being active across hilly regions is serious threat of climate induced health hazards.

3.3. Household total health cost distribution

The average annual health cost per household is estimated as NPR 58,574 in western Nepal. The average annual curative health cost is estimated as NPR 39,300 per household which is almost double of the average total preventive cost (Figure 3). Direct curative cost of household shares the highest among all cost components, mainly due to high medicine cost. Similarly, the annual direct health cost of household
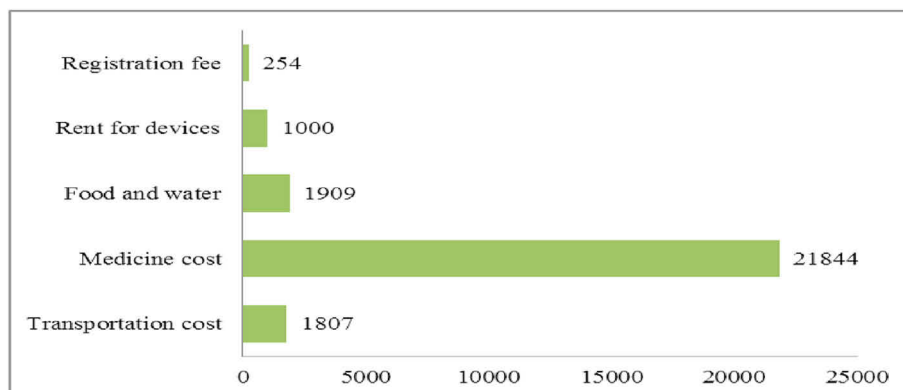

Figure 2. Household's direct curative cost distribution.

Table 2. Household's curative time cost.

Description	Mean	Time cost (NPR)
Rest days of patient	10.13	3900
Time to health facilities (days)	0.83	319
Hospitalized days	6.04	2,385
Restricted working capacity of patient (days)	9.00	3,465
Time given by caregiver (days)	6.28	2,417
Average total curative time cost (NPR)		12,486

Source: Field Survey, 2018

shares 60% of total health cost, which is more than the national average of 55.4% (MoHP, 2018).

A huge health cost in the poor society is another tragedy in this

3.6. Climate hazard costs

For those households facing natural disasters, the average annual total cost of climate hazards per household is estimated at NPR 41,797, mainly due to loss of crops, livestock and other household assets due to draught, flood and other climatic disasters (Supplementary Materials-Appendix 7). More than 50 percent of the households have been faced with drought and untimely heavy rainfall that result low production of crops. Thunderstorm seems to be another hazard impacting western residents' usual life. Landslides impact on household property loss, either home or land. Heat waves have restricted workability and working hours of people.

Geographically, the climate cost is found to be little different. Flood, Thunderstorm, landslide and drought are the main contributors to high climatic disaster cost in both study areas. The hilly areas that face

Table 3. Household direct preventive cost.

Descriptions	Minimum (NPR)	Maximum (NPR)	Mean (NPR)	Std. Deviation
Amount paid for window and door net	300	7,000	2,862	1345
Payment for mosquito net	200	1,400	2,432	980
Amount paid for pesticide	20	800	853	542
Payment for skin care product	100	1,000	467	107
Payment for the water treatment device	300	3,500	977	1049
Payment for toilet device	50	400	302	555
Payment for preventive program	0	500	237	563
Average total direct preventive cost			8,130	

Source: Field Survey, 2018

new era. As seemed a big total economic cost for the cure of disease signals that the society is leading towards further impoverishment. This amount of cost is quite higher than the cost of illness estimated in an Indian study (Dror et al., 2008). Preventive annual health cost of NPR 19,274 per household is another threat induced by the health hazards. Such big cost for prevention is mainly attributed to a long hour restriction in work (or staying inside for the protection of body) due to extreme weather events at different level of climatic vulnerability.

3.4. Effect of health treatment cost on household economy

On average 15.90 percent (S.D: 74.74) of household income is used for direct cost of health care (OOP payment). The average OOP payment for household's health care from household income shows that there is frequent catastrophic payment (more than 10% of household income) for human health services in western Nepal, likely leading to further impoverishment.

3.5. Climate adaptation cost

Almost every household has implemented at least one of the adaptation measures available. These includes house repair, water reserve tank for long drought, adding number of fans at home, remaining indoors, earthling lightening device etc.

Although the households' preventive cost may be indifferent to the adaptation cost, the sense of health preventive cost has taken on difference from the cost of adaptation. Nearly 96% of households incurred this cost for various items reflecting the societal cost of adjustment under changed climatic scenarios. On average, a household spends NPR 19,028 per annum exposing a question of added burden to the low-income society (Supplementary Materials-Appendix 6).

flooding and lightening are also vulnerable to community fire and landslide. Among the affected households, the average annual total cost of natural hazards in the hilly area is estimated as NPR 44,724 annually, which is nearly 16 percent higher than that in Terai region.

3.7. Total household cost

Total household costs induced by health and climate change include health inaction cost, adaptation cost and natural hazards cost, which aggregated NPR 119,319. The average total curative health cost is estimated as NPR 39,300 and average total preventive cost is found as NPR 19,274, which sums as NPR 58,574. Annual household costs for climate adaptation are estimated as NPR 19,028 and annual household direct costs due to climate-induced natural hazards are estimated as NPR 41,797.

3.8. Relationship between adaptation cost and most prevailing diseases

In general, adaptation cost of household is forward looking in nature while disease prevalence and its cost is ex-post cost for health care. As environmental change has been established, it will be responsible for disease prevalence in the community that almost all the households have spent money (OOP) for adaptation measures such as home repair, control of lightening, fan usage for sever summer, seasonal extra clothing and reservation tank for long drought. More specifically, the relationship between household's adaptations costs to mitigate future climate-induced hazards and disease prevalence and associated household health care cost is a proxy for the relationship between climate adaptation costs and disease prevalence in western Nepal.

First the correlation matrix is obtained for the relationships, followed by Probit regression analysis with adaptation cost as dependent variable and selected disease prevalence as independent variables and other

Table 4. Household's indirect preventive cost.

Descriptions	Mean	Time cost (NPR)
Bed net fitting time (days)	3.80	1,463
Time for solid waste disposal (days)	2.22	634
Staying inside days	23.50	9,047
Total preventive time cost (NPR)		11,144

Source: Field Survey, 2018

control variables. The coefficient of correlation matrix showed that there is no multi-co-linearity among the hypothesized explanatory variables as demonstrated in *Supplementary materials-Appendix 8*.

The results of Probit regression (Table 5) reveals that households suffering from malaria, typhoid and jaundice are more likely to incur adaptation costs with odds of 1.755 (95% CI: 0.921–2.518), 1.123 (95% CI: 1.123–2.902) and 1.246 (95% CI: 0.453–3.427) respectively. However, Gastritis and diarrhea tend to be significant but less likely to affect the adaptation cost at 5 percent level of significant, meaning that gastritis and diarrhea prevalence in the community acts as discouraging in the implementation of household adaptation measures compared to those not facing such diseases. Similarly, disease cost often has a greater risk of affecting the adaptation cost. More accurately, all else being equal, each rupee spent on health care increases the cost of climate adaptation at an odd rate of 1.083 (95% CI: 1.04–1.13). However, climate adaptation cost found not significant to affect the health cost in reverse regression performed alongside the same control variables.

In addition, higher the per capita household income higher is the adaptation cost at odd rate 1.020 (95% CI: 1.00–1.030), which indicates that being wealthier marginally promotes higher adaptation measures for own protection from environmental hazards. Similarly, large family size positively affects household adaptation costs. Households with a large family size may be concerned about potential effects of climate hazards and disease prevalence at home, which could result from high cost of loss of production for health and agriculture. Studies already suggest that agriculture is more affected by climate change. In the same way, households engaged on agriculture occupation are more likely to increase the adaptation cost with an odd ratio of 1.185 (95% CI: 0.998–1.408). Similarly, household heads who are exposed to awareness program are often more likely to use climate adaptation initiatives than the household heads who are not exposed to climate awareness program at the community level.

Among environmental factors, long drought appeared to have higher probability of raising adaptation cost with a high odd ratio of 3.091 (1.360–7.020), relative to those not affected by the drought. This might be because household economy may be affected by long drought in terms

of household agriculture income. On the other hand, households facing cold waves are less likely to protect against inevitable climatic hazards. This might be because cold waves are less harmful to health hazards at the household level and any other social losses.

4. Discussions

This study examined the economic burden of health and climate adaptation at the household level in western Nepal. We estimated the household's annual average out of pocket payment for the purchase of medication to be NPR 21,844, which is a significant burden in the study areas. This result is consistent with findings obtained in Kosovo by Arenliu Qosaj et al. (2018) and in Viet Nam by Van Minh et al. (2013). Parallel to Van Minh et al. (2013) and Rowell et al. (2011), this study also shows that the household curative health inaction cost appears to be the highest of all other household health costs. Notably, the direct curative cost in the study area is three times the indirect curative costs, which is exactly similar to Australia's study (Rowell et al., 2011). However, a recent Indian-based study (Rupert et al., 2017) and another South African study (Shah et al., 2013) found a lower cost of care compared with the other household health costs.

The curative health cost (NPR 39,300) is double the preventative health cost, and 67 percent of the overall health cost (NPR 58,574). This might be attributed to specific feeding habits and nutritional care quality during the recovery period. Similarly, household direct healthcare costs in western Nepal are much higher than indirect healthcare cost, consistent with a study linked to visual infection around the world (Gordois et al., 2012). However, in treating injury cases in the Unites States and South Korea, Corso et al. (2007) and Kim et al. (2011) found the greater proportion of indirect costs, respectively. Indirect preventive costs are considerably higher than direct costs, suggesting that households are now sparing time to remain at home to defend against the recent increase of severe weather events (Shrestha et al., 2017; Ebi, 2008).

Comparing these components of health cost with household economy rates, the average share of household income for health is estimated to be 15.9%, putting households at risk of catastrophic payment and further impoverishment. Xu et al. (2003) define catastrophic health expenditures as those surpassing 40% of the remaining income after subsistence, though arguing that the threshold should be 15% in low-income countries. Nonetheless, a study based in Viet Nam set the threshold at 10% (Kawabata et al., 2002), finding a marginally higher percentage of households facing catastrophic payment compared to this study's findings.

The annual expense of climate hazard cost is estimated as NPR 41,797 on average for those 204 households that are affected. Numerical analysis showed that as many as 76% of affected households were affected by
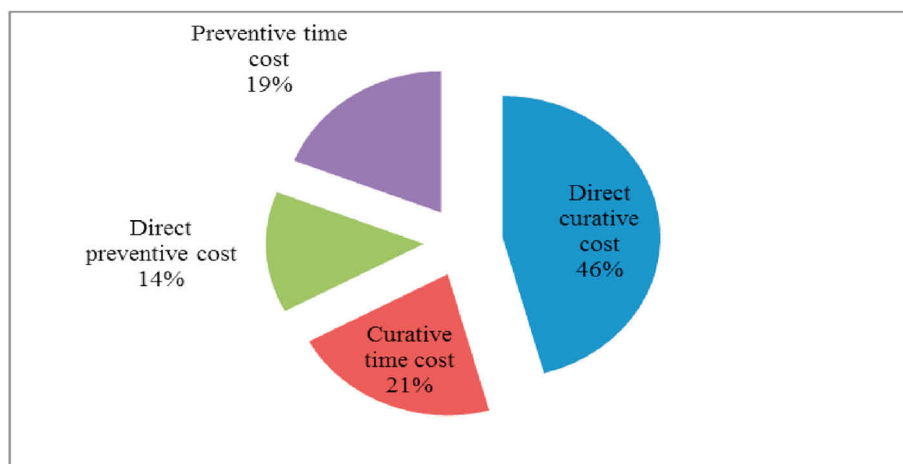

Figure 3. Household health cost distribution.

long drought which reduced agricultural productivity. Likewise, NPR 19,028 is found to be the average annual adaptation cost of more than 96% of households facing the environmental vulnerabilities. The average household cost of adaptation could not be compared with any literatures due to unavailability of scientific paper, but some studies (Ebi, 2008; Markandya and Chiabai, 2009) have established estimates of adaptation cost considering potential global projection horizon. Hutton (2011) found that the cost analyses carried out so far for global adaptation suggest health sector costs of approximately US$ 2 to 5 billion per annum.

Regarding regression results, this study showed that adaptation cost is positively correlated with prevalence of malaria, typhoid and jaundice; suggesting that increasing the disease prevalence has a greater risk of increasing the cost of adaptation. This is a novel result for the case of Nepal being consistent with Ebi (2008). However, diarrhea is negatively associated to the adaptation cost, which is opposite to the predictive study of Ebi (2008). This relationship might be a baseline information for the researchers working in parallel. Similarly, drought is found to be the main environmental factor affecting positively to increase the adaptation cost, compared to those who have not faced drought in western Nepal. This result is consistent with an Indian study based on drought and agriculture adaptation (Udmale et al., 2014). Similarly, Opiyo et al. (2015) also found the parallel result of positive relationship between the drought and adaptation expenses at household level in Kenya. Education awareness is considered a driver of socioeconomic change. Wamsler et al. (2012) also concluded that better exposure of climate education awareness program at community level increases the chance of increasing investment on adaptation measures, Similarly, increasing family size and per capita income of households are more likely to increase the adaptation cost, in alignment to a comprehensive European study (Cohen et al., 2017).

A significant size of OOP for health care is directly associated with inadequate funding strategy, posing threats to UHC's achievement. Nepal government has recently initiated establishment of a national financing strategy for health. This might be the high time for health assessment of the household OOP, based on the survey data. Evidently, the findings of this study can provide baseline information in planning strategy options for health financing for western Nepal. Considering the climate sensitive western Nepal, financing strategy should reduce the OOP on health and preserve inequity in health services access in western Nepal, if health cost information and adaptation costs at the household level is completely taken as a reference among the environment and health policymakers. Since healthcare costs in western Nepal are evidently proved to be one of the causes of adaptation costs. In this regard, Hutton (2011) argued that there is an urgent need for climate change-specific health economic guidance to ensure rigorous strategies, broader advocacy, and focused decision maker training to improve the take-up of economic evidence in decision-making.

Additionally, improved economic analyses of the costs associated with the climate-induced health impacts will be essential in health adaptation initiatives and to support mitigation policies that enhance health in developing countries. The main health co-benefits should be discussed through economic assessments of adaptation and mitigation policies, which cover most of the initial investment costs. But special methods particularly for reflecting uncertainty, relative value of potential benefits (e.g. discounting), and equity attainment are difficult. If these methods were applied to assess the health costs of climate change, the costs and benefits of investing in health adaptation would be more accurate at the global, regional or local level, as well as of mitigation measures that impact on health (WHO, 2009).

This study is not without limitations. First it estimates the demand-side cost of health care demand, ignoring the supply-side cost of service providers. Second, this study has not involved catastrophic events, the complete loss of productivity; our calculation would therefore underestimate all potential costs. Finally, the approach used to quantify losses in output does not take into account intangible

Table 5. Probit and logistic regression results for the relationship (Dependent Variable: Household adaptation cost).

Variables	Coefficients (Std. Error)	Odd ratios
Asthma	-0.080 (0.148)	1.155
Malaria	0.273 (0.154)*	1.523
Typhoid	0.363 (0.144)***	1.806
Jaundice	0.197 (0.087)**	1.246
Gastritis	-0.359 (0.177)**	0.592
Dysentery	-0.215 (0.232)	1.374
Diarrhea	-0.356 (0.155)***	0.559
Family size	0.040 (0.020)*	1.064
Per capita income	0.064 (0.021)***	1.020
Occupation	0.101 (0.051)**	1.185
Education awareness	0.484 (0.239)**	2.074
Disease Cost	0.046 (0.012)***	1.083
Draught	0.718 (0.238)***	3.091
Cold waves	-0.302 (0.145)**	0.618
R^2 = 16.04		

*** = $p < 0.01$, ** = $p < 0.05$, * = $p < 0.1$.
Source: Field Survey, 2018

costs, such as decreased quality of life, and the pain and suffering experienced by sick patients and their families as a result of the disease. These limitations may offer some implications for future research to study a more comprehensive picture of the burden of diseases in western Nepal and elsewhere. Though limited to the economic cost of health and household adaptation, this study provides a significant baseline of evidence for health finance and climate adaptation policymakers working especially for western Nepal. Therefore, people in the society should focus on climate resilience programs which minimize health cost and the loss of community welfare from the environmental hazards.

5. Conclusions

This study examined the economic burden of health and adaptation costs at the household level in western Nepal. It concluded that direct household health costs are the largest of all health costs components. Likewise, direct costs of health care at household level are nearly three times the indirect cost. The cost of adaptation is far too large to be addressed through an effective climate adaptation program in the area. The cost of climate threat is also noteworthy in terms of allowing social benefit from other opportunities. The relationship results proved that high health costs promote community adaptation cost. Drought experiences, per capita income, family size and education are the major factors that influence household-level decision on adaptation strategy. These findings suggest that health policymakers should put strong efforts into planning financial security strategy with successful implementation of a national health insurance program; and climate adaptation programs should consider climatic and socio-economic effects as identified in western Nepal.

Declarations

Author contribution statement

Uttam Paudel: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Krishna Prasad Pant: Conceived and designed the experiments; Wrote the paper.

Data availability statement

Data will be made available on request.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

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