

# Catastrophe and Impoverishment in Paying for Health Care: With Applications to Vietnam 1993-98

by

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## Abstract

This paper presents and compares two threshold approaches to measuring the fairness of health care payments, one requiring that payments do not exceed a pre-specified proportion of pre-payment income, the other that they do not drive households into poverty. We develop indices for "catastrophe" that capture the intensity of catastrophe as well as its incidence and also allow the analyst to capture the degree to which catastrophic payments occur disproportionately among poor households. Measures of poverty impact capturing both intensity and incidence are also developed. The arguments and methods are empirically illustrated with data on out-of-pocket payments from Vietnam in 1993 and 1998. This is a not uninteresting application given that 80% of health spending in that country was paid out-of-pocket in 1998. We find that the incidence and intensity of "catastrophic" payments—both in terms of pre-payment income as well as ability to pay—were reduced between 1993 and 1998, and that both incidence and intensity of "catastrophe" became less concentrated among the poor. We also find that the incidence and intensity of the poverty impact of out-of-pocket payments diminished over the period in question. Finally, we find that the poverty impact of out-of-pocket payments is primarily due to poor people becoming even poorer rather than the non-poor being made poor, and that it was not expenses associated with inpatient care that increased poverty but rather non-hospital expenditures.

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## 1. Introduction

The literature to date on distributional aspects of health care financing has been distinctly egalitarian, exploring, implicitly or explicitly, the impact of health care payments on income inequality [1-20]. In this paper, we explore two alternative approaches, both of which share the idea that health care payments should not exceed or fall short of a threshold. One approach sets the threshold in terms of proportionality of income. The concern is to ensure that households do not spend more than some pre-specified fraction of their income on health care (call it  $z$ ). Spending in excess of  $z$  is labelled "catastrophic". The idea is, in effect, to ensure that households have at least  $(1-z)$  of their income to spend on things other than health care. Support for this approach is evident in a number of policy documents, including a forthcoming report from the International Labour Organization (ILO) [21]. The other approach sets the minimum in terms of an absolute level of income, and the concern is to ensure that spending on health care does not push households into poverty—or further into it if they are already there. This approach appears to underpin the World Bank's 1997 strategy paper for its health sector [22], which committed the Bank to "working with countries to reducing the impoverishing effects of ill health...", but the theme also emerged in its *Voices of the Poor* consultative exercise [23] and in its 2000/2001 World Development Report (WDR) *Attacking Poverty* [24]. The issue of impoverishment through health expenses has also been emphasized by others. In the US, proposals have been made to take explicit account of health spending in computing poverty rates [25], while Whitehead et al. [26] draw attention to evidence from the developing world suggesting that household health spending is a major cause of poverty.

Our purpose in this paper is not to advocate either of these positions, or to argue in favour of one or other threshold approach over an egalitarian or inequality-based approach. Rather it is to shed some new light on the measurement issues involved in the two threshold approaches. We present measures of catastrophe in health spending and impoverishment, and illustrate them empirically using data on out-of-pocket payments for health care in Vietnam. This is not an uninteresting case study. In 1998, around 80% of health spending in Vietnam was paid out-of-pocket. Unsurprisingly, in *Voices of the Poor* [23], payments for health care came across as a

major concern of poor people in Vietnam. Three key changes occurred in Vietnam during the 1990s which make the study of Vietnam and the period chosen additionally interesting [27-32]. First, user fees in the public sector rose. The increase was especially pronounced for hospital care, where fees appear to have risen by over 1000% in real terms between 1993 and 1998, but were also noticeable in commune health centres even though these were still supposed to be free in 1998. Second, there was a large rise in fees for private clinics and doctors. These apparently rose by nearly 600% over the period 1993-98. Third, expenditures on drugs actually *fell* over the period 1993-98, due to a 30% fall in the real price of medicines during the period in question. The latter seems to have been due in part to deregulation of the pharmaceutical sector and in part to increased donor assistance in drug supplies. Fourth, social health insurance was introduced in 1993. Initially, this was on a compulsory basis for formal sector workers and civil servants. However, more recently the scheme has been opened up to others on a voluntary basis—including the family members of insureds. By 1998, 12% of the Vietnamese population was covered by social insurance, a little over half of these being covered on a voluntary basis. Compulsory social insurance covers some of the costs of both inpatient and outpatient care, and also pays for drugs used in inpatient treatment. The voluntary scheme has two levels of coverage, the less generous (and less expensive) of which covers only inpatient care, while the higher-priced more generous package includes outpatient care and some drug costs. Most voluntary enrollees have opted for the less costly package. Insurance coverage is most common amongst the higher income groups.

The paper is organized as follows. In section 2 we explore the idea that health care payments above a threshold can be considered "catastrophic" and we propose and implement a variety of measures that capture the incidence and intensity of catastrophe in health spending. We also present measures that capture the degree to which catastrophic health spending is concentrated amongst the poor. Section 3 addresses the issue of impoverishment—the extent to which people are made poor, or more poor, by health spending. We present measures that capture the impoverishing effects of health spending, distinguishing between the incidence and intensity of impoverishment, and showing how one can assess the extent to which greater intensity is due to people being made even poorer by health spending or by people becoming poor through such spending. In our coverage of both catastrophic health spending and impoverishment, we illustrate the measures with data on out-of-pocket payments from Vietnam

for both 1993 and 1998. In the case of impoverishment, we show the differential impacts of hospital costs and other health care spending.

## 2. Catastrophic health care costs

The ethical position here is that no one ought to spend more than a given fraction (say  $z_{cat}$ ) of their income on health care. A figure for such a threshold level  $z_{cat}$  is inevitably arbitrary, and it would clearly depend on whether income was defined in terms simply of pre-payment income,  $x$ , or in terms of some measure of “ability to pay”  $y=x-D(x)$ , where  $D(x)$  are “deductions” that are allowed in determining a household’s ability to pay (e.g. spending on food and other “necessities”). If the ability-to-pay approach is adopted, clearly one needs to consider the various issues concerning how  $D(x)$  is to be defined. If  $D(x)$  is to cover only food expenditures, should it cover actual expenses or should it be a flat-rate allowance? If the latter, what should be done with individuals whose pre-payment incomes fall short of the allowance? In this exercise, these last two strategies are problematic, since  $y$  could become zero or negative. In the case where  $y$  is zero, the ratio of health care spending to income is undefined, and individuals with negative values of  $y$  will end up with smaller (in numerical size) values of  $T/y$  than those with small health spending and/or large incomes.

### 2.1. *Measuring the incidence and intensity of catastrophic health care costs*

Suppose one has settled on whether  $x$  or  $y$  will be used, on the definition of  $D(x)$  in the event the latter is to be used, and on an approach to circumvent the problems noted above. Suppose too that a threshold  $z_{cat}$  has been agreed for  $T/x$  or  $T/y$  above which expenses are to be considered “catastrophic”. The obvious summary measure of the extent to which a given sample of individuals has been exposed to catastrophic expenses (defined along these lines) would be the number (or fraction) of individuals whose health care costs as a proportion of income exceeded the threshold. The horizontal axis in Figure 1 shows the cumulative share of the sample, ordered by the ratio  $T/x$ , beginning with individuals with the largest ratio. Reading off this parade at the threshold  $z_{cat}$ , one obtains the fraction  $H_{cat}$  of the sample whose expenditures as a proportion of their income exceed the threshold  $z_{cat}$ . This is the *catastrophic payment headcount*. Thus let  $O_i$

be the catastrophic ‘overshoot’, equal to  $T_i/x_i - z_{cat}$  (or  $T_i/y_i - z_{cat}$ ) if  $T_i/x_i > z_{cat}$  and zero otherwise, and let  $E_i = 1$  if  $O_i > 0$ . Then the *catastrophic payment headcount* is equal to:

$$(1) \quad H_{cat} = \frac{1}{N} \sum_{i=1}^N E_i = \mu_E,$$

where  $N$  is the sample size and  $\mu_E$  is the mean of  $E_i$ .

The difficulty with this measure is that this fails to capture the height above which individuals exceeding the threshold actually exceed it. This presumably matters. By analogy with the poverty literature, one could define not just a catastrophic payment headcount but also a measure analogous to the poverty gap, which we call the *catastrophic payment gap* (or *excess*). This captures the height by which payments (as a proportion of income) exceed the threshold  $z_{cat}$ . We divide this through by the sample size to get the average excess  $G_{cat}$ . Thus we measure the intensity or severity by defining the average ‘gap’ (or excess) of catastrophic payments as

$$(2) \quad G_{cat} = \frac{1}{N} \sum_{i=1}^N O_i = \mu_O,$$

where  $\mu_O$  is the mean of  $O_i$ . The *mean positive ‘gap’* is:

$$(3) \quad MPG_{cat} = \sum_{i=1}^N O_i / \sum_{i=1}^N E_i = \mu_O / \mu_E.$$

We therefore have:

$$(4) \quad \mu_O = \mu_E \cdot MPG_{cat}$$

In other words, the overall mean catastrophic ‘gap’ equals the fraction with a positive gap times the mean positive gap.

## 2.2. Measures that reflect that catastrophic costs matter more for the poor

There is a difficulty with the approach outlined above, namely that it is blind as to whether it is poor or better-off individuals who exceed the threshold. It seems likely most societies will care more if it is an individual in the lowest decile whose spending (as a share of its

income) exceeds the threshold than if it is one in the top decile. One way of shedding light on this is to see how the proportions of those exceeding the threshold vary across the income distribution. This can be done formally using a concentration index for  $E_i$ , which we define as  $C_E$ . This is defined with reference to a concentration curve plotting the cumulative share of the sample along the x-axis (ranked by pre-payment income) against the cumulative share of persons exceeding the threshold on the y-axis. Twice the area between the concentration curve and the line of equality is the concentration index,  $C_E$ . A positive value of  $C_E$  indicates a greater tendency for the better-off to exceed the payment threshold, whilst a negative value will indicate a greater tendency for the worse-off to exceed the threshold.

A difficulty is that the headcount,  $E$ , and the concentration index,  $C_E$ , could move in different directions over time. Or the former might be higher in country  $A$  than country  $B$ , but the latter might be lower in country  $A$  than  $B$ . In such circumstances, it would be useful to have an index trading off the two dimensions. We can do this by constructing a weighted version of the headcount that takes into account whether it is mostly poor people who exceed the threshold or better-off people. We do this by weighting the variable indicating whether the person has exceeded the threshold,  $E_i$ , by the individual's rank in the income distribution. Let  $r_i$  denote person  $i$ 's absolute rank. This is equal to 1 for person 1, 2 for person 2, and  $N$  for person  $N$ . Then define

$$(5) \quad w_i = 2 \frac{N + 1 - r_i}{N}.$$

Thus  $w_i$  is equal to 2 for the most disadvantaged person, declines by  $2/N$  for each one-person step up through the income distribution, and reaches  $2/N$  for the least disadvantaged person. Thus the difference in  $w_i$  between the most disadvantaged person and the second most disadvantaged person is the same as the difference between the second most advantaged person and the most advantaged person. If we weight the  $E_i$  by the  $w_i$ , we get:

$$(6) \quad W_{cat}^E = \frac{1}{N} \sum_{i=1}^N w_i E_i.$$

We have the following result (the proof of which is in the Appendix):

*Result 1.* Given the weighting used in (6), the index  $W_{cat}^E$  can be written as:

$$(7) \quad W_{cat}^E = \mu_E \cdot (1 - C_E).$$

Thus we can modify the catastrophic payments headcount by weighting the dummy status indicator,  $E_i$ , by the person's rank in the income distribution, giving larger weights to poorer people. The weighting scheme chosen results in an attractive and simple summary measure that is simply the catastrophic payment headcount multiplied by the complement of the concentration index. If those who exceed the threshold tend to be poor, the concentration index  $C_E$  will be negative, and this will raise  $W_{cat}^E$  above  $E$ . Thus the catastrophic payment problem is worse than it appears simply by looking at the fraction of the population exceeding the threshold, since it overlooks the fact that it tends to be the poor who exceed the threshold. By contrast, if it is *better-off* individuals who tend to exceed the threshold,  $C_E$  will be positive, and  $E$  will overstate the problem of the catastrophic payments as measured by  $W_{cat}^E$ .

We can apply the same logic to the catastrophic payment excess. We define a concentration index for the overshoot variable,  $O_i$ , which we denote by  $C_O$ . Then we can define an analogue of  $W_{cat}^E$ , which can be shown to be equal to:

$$(8) \quad W_{cat}^G = \mu_O \cdot (1 - C_O).$$

A tendency for large excesses to be concentrated amongst poorer individuals results in a negative value of  $C_O$ , which will raise  $W_{cat}^G$  above  $O$ —the "excess payment problem" is worse than it appears simply by looking at the mean catastrophic payment excess, since this overlooks the fact that the large catastrophic payments are concentrated amongst the worse off. By contrast, if it is the *better-off* individuals who have the largest excesses,  $C_O$  will be positive, and  $O$  will overstate the severity of the catastrophic payment problem as measured by  $W_{cat}^G$ .

### 2.3. Empirical illustration of the catastrophe approach

The data we use to illustrate these measures are taken from the 1992-93 and 1997-98 *Vietnam Living Standards Surveys* (VLSS), undertaken jointly by the government of Vietnam and the World Bank. For the purpose of this exercise, the household is taken as the sharing unit for income and payments (both being assumed to be shared equally across household members), but the individual is taken as the unit of analysis. In the case of the 1997-98 survey (which is not nationally representative) the sample is weighted using sampling weights. Household pre-payment income is measured by total household consumption, gross of out-of-pocket payments for health services. Household post-payment income is simply pre-payment income so defined *net* of out-of-pocket payments. Pre-payment and post-payment income are both defined to be gross of food consumption. Both pre-payment and post-payment income are defined on a per capita basis. Out-of-pocket payments are derived in both years from two questions on health spending over the last 12 months, one specifically on inpatient care, the other on all other goods and services associated with the treatment and diagnosis of illness and injury.

We measured  $O_i$  by the ratio  $T/x$  (i.e. out-of-pocket payments as a fraction of pre-payment income), and set thresholds (i.e.  $z_{cat}$ ) at 2.5%, 5%, 10%, and 15%. Table 1(a) presents these results. We then re-did the exercise with  $O_i$  defined as the ratio  $T/y$  (i.e. out-of-pocket payments as a fraction of ATP), where  $y$  was defined as pre-payment income less *actual* food spending. The ratio  $T/y$  thus gives the share of non-food consumption absorbed by out-of-pocket payments. In this second case, we used thresholds of 10%, 15%, 20%, 25%, 30% and 40% and the results are in Table 1(b).

The tables show that in 1993, for instance, as much as 38% of the sample recorded out-of-pocket payments in excess of 5% of their pre-payment income and that 34% of the sample spent more than 15% of their non-food consumption on out-of-pocket expenditure. Inevitably, in both years, and for both income shares, both the proportion of the sample exceeding the threshold ( $H_{cat}$ ) and the mean excess ( $G_{cat}$ ) fall as the threshold ( $z_{cat}$ ) is raised. More interesting is the fact that for both income shares and for all the thresholds in the range explored, both the proportion exceeding the threshold and the mean excess were lower in 1998 than in 1993. This suggests that, in general, the catastrophic character of out-of-pocket payments was reduced over



the period in question. In Table 1(a), the mean positive gap  $MPG_{cat}$  has decreased (slightly) for the first two thresholds, but increased (slightly) for the two highest thresholds. It is therefore clear that most of the decline in the mean overall gap  $G_{cat}$  is due to the decline in the headcount  $H_{cat}$ . In Table 1(b), the  $MPG_{cat}$  for ability to pay is always lower in 1998.

Table 1(a) shows that at the lower thresholds, the incidence of “catastrophic” health costs is more concentrated amongst the poor in both years, though more so in 1998 than in 1993. By contrast, at the higher thresholds the incidence of “catastrophic” health costs is more concentrated amongst the *rich* in both years, and more so in 1998 than in 1993. The better off are more likely to overshoot the threshold by a larger amount in both years whatever the threshold, and for each threshold there is more concentration of “overshooting” amongst the better-off in 1998 than in 1993. This coupled with the results mentioned above indicates that whilst at low thresholds it is the poor who are more likely to exceed them, they do not spend so far above the threshold as do the better-off. Since the concentration indices are all positive, the index  $W_{cat}^G$  is smaller than the mean catastrophic excess,  $\mu_{cat}^G$ . Catastrophic costs are thus less of a “problem” in both 1993 and 1998 than they would have been if the large “catastrophes” had been concentrated amongst the poor.

The story is somewhat different in terms of ability to pay (or non-food consumption). First, Table 1(b) shows that the incidence of “catastrophe” is *always* more concentrated amongst the poor, in both years, and for all thresholds. Another difference with respect to the same exercise based on pre-payment income is that the magnitude of the “catastrophic overshoot” of ability to pay is more concentrated amongst the poor, but much more so in 1993 than in 1998. Only at higher thresholds in 1998 does it become more concentrated amongst the rich. Because most concentration indices are negative, the rank-weighted indices tend to be higher than the headcount-based measures. In general, both the  $x$ -based and the  $y$ -based approaches give very similar results in terms of the rank-weighted welfare measures: when taking into account people’s location in the income ranking in either the incidence ( $W_{cat}^E$ ) or intensity ( $W_{cat}^G$ ), the measures decrease with rising thresholds but the index values are always higher in 1993 than in 1998. In other words, the catastrophic out-of-pocket expenditure “problem” has unequivocally lessened over the period in question.

### 3. Impoverishing health care costs

A difficulty with the “catastrophic” payment approach is that it is blind as to how far “catastrophic” payments cause hardship. It seems likely most societies will be more concerned about someone exceeding the threshold by, say, five percentage points if their income is \$0.75 a day than if it is \$30 a day. An alternative perspective is that of impoverishment, the core idea being that no one ought to be pushed into poverty—or further into poverty—because of health care expenses. This position is evident in the discussions in the World Bank's 2000/2001 WDR [24] and in its *Voices of the Poor* consultative exercise [23]. In a sense, this approach gets to the heart of the concerns over health care payments—that health care utilization is a response to an unforeseen and unsolicited “shock” and can be sufficiently costly to represent a threat to a household’s ability to purchase other goods and services that may, like health care, make a difference to its members’ ability to survive and flourish as a human beings.

#### 3.1. Measuring the impoverishing effects of health care costs

Figure 2 provides a simple framework for examining the impact of out-of-pocket payments on the two basic measures of poverty—the headcount and the poverty gap. The figure is a variant on Pen's parade. The two parades plot income (before and after out-of-pocket payments) along the  $y$ -axis against the cumulative percentage of individuals ranked by pre-payment income along the  $x$ -axis. Reading off each parade at the poverty line gives the fraction of people living below poverty, while the area below the poverty line above each parade gives the poverty gap. It is assumed in Figure 2 that the poverty line is the same for post-payment income as for pre-payment income—this is an issue we return to in a moment.

Formally, the relevant concepts and measures can therefore be defined as follows. Let  $z_{pov}^{pre}$  be the pre-payment poverty line (which may be different from the post-payment poverty line for reasons discussed below) and  $x_i$  be individual  $i$ 's pre-payment income. Then define  $P_i^{pre} = 1$  if  $x_i < z_{pov}^{pre}$ . Then the *pre-payment poverty headcount* is equal to:

$$(9) \quad H_{pov}^{pre} = \frac{1}{N} \sum_{i=1}^N P_i^{pre} = \mu_{pre},$$

where  $N$  is the sample size. Denote by  $g_i^{pre}$  the pre-payment poverty gap, which is equal to  $x_i - z_{pov}^{pre}$  if  $x_i < z_{pov}^{pre}$ , and zero otherwise. The average *pre-payment poverty gap* is defined as:

$$(10) \quad G_{pov}^{pre} = \frac{1}{N} \sum_{i=1}^N g_i^{pre} = \mu_{g^{pre}},$$

the *normalized pre-payment poverty gap* as

$$(11) \quad NG_{pov}^{pre} = \frac{G_{pov}^{pre}}{z_{pov}^{pre}}$$

and the *mean positive pre-payment poverty gap* as

$$(12) \quad MPG_{pov}^{pre} = \frac{\sum_{i=1}^N g_i^{pre}}{\sum_{i=1}^N p_i^{pre}} = \mu_{g^{pre}} / \mu_{p^{pre}}.$$

We therefore have

$$(13) \quad \mu_{g^{pre}} = \mu_{p^{pre}} \cdot MPG_{pov}^{pre}$$

In other words, the average (pre-payment) poverty gap equals the fraction with a positive gap times the mean positive gap. Replacing the pre-payment poverty line  $z_{pov}^{pre}$  by the post-payment poverty line  $z_{pov}^{post}$ , and all other superscripts ‘pre’ by the superscript ‘post’ gives the analogous post-payment measures.

The measures of poverty impact of out-of-pocket payments are then simply defined as the difference between the relevant pre-payment and post-payment measures, i.e.

$$(14) \quad PI^H = H_{pov}^{post} - H_{pov}^{pre},$$

$$(15) \quad PI^G = G_{pov}^{post} - G_{pov}^{pre}, \text{ and}$$

$$(16) \quad PI^{NG} = NG_{pov}^{post} - NG_{pov}^{pre}.$$

### 3.2. *Empirical illustration of the impoverishment approach*

We consider two candidates for the poverty line. The first is a food poverty line giving the cost of reaching 2100 calories a day. This is often termed an extreme poverty line. Clearly, this is applicable whether income is pre-payment or post-payment. In each case, one is asking whether the person's pre- or post-payment income is sufficient for them to purchase enough food to produce 2100 calories per day. Clearly, some individuals may cross such a poverty line as the result of spending on health care, and some may sink further below it. By comparing the headcounts and poverty gaps before and after health care spending, one can get a sense of its impoverishing effects, whether in terms of additions to the number of people classified as extremely poor or in terms of deepening poverty amongst the extreme poor.

The second poverty line we use captures the spending requirements for both food and non-food items. The difficulty here is that the poverty line for pre-payment income ought to include an element for health spending, whilst the poverty line for post-payment income ought not. One needs to deduct an amount from the poverty line corresponding to health spending to arrive at the post-payment poverty line  $z_{pov}^{post}$ . This means that whilst some people may not be poor before health spending and be poor after it, there will be some who are marginally poor before health spending but *not* poor after it (they spend nothing on health care or they spend appreciably less than the health spending component of the pre-payment poverty line). Thus, whereas in the case where the extreme poverty line is used poverty will necessarily be higher "after" health spending than "before", in the case where the poverty line covers food *and* non-food items, poverty may, in fact, be higher pre-payment than post-payment.

In applying these methods to the data on out-of-pocket payments in Vietnam, we employed a food (extreme) poverty line and a broader-based poverty line based on food and non-food requirements derived from calculations by Glewwe et al. [33]. In the case of the food poverty line, the amounts used for the pre-payment and the post-payment lines were 750 and 1287 thousand dong for 1993 and 1998 respectively. In the case of the broader poverty line, a lower line was set for post-payment income, reflecting the fact that health care payments have to be met from pre-payment income but have already been met at the post-payment stage. The amount we took out from the pre-payment poverty line was derived from health spending

amongst the third quintile in 1993, since this was the group that provided the reference for the food-based poverty line (this group consumed, on average, around 2000 calories). In 1993, people in the third quintile averaged 70 thousand Dong (current prices) per person per year on out-of-pocket payments for health care. We then computed a Laspeyres price index for the health sector for Vietnam for 1998, using data for 1993 and 1998 on contacts per person per year and out-of-pocket payments per contact, broken down by provider type and by quintile of per capita consumption [32]. For all quintiles combined (there was little variation across quintiles), this gave a figure for 1998 of 1.289. This compares to a figure for all non-food items of 1.225 and a figure for the overall CPI of around 1.430. Applying this index value to the health spending component of the poverty line for 1993 gives a figure for 1998 of 90 thousand Dong ( $=70 \times 1.289$ ). From these calculations we obtained pre-payment and post-payment poverty lines for 1993 equal to 1160 and 1091 thousand dong respectively, and lines for 1998 equal to 1790 and 1700 thousand dong respectively.

Figure 3 shows the chart of Pen's parade for households (individuals are used in the analysis that follows) for pre-payment income and extreme poverty in 1998. Overlaid on the chart are the out-of-pocket payments of each household. In some cases, households are clearly pushed further into extreme poverty by out-of-pocket payments, whilst in others they are pushed below the extreme poverty line having started out "before" out-of-pocket payments above it.

Table 2(a) shows that in the case of the food poverty line, out-of-pocket payments increase the headcount ratio by 4.4 percentage points in 1993 and by 3.4 percentage points in 1998. The poverty gap comparisons across years are most meaningful when *normalized* poverty gaps are used (i.e. poverty gaps are divided through by the poverty line). Out-of-pocket payments increase the normalized gap by only 1.4 percentage points in 1993 and by only 0.8 percentage points in 1998. In both years, around three quarters of the addition to the poverty gap was from previously poor people being further impoverished by out-of-pocket payments, and only one quarter was attributable to previously non-poor people being pushed into extreme poverty as a result of out-of-pocket payments.

From Table 2(b) it is clear that out-of-pocket payments have a smaller impact on the headcount in the case of the broader-based poverty line. This reflects the lower poverty line for

post-payment income. Indeed, there is no assurance—as indicated above—that the impact of out-of-pocket payments on the headcount will be positive in this case. In the event, out-of-pocket payments increase the headcount ratio but by only 0.4 percentage points in 1993 and 0.5 percentage points in 1998. These low increases reflect the fact that the percentages of the sample becoming poor through out-of-pocket payments (1.9% in 1993 and 2.3% in 1998) are almost matched by the percentages of persons who were amongst the pre-payment poor but *not* amongst the post-payment poor (1.5% of the sample in 1993 and 1.7% in 1998). The need for the use of the normalized poverty gap is, of course, even greater in this case than in the case of the food poverty line, given that the poverty line is different pre-payment and post-payment, as well as across years. In 1993, the normalized poverty gap is 0.4 percentage points higher post-payment, while in 1998 out-of-pocket payments increase the normalized gap by 0.2 percentage points.

The impoverishment measurement methodology can be used to quantify the different poverty impacts of hospital and other health spending. In the 1998 Vietnam data, we separated hospital expenses (defined as costs associated with inpatient care over the previous 12 months) and all other health care costs over the previous 12 months. On average, the former account for around 20% of the total. Table 3 shows the results of an analysis of the poverty impacts of these two categories of expense, using the extreme food-based poverty line in order to explore which of the two types is the main source of impoverishment. Looking at hospital costs, the increase in the headcount ( $PI^H$ ) is a mere 0.5 percentage points, while the value of  $PI^H$  associated with non-hospital expenses is 2.9 percentage points. The values of the impact on the mean poverty gap ( $PI^G$ ) are 1.07 and 8.54 respectively. Clearly, and perhaps in contrast to prior expectations, non-hospital expenditure has a larger poverty impact in Vietnam than hospital expenditure. What is striking for hospital costs, however, is that although most of the rise in the poverty gap is still due to poor people getting poorer, this element is proportionally less than in the case of non-hospital expenses. In other words, the share of the rise in the poverty gap accounted for by deepening poverty amongst the pre-payment poor is smaller in the case of hospital costs than in the case of non-hospital costs.

#### 4. Conclusions and discussion

In this paper we present two minimum standards (or threshold) approaches to measuring the fairness of a distribution of health care payments. We clarify the meaning of these terms and show how each might be measured. In the first, the threshold is in terms of payments, and set as a proportion of pre-payment income. In the second, the threshold is set in terms of post-payment income, in terms of a poverty line. Payments resulting in people crossing the first threshold are classified as "catastrophic" while payments resulting in people crossing the second are labelled "impoverishing". For both approaches, we define indices which can be used to measure both the incidence and intensity of the catastrophic or impoverishing impact. For the catastrophic impact measure, we also show how it can be made sensitive to the location of its occurrence in the income distribution—"catastrophic" payments presumably matter more for poor households than for better-off ones.

We illustrate both approaches using household data on annual out-of-pocket expenditures on health care taken from the 1992-93 and 1997-98 Vietnam Living Standards Surveys (VLSS). In general, using the minimum standards "yardstick", things appear to have improved in Vietnam over the period considered. Both the incidence and the intensity of "catastrophic" payments fell, whether defined in terms of pre-payment income or ATP. The incidence and intensity also became less concentrated amongst the poor. Furthermore, the incidence and intensity of the poverty impact of out-of-pocket payments were both much lower in 1998 than in 1993. We also show how the methods can be used to see to what extent the poverty impact is due to poor people getting poorer or previously non-poor people falling into poverty, and which types of out-of-pocket expenditure can be held responsible for most of the impact. We found that in the case of Vietnam most of the poverty impact is due to the poor getting even poorer and to non-hospital care outlays rather than payments for hospital care.

Several issues arise from the foregoing that merit discussion. First, we have focused in our empirical illustration on out-of-pocket payments. Clearly, the methods could be applied to *all* health care payments, and symmetry would seem to require that they be included. Payments into a pre-payment scheme (e.g. social insurance contributions, payments to a community financing scheme, etc.) can be large relative to the normal consumption level of a poor

household, and it could be argued that it is just as important to take these into account as it is to capture out-of-pocket payments.

Second, it is important to be clear that we have focused solely on the consumption implications of health care spending. Our measures—like other measures of equity in health care payments—do not reflect the impact that liability for payments has on the utilisation of health care. This is not to say the latter is unimportant. Far from it. Rather that it is a separate exercise requiring separate methods [34-37].

Third, in comparing health spending with total household consumption (i.e. household consumption including health spending), we—and others who advocate looking at the distribution of household payments for health care—are implicitly making two assumptions. The first is that health care payments ought to be thought of as involuntary, undeliberate and non-discretionary—the result of a “shock”, unforeseen and unwanted, rarely the result of a deliberate choice by the individual concerned. Health care payments, in this view, stand apart from most other items of household consumption that contribute to household welfare or utility [38, 25]. This is not an uncontroversial view, as in some cases there is undoubtedly some discretion (at least at the margin) over health expenditures. On balance, however, it seems reasonable to treat health spending as non-discretionary and not to include it with other items of household spending when constructing consumption aggregates. This is the conclusion that Deaton and Zaidi [38] reach, in part based on the low income-elasticities of health spending they find in six out of the seven developing countries they study. Burtless and Siegel [25] also incline to this view in their discussion of proposals to take explicit account of health care spending in computing US poverty rates.

The second implicit assumption we have made is that in the absence of the health shock that necessitated the health spending, households would have enjoyed a higher level of consumption equal to the level of consumption including health expenditures. This assumption results in us regarding some households as well-off largely because they have large health expenditures (see Fig 3). This assumption is debatable. The crux is whether the resources used to finance health spending would have been available for other items of consumption had the health shock that necessitated the spending not occurred. Insofar as the spending is financed out



of current consumption, health spending clearly has an opportunity cost equal to the amount involved. Suppose, though, it is financed by dissaving—e.g. by selling livestock or other assets. The cost in this case is the loss of the use value of the asset, but this loss is felt in each of the remaining years of the asset's life. Assuming the forgone consumption is felt all at once overstates the consumption shock in the current period, and underestimates in subsequent periods. Suppose, by contrast, the health spending is financed through borrowing. In this case, too, since the loan will presumably be paid off over several periods, assuming the cost falls entirely in the current period results in an overestimate of the forgone consumption in the current period and an underestimate of the forgone consumption in the subsequent periods. Thus if the expenditure consequences of health shocks are smoothed over time by dissaving or borrowing, we will overstate the degree to which health expenditures result in catastrophe and impoverishment. Empirical evidence on this topic is very limited, and since panel data are required with good measures of health, the scope for getting better evidence is also limited. The only study to date, based on Indonesian data, explores both the direct and indirect (i.e. forgone earnings) costs of health shocks [39]. It finds that, through consumption smoothing, households appear to be capable of (self-) insuring around two thirds of the effects of small health shocks, but only around one third of the effects of large health shocks. In this particular setting, it is the indirect costs that appear more important.

In effect, this discussion over the consumption smoothing associated with health spending is the issue of *incidence*. In this case, the issue is not *who* bears the burden—e.g. whether it is, say, the worker, the consumer, or the owner of a company who bears the cost of a social insurance contribution [3]. Rather it is *when* the household bears the cost of health spending brought about through a health shock. However, this issue is one that matters just as much for the egalitarian inequality-based approach to health care payments as it does to the threshold approach, but to our knowledge has not been addressed there. *Whatever approach is being used*, there is clearly scope for exploiting panel data to provide better evidence on when households bear the costs of health shocks.

## Appendix

*Proof of Result 1.*

Substituting (5) in (6), and expanding gives

$$\begin{aligned}
 (A1) \quad W_{cat}^E &= \frac{1}{N} \sum_{i=1}^N 2 \left[ \frac{N+1-r_i}{N} \right] E_i \\
 &= \frac{2}{N} \sum_{i=1}^N \left[ \frac{N+1}{N} - R_i \right] E_i \\
 &= \frac{2}{N} \sum_{i=1}^N E_i - \frac{2}{N} \sum_{i=1}^N R_i E_i \quad \text{for large } N.
 \end{aligned}$$

In eqn (A1),  $R_i$  is the person's relative rank (ranging from 0 to 1). Eqn (A1) can be simplified. The first term is equal to  $2 \mu_{cat}^E$ . The second can be simplified using the following expression for the concentration index given in Kakwani et al. [40]:

$$(A2) \quad C_{cat}^E = \frac{2}{N \mu_{cat}^E} \sum_{i=1}^N R_i E_i - 1,$$

so that the second term in (A1) is equal to  $(C_{cat}^E + 1) \mu_{cat}^E$ . Substituting these expressions for the first and second terms of eqn (A1) gives eqn (7) in the text.



*Table 1:  
Incidence (headcount) and intensity (or gap) of catastrophic out-of-pocket payments in Vietnam,  
1993-1998*

*Table 1 (a): Share of pre-payment income (T/x)*

threshold level $z_{cat}$	1993				1998			
	2.5%	5%	10%	15%	2.5%	5%	10%	15%
Headcount measures								
$H_{cat}$	60.97%	38.19%	18.40%	9.26%	55.47%	33.02%	14.20%	7.73%
$C_E$	-0.0161	-0.0113	0.0125	0.0068	-0.0391	-0.0290	0.0279	0.1123
$W_{cat}^E$	61.95%	38.62%	18.17%	9.20%	57.63%	33.98%	13.80%	6.86%
Gap measures								
$G_{cat}$	4.06%	2.85%	1.51%	0.84%	3.41%	2.34%	1.24%	0.71%
$MPG_{cat}$	6.66%	7.47%	8.21%	9.06%	6.14%	7.09%	8.76%	9.20%
$C_O$	0.0057	0.0151	0.0298	0.0408	0.0513	0.0932	0.1829	0.2794
$W_{cat}^G$	4.04%	2.81%	1.47%	0.80%	3.23%	2.12%	1.02%	0.51%

*Table 1(b):  
Share of ability to pay (T/y)*

Threshold level $z_{cat}$	1993				1998			
	10%	20%	30%	40%	10%	20%	30%	40%
Headcount measures								
$H_{cat}$	46.89%	24.35%	13.19%	6.92%	41.52%	19.26%	10.34%	5.13%
$C_E$	-0.0991	-0.1214	-0.1252	-0.1219	-0.1373	-0.1267	-0.0836	-0.0076
$W_{cat}^E$	51.54%	27.30%	14.84%	7.77%	47.22%	21.70%	11.20%	5.17%
Gap measures								
$G_{cat}$	7.12%	3.70%	1.90%	0.92%	5.66%	2.76%	1.33%	0.61%
$MPG_{cat}$	15.17%	15.20%	14.38%	13.30%	13.64%	14.32%	12.91%	11.88%
$C_O$	-0.1168	-0.1236	-0.1180	-0.1202	-0.0936	-0.0505	0.0126	0.0867
$W_{cat}^G$	7.95%	4.16%	2.12%	1.03%	6.19%	2.90%	1.32%	0.56%

Table 2(a):  
Poverty impact of out-of-pocket payments in Vietnam, 1993-1998—Food poverty line

Food poverty line		
	1993	1998
Poverty lines		
$z_{pov}^{pre}$	750	1287
$z_{pov}^{post}$	750	1287
Poverty headcounts		
$H_{pov}^{pre}$	23.4%	15.0%
$H_{pov}^{post}$	27.7%	18.4%
$PI^H = H_{pov}^{post} - H_{pov}^{pre}$	4.4%	3.4%
Poverty gaps		
$G_{pov}^{pre}$	38.05	40.56
$G_{pov}^{post}$	48.18	50.24
$PI^G = G_{pov}^{post} - G_{pov}^{pre}$	10.13	9.68
Normalized poverty gaps		
$NG_{pov}^{pre}$	5.1%	3.2%
$NG_{pov}^{post}$	6.4%	3.9%
$PI^{NG} = NG_{pov}^{post} - NG_{pov}^{pre}$	1.4%	0.8%
Prepay PG prepay poor (A)	907078	3074346783
PG increase prepay poor (B)	182475	540819857
PG increase prepay nonpoor (C)	58965	193279823
A as % of (A+B+C)	79%	81%
B as % of (A+B+C)	16%	14%
C as % of (A+B+C)	5%	5%
B as % of (B+C)	76%	74%
C as % of (B+C)	24%	26%

Table 2(b):  
Poverty impact of out-of-pocket payments in Vietnam, 1993-1998—Overall poverty line

Overall poverty line		
	1993	1998
Poverty lines		
$z_{pov}^{pre}$	1160	1790
$z_{pov}^{post}$	1091	1700
Poverty headcounts		
$H_{pov}^{pre}$	54.0%	37.4%
$H_{pov}^{post}$	54.4%	37.9%
$PI^H = H_{pov}^{post} - H_{pov}^{pre}$	0.4%	0.5%
Poverty gaps		
$G_{pov}^{pre}$	199	171
$G_{pov}^{post}$	192	166
$PI^G = G_{pov}^{post} - G_{pov}^{pre}$	-7.79	-5.05
Normalized poverty gaps		
$NG_{pov}^{pre}$	17.2%	9.5%
$NG_{pov}^{post}$	17.6%	9.7%
$PI^{NG} = NG_{pov}^{post} - NG_{pov}^{pre}$	0.4%	0.2%
# entering	454	1721643
# leaving	365	1311036
# staying	12517	27019071
Total # pool of poor (N)	23839	75806642
% entering pool of poor	1.9%	2.3%
% leaving pool of poor	1.5%	1.7%
% staying in pool of poor	52.5%	35.6%
Total pool of poor (%)	100.0%	100.0%

Table 3:  
Poverty impact of total, hospital and other out-of-pocket expenditure, Vietnam 1998

	Total	Hospital	Other
Food poverty lines			
$z_{pov}^{pre}$	1287	1287	1287
$z_{pov}^{post}$	1287	1287	1287
Poverty headcounts			
$H_{pov}^{pre}$	15.0%	15.0%	15.0%
$H_{pov}^{post}$	18.4%	15.4%	17.8%
$PI^H = H_{pov}^{post} - H_{pov}^{pre}$	3.4%	0.5%	2.9%
Poverty gaps			
$G_{pov}^{pre}$	40.56	40.56	40.56
$G_{pov}^{post}$	50.24	41.63	49.09
$PI^G = G_{pov}^{post} - G_{pov}^{pre}$	9.68	1.07	8.54
Normalized poverty gaps			
$NG_{pov}^{pre}$	3.2%	3.2%	3.2%
$NG_{pov}^{post}$	3.9%	3.2%	3.8%
$PI^{NG} = NG_{pov}^{post} - NG_{pov}^{pre}$	0.8%	0.1%	0.7%
Prepay PG prepay poor (A)	3074346783	3074346783	3074346783
PG increase prepay poor (B)	540819857	54727806	508083771
PG increase prepay nonpoor (C)	193279823	26725566	139066114
A as % of (A+B+C)	81%	97%	83%
B as % of (A+B+C)	14%	2%	14%
C as % of (A+B+C)	5%	1%	4%
B as % of (B+C)	74%	67%	79%
C as % of (B+C)	26%	33%	21%





Figure 1: Catastrophic out-of-pocket expenditures as share of pre-payment income, by cumulative % of population

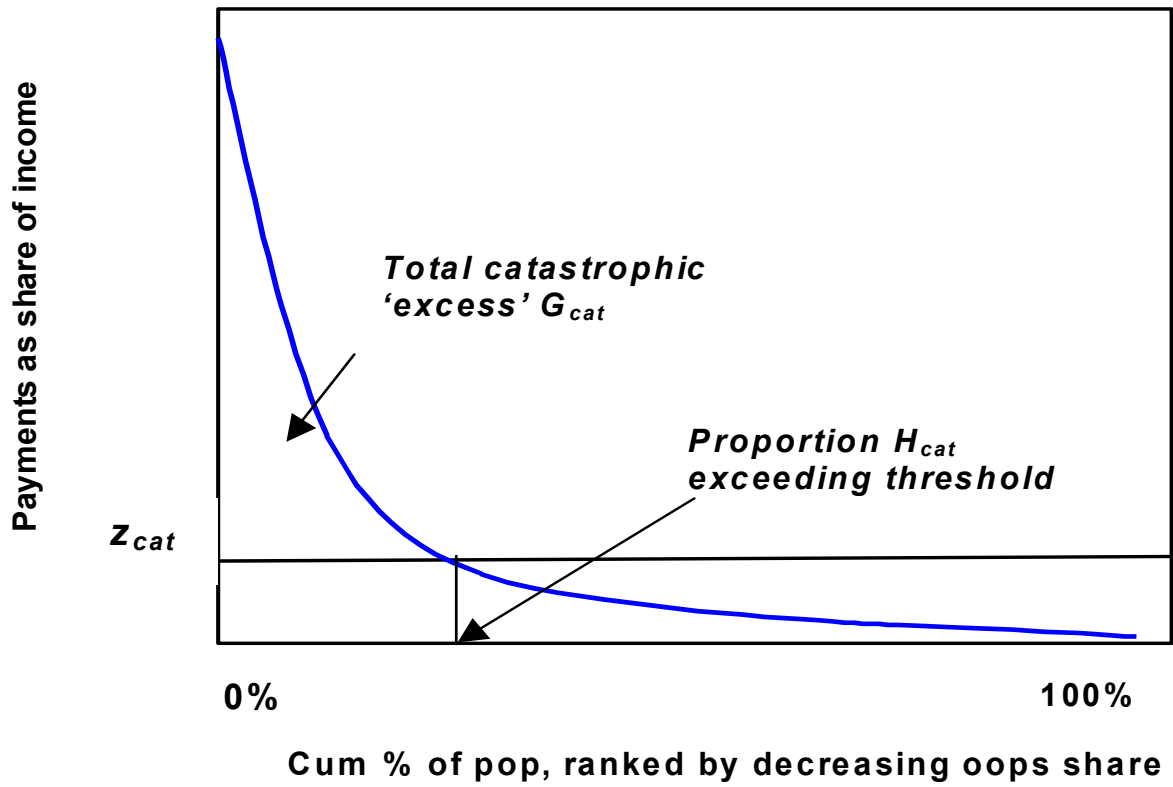


Fig 2: Poverty impact on Pen's Parade —before and after out-of-pocket payments

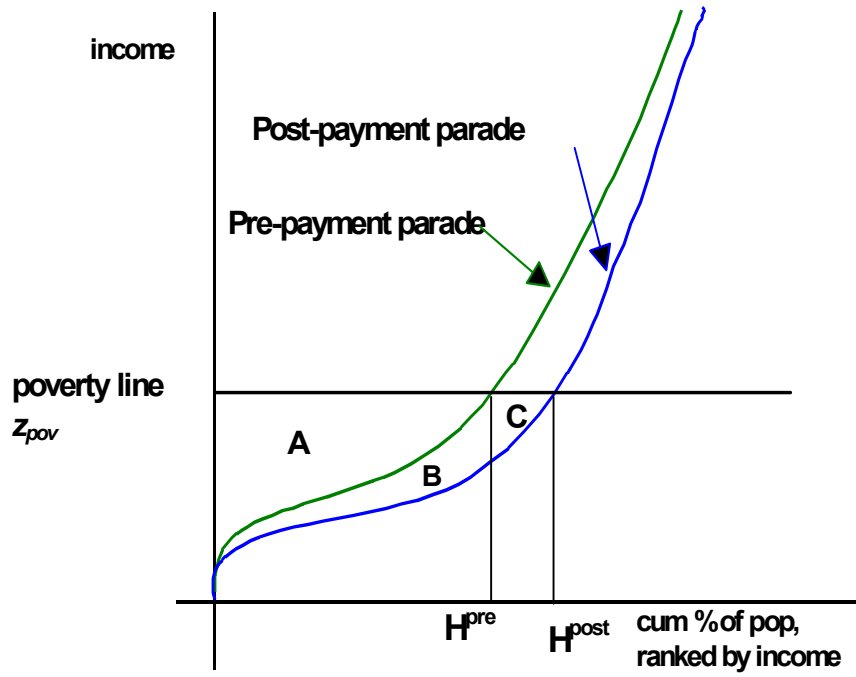
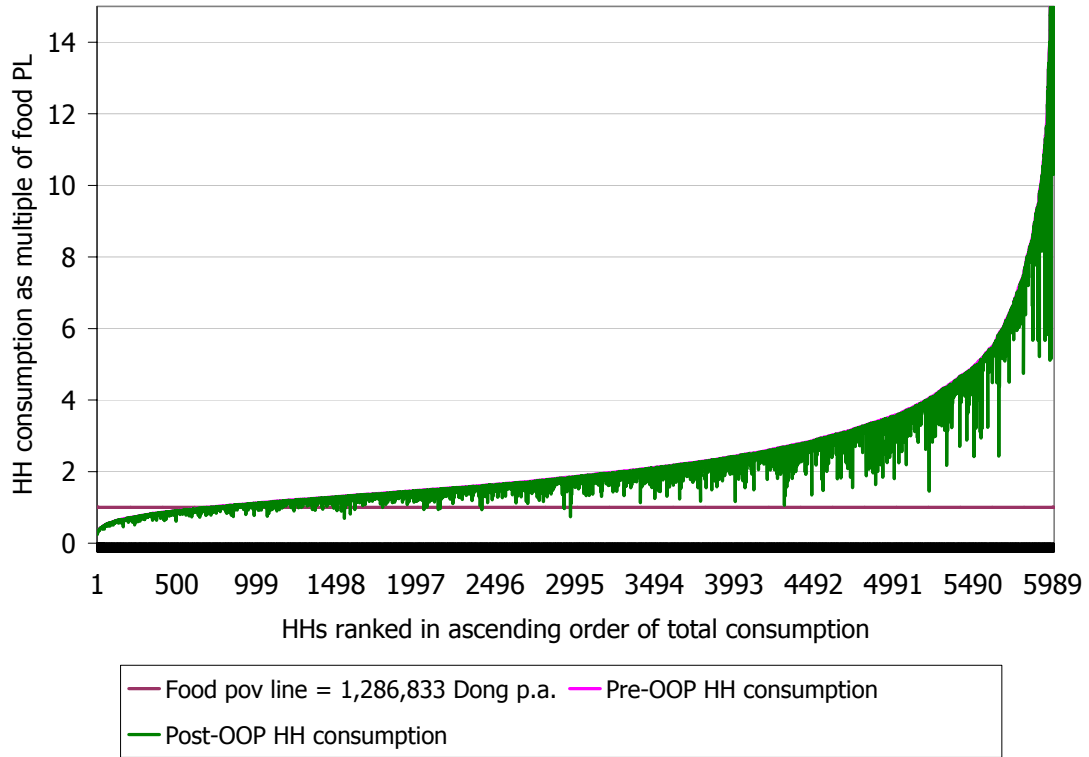


Figure 3:  
Extreme poverty, pre-payment and post-payment income, Vietnam 1998



## References

1. Hurst, J.W., *Financing health services in the United States, Canada and Britain*. 1985, London: King Edward's Hospital Fund for London, Nuffield/Leverhulme Fellowship Report.
2. Wagstaff, A., E. van Doorslaer, and P. Paci, Equity in the finance and delivery of health care: Some tentative cross-country comparisons. *Oxford Review of Economic Policy*, 1989. **5**: p. 89-112.
3. Wagstaff, A., E. van Doorslaer, S. Calonge, T. Christiansen, M. Gerfin, P. Gottschalk, R. Janssen, et al., Equity in the finance of health care: some international comparisons. *Journal of Health Economics*, 1992. **11**(4): p. 361-388.
4. Rasell, E., J. Bernstein, and K. Tang, The impact of health care financing on family budgets. *International Journal of Health Services*, 1994. **24**(4): p. 691-714.
5. Lairson, D.R., P. Hindson, and A. Hauquitz, Equity of health care in Australia. *Social Science & Medicine*, 1995. **41**(4): p. 475-82.
6. Pannarunothai, S. and A. Mills, The poor pay more: health-related inequality in Thailand. *Social Science and Medicine*, 1997. **44**(12): p. 1781-90.
7. Sen, B., *Health and poverty in the context of country development strategy: A case study on Bangladesh*. 1997, Geneva: WHO, Macroeconomics and Health Development Series No. 26.
8. Wagstaff, A. and E. Van Doorslaer, Progressivity, horizontal equity and reranking in health care finance: a decomposition analysis for The Netherlands. *Journal of Health Economics*, 1997. **16**: p. 499-516.
9. Hotchkiss, D.R., J.J. Rous, K. Karmacharya, and P. Sangraula, Household health expenditures in Nepal: implications for health care financing reform. *Health Policy Plan*, 1998. **13**(4): p. 371-83.
10. Fabricant, S.J., C.W. Kamara, and A. Mills, Why the poor pay more: household curative expenditures in rural Sierra Leone. *Int J Health Plann Manage*, 1999. **14**(3): p. 179-99.
11. Hotchkiss, D.R. and A. Gordillo, Household health expenditures in Morocco: implications for health care reform. *Int J Health Plann Manage*, 1999. **14**(3): p. 201-17.
12. Parker, S. and E. Pier, Mexico, in *Health systems inequalities and poverty in Latin America and the Caribbean*, E. Greene, J. Zevallos, and R. Suarez, Editors. 1999, Pan American Health Organization/World Bank: Washington DC.

13. Van Doorslaer, E., A. Wagstaff, H. van der Berg, T. Christiansen, G. Citoni, R. Di Biase, U. Gerdtham, et al., The redistributive effect of health care finance in twelve OECD countries. *Journal of Health Economics*, 1999. **18**(3): p. 291-314.
14. Wagstaff, A., E. van Doorslaer, H. van der Berg, S. Calonge, T. Christiansen, and G. Citoni, Equity in the finance of health care: some further international comparisons. *Journal of Health Economics*, 1999. **18**: p. 263-290.
15. Makinen, M., H. Waters, M. Rauch, N. Almagambetova, R. Bitran, L. Gilson, D. McIntyre, et al., Inequalities in health care use and expenditures: empirical data from eight developing countries and countries in transition. *Bull World Health Organ*, 2000. **78**(1): p. 55-65.
16. World\_Health\_Organization, *The World Health Report 2000. Health Systems: Improving Performance*. 2000, Geneva: The World Health Organization.
17. Gao, J., S. Tang, R. Tolhurst, and K. Rao, Changing access to health services in urban China: implications for equity. *Health Policy Plan*, 2001. **16**(3): p. 302-12.
18. Wagstaff, A. and E. van Doorslaer, *Paying for health care: Quantifying fairness, catastrophe and impoverishment, with applications to Vietnam 1993-98*. 2001, Washington DC: World Bank, Policy Research Working Paper #2715.
19. World\_Bank, *India. Raising the Sights: Better Health Systems for India's Poor*. 2001, Washington DC: World Bank, Report No. 22304.
20. Wagstaff, A., Measuring equity in health care financing: reflections on and alternatives to WHO's fairness of financing index. *Health Economics*, 2002. **11**(2).
21. Baeza, C., P. Crocco, M. Nunez, and M. Shaffer, *Towards Decent Work: Social Protection in Health for all Workers and their Families. The ILO/STEP Framework for the Extension in Social Protection in Health*. 2001, Geneva: International Labour Organization.
22. World\_Bank, *Health, Nutrition and Population Sector Strategy*. 1997, Washington DC: The World Bank.
23. Narayan, D., R. Patel, K. Schafft, A. Rademacher, and S. Koch-Schulte, *Voices of the Poor: Can Anyone Hear Us?* 2000, New York, N.Y.: Oxford University Press.
24. World\_Bank, *World Development Report 2000/2001: Attacking Poverty*. 2000, Oxford, New York: Oxford University Press.
25. Burtless, G. and S. Siegel, *Medical Spending, Health Insurance, and Measurement of American Poverty*. 2001, Washington DC: Brookings Institution, CSED Working Paper No. 22.

26. Whitehead, M., G. Dahlgren, and T. Evans, Equity and health sector reforms: can low-income countries escape the medical poverty trap? *Lancet*, 2001. **358**(9284): p. 833-6.
27. Ensor, T., Introducing health insurance in Vietnam. *Health Policy Plan*, 1995. **10**(2): p. 154-63.
28. Ensor, T. and P.B. San, Access and payment for health care: the poor of Northern Vietnam. *Int J Health Plann Manage*, 1996. **11**(1): p. 69-83.
29. Witter, S., 'Doi moi' and health: the effect of economic reforms on the health system in Vietnam. *Int J Health Plann Manage*, 1996. **11**(2): p. 159-72.
30. Bloom, G., Primary health care meets the market in China and Vietnam. *Health Policy*, 1998. **44**(3): p. 233-52.
31. Bhusan, I., E. Bloom, N. Hai Huu, and N. Minh Thang, *Human Capital and the Poor in Viet Nam*. 2001, Manila: Asian Development Bank.
32. World\_Bank, SIDA, AusAID, Royal\_Netherlands\_Embassy, and Ministry\_of\_Health\_of\_Vietnam, *Vietnam. Growing Healthy: A Review of Vietnam's Health Sector*. 2001, Hanoi: The World Bank.
33. Glewwe, P., M. Gragnolati, and H. Zaman, *Who gained from Vietnam's boom in the 1990s?* 2000, Washington DC: The World Bank, Policy Research Working Paper #2275.
34. Wagstaff, A., E. Van Doorslaer, and P. Paci, On the measurement of horizontal inequity in the delivery of health care. *Journal of Health Economics*, 1991. **10**(2): p. 169-205.
35. Van Doorslaer, E., A. Wagstaff, S. Calonge, T. Christiansen, M. Gerfin, P. Gottschalk, R. Janssen, et al., Equity in the delivery of health care: some international comparisons. *Journal of Health Economics*, 1992. **11**(4): p. 389-411.
36. Van Doorslaer, E., A. Wagstaff, H. van der Burg, T. Christiansen, D. De Graeve, U.-G. Gerdtham, M. Gerfin, et al., Equity in the delivery of health care in Europe and the US. *Journal of Health Economics*, 2000. **19**(5): p. 553-584.
37. Wagstaff, A. and E. Van Doorslaer, Measuring and testing for inequity in the delivery of health care. *Journal of Human Resources*, 2000. **35**(4): p. 716-733.
38. Deaton, A. and S. Zaidi, *Guidelines for constructing consumption aggregates for welfare analysis*. 1999, Princeton NJ: Princeton University Woodrow Wilson School of Public and International Affairs, Research Program in Development Studies Working Paper #192.
39. Gertler, P., Insuring the economic costs of illness, in *Shielding the Poor: Social Protection in the Developing World*, N. Lustig, Editor. 2001, Brookings Institution Press: Washington, DC.

40. Kakwani, N.C., A. Wagstaff, and E. Van Doorslaer, Socioeconomic inequalities in health: Measurement, computation and statistical inference. *Journal of Econometrics*, 1997. **77**(1): p. 87-104.