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# Catastrophic medical expenditure risk

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ABSTRACT

We propose a measure of household exposure to particularly onerous medical expenses. The measure can be decomposed into the probability that medical expenditure exceeds a threshold, the loss due to predictably low consumption of other goods if it does and the further loss arising from the volatility of medical expenses above the threshold. Depending on the choice of threshold, the measure is consistent with a model of reference-dependent utility with loss aversion. Unlike the risk premium, the measure is only sensitive to particularly high expenses, and can identify households that expect to incur such expenses and would benefit from subsidised, but not actuarially fair, insurance. An empirical illustration using data from seven Asian countries demonstrates the importance of taking account of informal insurance and reveals clear differences in catastrophic medical expenditure risk across and within countries. In general, risk is higher among poorer, rural and chronically ill populations.



## 1. Introduction

Measurement of financial protection against medical expenditure risks is a key component of the assessment of health systems. The proportion of households with uninsured medical expenses exceeding some fraction of income has been proposed as a measure of the prevalence of *catastrophic medical expenditures* (Berki, 1986; Feenberg and Skinner, 1994; Wagstaff and Van Doorslaer, 2003; Xu et al., 2003). This intuitively appealing index has been very widely applied (Van Doorslaer et al., 2007; Xu et al., 2007; Dmytraczenko and Almeida, 2015; World Health Organization and World Bank, 2015), and yet it has four main limitations. First, it does not necessarily identify the average level of medical expenditure risk in a population and is not informative of the distribution of risk. It does not discriminate between one situation in which the same households always spend a large proportion of their incomes on health care and no household faces risk, and another in which all households face a chance of spending excessively. Second, even if the probability of incurring so-called catastrophic medical expenditures is estimated for each household, this is still a very partial measure of risk. It is part of the expectation of particularly burdensome expenses and does not capture their variability (Gruber and Levy, 2009; National Research Council and Institute of Medicine, 2012). Third, while there are equity and efficiency arguments for relating coverage of a given medical expense to income, the fraction of income at which the catastrophic payments threshold is set is typically arbitrary and not easily reconciled with preferences. Fourth, there is no allowance for the exercise of informal insurance through saving and credit that may cushion the impact of out-of-pocket (OOP) medical expenses that are large in relation to income (Flores et al., 2008).

This paper offers an approach to the measurement of medical expenditure risk that addresses these limitations while maintaining focus on particularly burdensome expenses. The first two limitations are dealt with by measuring household exposure to such

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expenses through an index that decomposes into the probability that medical spending pushes consumption of other goods below a threshold, the utility deficit at a predictably low level of consumption if the threshold is not reached and the additional loss due to consumption uncertainty below the threshold that is generated by volatile medical expenses. This decomposition makes it possible to distinguish households that face a large expected burden of medical expenses from those exposed to the greatest risk due to highly variable expenses at the upper end of the distribution.

Although the measure can be implemented with a medical expenditure threshold defined as an ad hoc fraction of income, we address the third limitation of the prevailing catastrophic payments index by offering the possibility of placing the benchmark at expected expenses and so making it integral to preferences within a model of reference-dependent utility (Sugden, 2003; Kőszegi and Rabin, 2006) with loss aversion (Kahneman and Tversky, 1979). The household experiences distress when medical expenses rise so high that the anticipated level of consumption of other goods cannot be realised. While evaluation relative to the expectation certainly weakens the credentials of the index as a measure of *catastrophic* risk, the high degree of skewness in medical expenses ensures that focus is still on the top of the distribution.

To compute the proposed measure, we approximate the ex ante variability of medical expenditures faced by a household with the cross-sectional dispersion across observationally equivalent households. Unlike others who have taken this approach assuming that OOP medical expenses are paid for entirely from current income (Finkelstein and McKnight, 2008; Engelhardt and Gruber, 2011; Shigeioka, 2014; Limwattananon et al., 2015), we show how even limited information on the reported means of financing health payments can be exploited to simulate the distribution of OOP payments that are not informally insured through savings or borrowing and so are at the expense of non-medical consumption. Integration over this distribution gives a measure of risk remaining after the exercise of informal insurance and deals with the final limitation of the prevailing approach referred to above.

Our favoured measure is scale invariant and can be used to compare catastrophic medical expenditure risk across households and countries with different levels of income. It differs from the relative risk premium for full insurance by focussing only on high medical expenses. The relative risk premium for major risk insurance could also be used for this purpose but, unlike the proposed measure, it is potentially sensitive to medical expenses below the threshold level that defines catastrophic payments. A further advantage of the proposed measure over the risk premium is that it can be used to identify households facing predictably high expenses that would benefit from subsidised cover and not only those facing uncertain expenses that would benefit from actuarially fair insurance. And these households can be distinguished using the decomposition property.

We use comparable cross-section data from the World Health Surveys (World Health Organization, 2011) for seven low- and middle-income Asian countries to illustrate the proposed methods. This demonstrates that taking account of informal insurance makes a substantial difference to measures of catastrophic medical expenditure risk. Clear cross-country differences in risk emerge using the proposed measure but there is also substantial variation in risk exposure within each country. In general, risk is higher among households that are poorer, rural and troubled by chronic illness.

In the next section, we introduce a measure of catastrophic medical expenditure risk that captures household exposure to medical expenses that are large in relation to a benchmark purported to represent an excessive economic burden. In Section 3, we consider specification of the threshold, including the possibility that it is made part of preferences rather than being an ad hoc fraction of income. Section 4 presents a method of simulating household-specific distributions of OOP payments and consumption that take account of the exercise of informal insurance and over which the proposed risk measure is calculated. Section 5 describes the World Health Survey data used to illustrate the measure and Section 6 presents the results from that application. The final section summarises and acknowledges limitations of the approach.

## 2. Risk measures

### 2.1. Upper partial moments of medical expenditure

In order to place the measure we propose in context, we first consider measures that are closest to those currently being used to represent catastrophic medical expenditures, although with the important distinction that we consider measures of ex ante risk exposure at the household level as opposed to ex post prevalence in a population.

Consider a household's OOP medical expenditure, a random variable $M \in [0, \bar{m}]$ with distribution $F_M$ [1]. Exposure to expenditures above a threshold $\zeta$, which could be defined in relation to income $(y)\ \zeta = \tau(y)y,\ \ 0 < \tau(y) < 1$, can be measured by the upper partial moments of $F_M$ [2],

$$\mathrm{UPM}_\alpha^\zeta = \int_\zeta^{\bar{m}} (m-\zeta)^\alpha \mathrm{d}F_M, \quad \alpha \geq 0. \tag{1}$$

With $\alpha = 0$, this gives, for example, the probability the household spends more than some fraction of its income on medical care. The popular catastrophic payments headcount $-(1/n)\sum_i 1(m_i > \zeta_i)$, where $i$ is a household index, $1()$ is the indicator function and $n$ the sample size (Wagstaff and Van Doorslaer, 2003)—can be interpreted as an estimate of the average of this probability in a population. The extreme sensitivity of this measure to marginal changes in expenses around the threshold is a disadvantage given that the benchmark is likely to be somewhat arbitrary and the density of a household's distribution of medical expenses around any point will be estimated with error[3]. Further, with this parameterisation the measure does not distinguish between households that have the same chance of reaching the threshold but expect different expenses in excess of it. Both limitations can be rectified by setting $\alpha = 1$ to give the expected payment in excess of the threshold but this fails to discriminate between (presumably risk averse) households facing different degrees of dispersion beyond the threshold[4]. This can be resolved by setting, for example, $\alpha = 2$ to get the semi-variance, a popular measure of downside risk (Markowitz, 1959), and so giving greater weight to marginal departures that occur further from the threshold. But there is no reason why this particular parameterisation should adequately capture risk attitudes (Fishburn, 1977) and without specifying preferences there is no way to evaluate the extent to which it does.

[1] We omit a household index but it should be recognised that all variables and distributions are specified at the household level. Upper case is used to indicate random variable and lower case to indicate realisations.

[2] In finance, lower partial moments of returns are often used to measure exposure to downside risk (Fishburn, 1977) and these measures are structurally equivalent to many poverty indices (Breitmeyer et al., 2004).

[3] Borrowing terminology from the poverty measurement literature, this measure does not satisfy the *continuity axiom* (Zheng, 1997). For estimation of the prevalence of catastrophic payments across households, this is problematic not only because of the arbitrariness of the threshold but also since substantial measurement error in household medical expenditure data is likely.

[4] Wagstaff and Van Doorslaer (2003) propose the mean payment in excess of the threshold across all households as a measure of the intensity of catastrophic payments, in aggregate.