Practical measurement of affordability: an application to medicines

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Practical measurement of affordability: an application to medicines.

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Summary
BACKGROUND Estimating affordability is not straightforward due to the vagueness of the concept. This paper draws upon the literature on catastrophic and impoverishing payments to develop two practical methods to measure the affordability of medicines, in particular for low and middle income countries which often lack the data sets required for alternative analyses.

METHODS The catastrophic method quantifies the proportion of the population for which expenditures on a certain medicine would exceed a threshold of total resources. The impoverishment method looks at the impoverishing effect of the procurement of medicines, in terms of the proportion of the population that is pushed below the poverty line due to procurement of a specific medicine. We illustrate these methods by calculating affordability of an anti-hypertensive medicine, atenolol, in Indonesia.

FINDINGS The proposed methods use easily accessible aggregated data and take into account a country’s income distribution and absolute level of income. The results regarding the affordability of medicines can easily be interpreted and compared across countries.

INTERPRETATION The catastrophic and impoverishment method can provide a suitable estimate of medicine affordability for use in situations where the information to carry out more sophisticated studies is not available. The results suggest that these methods could be used to obtain an estimate of affordability that is sufficiently accurate yet still practical, however, further research is needed to validate the methods. Their application to other areas of healthcare and other settings could also be explored.

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INTRODUCTION

The issue of affordability is not an unequivocal concept. The way various scholars operationalise it is diverse. Whereas Bradley (2008) calls it a vague concept, Whitehead (1991) and Milne (2006) acknowledge it is almost extrinsic to has no basis in, economic theory. As described by Komnives et al (2005), part of the concept’s ‘vagueness’ stems from the fact that its operationalization is dependent on the specific commodity it relates to:

“From an economic perspective, households choose the bundle of goods and services that maximizes their utility, subject to preferences and budget constraints. Preferences differ substantially across households, reflecting varying income levels, demographics, and health, as well as social and cultural factors, and can, therefore, lead to widely diverging choices about how much to spend on a given service. There is thus no economic basis for judging whether a particular household is spending too much on, or consuming too little of, any particular utility service. Thus, the concept of an affordable tariff has no real basis in economic theory.”

Affordability only has meaning in relation to something else. Because people differ in what they consider ‘affordable’, it is a normative concept (Stone, 2006). This becomes clear in the definition used by Maclellan and Williams (1990) who state that affordability is concerned with securing some standard (or different standards) of housing, education or transport at a price “which does not impose, in the eyes of a third party (usually government) an unreasonable burden on household incomes” (Maclellan and Williams, 1990, in: Hancock, 1993). In an attempt to operationalize the affordability concept, this paper applies two methods that could be practically applicable to a broad range of commodities, and explores their use in elucidating medicine affordability.

In the developing world, medicines account for a substantial part of health care costs (WHO, 2000 and 2004; Van Doorslaer et al, 2006; Cameron et al, 2008). As the majority of the population in many of these countries does not have health insurance (Dror et al, 2002), this implies that medicines are paid for out-of-pocket at the time of illness and that if medicine prices are too high, people will not be able to procure them or will go into debt. Gaining some insight into the affordability of medicines in the developing world is therefore important, yet not straightforward, due to the vagueness of the affordability concept and the lack of reliable and validated methods and data.

This paper draws upon the literature of affordability across various fields of study and proposes two practical applications to measure affordability of medicines. The first is based upon the ratio of
the costs of a particular medicine to total resources, while the second looks at the residual income after paying for this medicine. Hereafter the former approach will be referred to as “the catastrophic method” while the latter is denoted “the impoverishment method”. We operationalize these methods using widely available aggregated data. As such, they can easily be implemented and compared across countries.

**MEASURING AFFORDABILITY**

To estimate affordability of medicines, WHO and Health Action International (HAI) (2008) have proposed a standard survey tool that uses the Lowest Paid unskilled Government Worker (LPGW) concept (see also Cameron et al (2008)). Affordability is then expressed in terms of the number of days the LPGW has to work to be able to pay for a course of treatment. This LPGW-metric has the advantage that it is easily understandable; people within one country can quite easily position themselves relative to the LPGW. However, as often a substantial proportion of the population earns less than the LPGW, this metric may overestimate the affordability of medicines (Cameron et al 2008; Niëns and Brouwer, 2009). Further, it is unclear when to consider something unaffordable in terms of days’ wages of the LPGW, as this income metric is not used in other studies and therefore no reference points are available in the literature. As such, the exploration of alternative methods of estimating medicine affordability is warranted.

Across various sectors and fields of research, two approaches are generally used to estimate affordability. The first is based upon the ratio of payments to household resources while the second focuses on the residual income after payment.

With respect to the first approach, the payment for a commodity is deemed catastrophic (unaffordable) when its costs exceed a certain percentage of household resources. The idea is that spending a large fraction of the available budget on a specific item must be at the expense of the consumption of other goods and services. The choice of this affordability threshold (i.e. the proportion) is subjective (Stone, 2006; Komives et al, 2005; Xu et al 2003). Studies using this approach have focused on the affordability of transportation (Carruthers et al, 2005), education
(Murakami and Blom, 2008), health care (Xu et al, 2003; Wagstaff and Van Doorslaer 2003) and utilities like energy and water (Frankhauser and Tepic, 2005; OECD, 2003). All these studies define affordability of a commodity in relation to the share of available resources that is taken up by this commodity. Because for very poor individuals, even a small budget share may have catastrophic consequences, it makes sense to define affordability with respect to the share of the budget that is left after spending on basic necessities (usually food). The latter has been referred to as “nondiscretionary expenditure” or “capacity to pay” (Wagstaff and Van Doorslaer, 2003; Xu et al, 2003). A drawback of this catastrophic approach is that it does not reflect the degree to which catastrophic payments actually cause hardship and poverty. This can be done by measuring the proportion of the population that drops below the poverty line because of certain expenditures which is done in the impoverishment method.

This second approach considers the absolute level of available resources before and after payment for a commodity. If the former is above the poverty line and the latter not, it can be said that the household ‘became poor’ because of this payment (Dolbeare, 1966; Kutty, 2005, Wagstaff and Van Doorslaer 2003, Xu et al 2003). This approach has been commonly used to study housing affordability (see e.g. Stone (2006) and Kutty (2005)), and has also been applied in the field of health care (Wagstaff and Van Doorslaer 2003, Xu et al 2003). This method clearly focuses more on the poor population groups within society, as the closer you are to the poverty line, the more likely you will be pushed below it due to certain expenditures. However, a drawback of this method is that it does not take into account the proportion of the population that already falls under the poverty line before making the expenditures.

In the remainder, the methodological details of both the catastrophic and impoverishment method are explained and illustrated by calculating the affordability of the anti-hypertension medicine atenolol using data from a price survey undertaken with the WHO/HAI price measurement tool in Indonesia in 2004. Being a chronic condition, a lifelong course of treatment will likely cause this treatment to be less affordable than short-term therapy for acute conditions. Note that similar methods were applied to measure the affordability of a range of medicines in a range of countries (Niëns et al, 2009).
DATA

Household surveys are a common source of data when calculating the catastrophic and impoverishing effect of healthcare costs (Xu et al, 2003; Wagstaff et al, 2003; O’Donnell et al, 2008). However, such surveys are resource intensive, and in low- and middle-income countries they are not conducted on a regular basis. Also, across countries, individual household surveys suffer from methodological heterogeneity. Therefore, comparisons across countries and over time can be quite difficult and time consuming. To address these issues, we propose the catastrophic and impoverishment methods to assess medicine affordability using aggregated data available from the WHO/HAI database of medicine prices (HAI, 2008) and the World Development Indicators (World Bank, 2008). These data are easily and regularly available for a broad set of developing countries.

Both the catastrophic and impoverishment method are based on three components, (i) the price of a (treatment with a) medicine, (ii) the income level, (iii) the income distribution within a country. The median daily treatment price for atenolol in Indonesia (using the standard treatment regimen of 1 tablet a day) was obtained from the WHO/HAI database (HAI, 2008) and converted to US$. It came to US$0.19 a day, when procured as the lowest-priced generic in the private sector. In the WHO/HAI methodology medicine prices are collected from five medicine outlets per sector in at least four\(^1\) geographic or administrative regions in the survey area. For each medicine, prices are collected for both the Originator Brand (OB) and Lowest-priced Generic (LPG) equivalents.

The average income level and income distribution of Indonesia were retrieved from the World Bank’s World Development Indicators (WDIs). Often GDP per capita is used as a proxy for people’s actual incomes (O’Donnell et al, 2008). A country’s GDP consists of \(\text{consumption} + \text{gross investment} + \text{government spending} + (\text{exports} - \text{imports})\). For this study, however, \text{consumption} is of primary interest as it reflects the amount of money people can actually spend. Therefore, \text{Household Final}\n
\(^1\) At least six regions in the 2\(^\text{nd}\) edition of the WHO/HAI manual \textit{Measuring medicine prices, availability, affordability and price components.}
Consumption Expenditure (HHFCE), as provided in the WDIs, is used.\textsuperscript{2,3} For Indonesia, total HHFCE in 2004 amounts to US$ 171,486,085,120.

Regarding income distribution, the WDIs provide the percentage of total income earned in seven income groups. These consist of the five quintiles whereby the upper and lower quintiles are split up in two groups of 10% each (deciles) (see Table 1). Because 2004 WDI data for Indonesia (the same year as the Indonesia price survey) was not available, the most recent income distribution data prior to 2004 was used, i.e. 2002.

[Table 1 here]

METHODS AND RESULTS

As a first step, the HHFCE, the income distribution (seven groups) and the total population is used to calculate the daily average income per capita per income group (see Table 1).\textsuperscript{4} Average daily income per capita in the lowest 10% income group is calculated as (HHFCE*percentage of total income) / (total population*10%), and in a similar way for the other income groups.

Dividing the HHFCE by total population assumes that the average household size is similar across income groups. As poorer households are usually larger (Lipton and Ravaillon, 1994), the average income per capita is overestimated in the lower income distribution ranges hence estimates of impoverishment are conservative.

In Figure 1 this income distribution is plotted graphically. As we do not have information on how income is distributed within each income group, linearity is assumed. For Indonesia, where the poorest 10% of the population on average earns US$0.79 a day, this is plotted at 5%, i.e. the halfway point in the income group. Thus, the coordinates of this point are (5; 0.79). For the other income groups the coordinates were plotted in a similar way. The result is a shape that resembles a Lorenz curve, as

\textsuperscript{2} When the WDIs do not list this information, the Economist Intelligence Unit (EIU) provides in a nominal private consumption figure, which denotes the same (EIU, 2008).

\textsuperscript{3} In the remainder, when we refer to income or resources, we are actually using final consumption expenditures. Note that also in micro-level analysis, expenditure data is usually preferred to income data as the former is believed to better reflect household resources in developing countries (O’Donnell et al 2008).

\textsuperscript{4} The upper and lower quintiles can be split up in deciles by subtracting group 1 from group 2 and group 7 from group 6. In table 1 these calculations are done.
shown in Figure 1. However, it is not cumulative and only displays average daily incomes. Assuming linearity within income groups clearly is a simplification. In reality, the actual income distribution within the income groups will be skewed, and it is likely that the majority of the people in an income group earn less than the average, and only some earn more. This means that, whereas we plot the US$0.79 at the fifth percentile, it is likely to be positioned further on the distribution, i.e. at the fifth percentile the actual daily income is likely to be a bit lower than US$0.79. The most important implication of this assumption is that it probably causes the affordability results to be conservative (i.e. only when the actual distribution is not convex it is not a conservative estimation). The affordability of private sector Lowest Price Generic (LPG) atenolol, is estimated using both the catastrophic and impoverishment methods.

[Figure 1 here]

The catastrophic effect of expenditures on medicines

Expenditures on medicines can be considered catastrophic if they exceed a certain proportion of households’ resources. In the existing literature, total health care expenditures, are usually considered catastrophic if they exceed 10% of households’ total resources (O’Donnell et al, 2008). This 10% threshold is also used by Prescott (1999) and Ranson (2002) (both in McIntyre et al, 2006) and Wagstaff and Van Doorslaer (2003).\(^5\) Medicines make up for a relatively large portion of total health expenditure in developing countries (although a smaller proportion per episode than inpatient costs) (WHO, 2000 and 2004; Van Doorslaer et al, 2006). As such, we propose to calculate medicine affordability with a threshold that is roughly half the one generally used when calculating total healthcare expenditure, i.e. 5 percent. As this 5% threshold is still rather arbitrary, we prefer to use several thresholds and let the reader decide on which one to apply as is also advised by O’Donnell et al (2008). So, while we propose to use a 5 percent threshold in measuring the catastrophic effect of expenditures on medicines, we also test sensitivity by using other thresholds, i.e. 1 percent, 2.5 percent, 5 percent, 7.5 percent and 10 percent of total income.

\(^5\) If one looks at the ratio of health expenditures to ‘capacity to pay’ (basically non food expenditures). In this case a higher threshold is used (see Xu et al, 2003).
We consider expenditures on atenolol in Indonesia, which has a daily cost of US$0.19, to be catastrophic (and therefore unaffordable) if they take up more than 5% of individuals’ daily income. It follows that people need a minimum daily income of US$3.80 to be able to afford this medicine. To estimate for which percentage of the Indonesian population private sector LPG atenolol is unaffordable, we need to know the proportion of the population earning less than US$3.80 per day. To estimate this, a linear line is drawn from the first average income point below US$3.80 (in this case point F) to the average income point above US$3.80 (point G) (see Figure 1). As the coordinates of points F (85; 3.13) and G (95; 6.14) are known, it is possible to calculate the linear function associated with this line. In our example the function that goes with points F and G is: \( Y = 0.301X - 22.455 \).

Note that we use \( Y \) to denote the average daily income, and \( X \) the proportion of the population (ranked by income). If \( Y \) is set to US$3.80, it follows \( X \) equals 87.2%, meaning that 87.2% of the population is estimated to earn less than US$3.80 a day. In sum, this means that 87.2% of the Indonesian population cannot afford private sector LPG atenolol at a daily cost of US$0.19, if unaffordability is expressed in terms of drug expenditures exceeding 5% of individuals’ daily income. As discussed before, the linearity assumption (i.e. the mean equals the median) renders the affordability result conservative, i.e. in reality the income of US$3.80 will fall a bit further to the right on the income distribution.

**Sensitivity analysis**

Table 2 shows results on the affordability of atenolol using the catastrophic method with varying thresholds (1%, 2.5%, 7.5% and 10%) of the budget share. Calculations are done in the exact same way as discussed before, the only difference being that depending on the budget share we need to look at different segments of the curve in Figure 1. For example, if we consider expenditures to be catastrophic if they exceed 7.5% of households’ resources, only those households earning less than \((0.19/7.5)*100=2.53\) US$ are at the risk to incur these catastrophic expenditures and only the segment between E and F of the curve in Figure is relevant for quantifying the proportion of the population earning less than 2.53 US$.

[Table 2 here]
The impoverishing effect of expenditures on medicines

The impoverishment approach investigates the extent to which expenditures on medicines push people’s income below a certain absolute threshold. The method aims to compare the proportion of the population below the poverty line before and after procurement of medicines. For Indonesia, a lower-middle income country according to World Bank classifications (World Bank, 2008) the threshold was set to the US$1.00 per day poverty line. Table 2 shows that the average daily income of the first decile (US$0.79) already lies below the US$1.00 per day poverty line. Although these people cannot be pushed below the poverty line due to procurement of atenolol anymore, the medicine is clearly unaffordable for this group. As the daily cost of atenolol is US$0.19, those people earning between US$1.00 and US$1.18 are at risk of being pushed into poverty due to expenditures on atenolol.

To calculate the proportion of the population below the US$1.00 poverty line before and after procuring atenolol, we focus on the income distribution between the 15th (point B) and 30th (point C) percentile of the total income distribution. This is because points B and C encompass both the US$1.00 and critical limit of US$1.18 thresholds. A straight line was again drawn, this time between points B and C. With the coordinates of point B (15; 1.00) and C (30; 1.28) known, the linear function that goes with this (dashed) line is: $Y = 0.01866X + 0.72$. Using this linear function, 15% of population is estimated to live off less than US$1.00 a day. However, if everyone needed to procure atenolol, all incomes would drop by US$0.19. The new income distribution is calculated by subtracting US$0.19 from the intercept (i.e. 0.72) in the pre-payment equation, i.e. the post-payment distribution is represented by $Y = 0.01866X + 0.53$. The proportion of the population below the poverty line would then equal 25%. It follows that procuring atenolol has an impoverishment effect of 25 – 15 = 10%. Thus, an additional 10% of the population would fall below US$1.00 a day if the total population needed to take this medicine. Atenolol could then be deemed unaffordable for 25% of the population while it would impoverish 10%.

The relevant segment of the curve in Figure 1, in this case between B and C, depends on the daily cost of the medicine. It has to cover those population groups that are at risk of falling under the poverty line. Therefore, the lower average income point should always be the first below (or, as in our example, equal to) the poverty threshold chosen, while the upper average income point should be
chosen so that the difference between this point and the threshold at minimum equals the highest daily medicine cost for which affordability is estimated.⁶

**Sensitivity analysis**

Table 3 shows the effects of varying the slope (through increase/decrease of C) of the linear function on the impoverishment rates at the US$1 thresholds for US$0.19 private sector LPG atenolol in Indonesia. If the slope is decreased, the impoverishment rates go up whilst an increase of the slope causes impoverishment rates to decline.

[Table 3 here]

**DISCUSSION**

This paper aimed to explore two methods for estimating medicine affordability in low- and middle-income countries: the catastrophic and impoverishment method. These methods are practically applicable in the sense that they demand little data that are easily accessible, while addressing the limitations of the LPGW approach. Given the vague nature of affordability, multiple measures are valuable in gaining a robust understanding of this concept as it applies to medicine expenditure. Therefore, the methods presented here may be useful complements to the LPGW measure by providing supplementary means of interpreting medicine prices in relation to their affordability for different income groups.

As these methods require only aggregated data on medicine price, income levels, and distributions that is available for a broad set of developing countries, they can easily be implemented and compared across countries. However, the use of such aggregated data does require some simplifying assumptions. First, assuming linearity across regions of the income distribution will tend to bias the affordability results downward. A second limitation is that in being medicine-specific, the methods do not provide an overall measure of medicine affordability and the fact that treating a disease often requires more than one medicine. Third, although rather arbitrary, the choice of the

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⁶ When looking at affordability of a more expensive medicine, the function can span over two or more average income points. In this case, the distance between the actual income curve and the linear approximation increases, which will imply overestimating the affordability of these medicines.
threshold in the catastrophic approach is an important one as it significantly influences the affordability outcomes. On setting a threshold O’Donnell et al (2008) write that this: “is obviously a matter of judgment. Researchers should not impose their own judgment but rather should present results for a range of values … and let the reader choose where to give more weight.” In line with this statement, when applying the catastrophic method we propose that the calculations be conducted for a range of thresholds. The absolute threshold required in the impoverishment method should be determined according to the living standards in a country.

The methods presented here may be informative for, and applicable to, other commodities. They are a tool for providing insight to people’s purchasing power, the results of which can be used in policy development aimed at improving the affordability of essential medicines. These possible other applications present ample opportunities for future research. Further investigating the methods highlighted here, including their validity, is necessary as well.

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**Contributors**
All authors contributed to the different phases of writing this paper.

**Conflict of interest statement**
We declare that we have no conflict of interest.

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**REFERENCES**


Table 1: Using aggregated income data to calculate daily average income per capita.

<table>
<thead>
<tr>
<th>HHFCE</th>
<th>US$ 171,486,085,120</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Population</td>
<td>217,587,498</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cum. % of population ranked by HHFCE</th>
<th>Percentage of total income</th>
<th>Average daily income per capita in US$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 0 – 10</td>
<td>Poorest 10%</td>
<td>3.67</td>
</tr>
<tr>
<td>2. 10 – 20</td>
<td>2nd poorest 10%</td>
<td>4.65</td>
</tr>
<tr>
<td>3. 20 – 40</td>
<td>2nd quintile</td>
<td>11.82</td>
</tr>
<tr>
<td>4. 40 – 60</td>
<td>3rd quintile</td>
<td>15.67</td>
</tr>
<tr>
<td>5. 60 – 80</td>
<td>4th quintile</td>
<td>21.27</td>
</tr>
<tr>
<td>6. 80 – 90</td>
<td>2nd richest 10%</td>
<td>14.49</td>
</tr>
<tr>
<td>7. 90 – 100</td>
<td>Richest 10%</td>
<td>28.43</td>
</tr>
</tbody>
</table>

Figure 1: Income distribution in Indonesia (2002)

Table 2: Sensitivity of the catastrophic method: affordability private sector LPG atenolol – Indonesia, 2002.

<table>
<thead>
<tr>
<th>Thresholds</th>
<th>Min. income</th>
<th>Line on points</th>
<th>Function (Y=)</th>
<th>Unaffordable for:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1%</td>
<td>US$19</td>
<td>F – G</td>
<td>0.301X – 22.455</td>
<td>99%</td>
</tr>
<tr>
<td>2.5%</td>
<td>US$7.60</td>
<td>F – G</td>
<td>0.301X – 22.455</td>
<td>99.85%</td>
</tr>
<tr>
<td>7.5%</td>
<td>US$2.53</td>
<td>E – F</td>
<td>0.05533X – 1.5733</td>
<td>74.16%</td>
</tr>
<tr>
<td>10%</td>
<td>US$1.90</td>
<td>D – E</td>
<td>0.0305X + 0.165</td>
<td>56.89%</td>
</tr>
</tbody>
</table>
Table 3: Sensitivity of the impoverishment method: affordability private sector LPG atenolol – Indonesia, 2002.

<table>
<thead>
<tr>
<th>% change in point C (1.28)</th>
<th>New C</th>
<th>Pre-payment Function (Y=)</th>
<th>Post-payment Function</th>
<th>Unaff. for Impov. Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1% increase</td>
<td>1.293</td>
<td>0.01952X + 0.707</td>
<td>0.01952X+0.5172</td>
<td>24.73%</td>
</tr>
<tr>
<td>5% increase</td>
<td>1.344</td>
<td>0.02293X + 0.656</td>
<td>0.02293X + 0.466</td>
<td>23.28%</td>
</tr>
<tr>
<td>10% increase</td>
<td>1.408</td>
<td>0.02720X + 0.592</td>
<td>0.02720X + 0.402</td>
<td>21.99%</td>
</tr>
<tr>
<td>1% decrease</td>
<td>1.267</td>
<td>0.01781X + 0.733</td>
<td>0.01781X + 0.543</td>
<td>25.66%</td>
</tr>
<tr>
<td>5% decrease</td>
<td>1.216</td>
<td>0.01440X + 0.784</td>
<td>0.01440X + 0.594</td>
<td>28.2%</td>
</tr>
<tr>
<td>7% decrease*</td>
<td>1.190</td>
<td>0.01269X + 0.810</td>
<td>0.01269X + 0.620</td>
<td>30.0%</td>
</tr>
</tbody>
</table>

*Calculating impoverishment rates for US$0.19 private sector LPG atenolol in Indonesia requires C to be at least US$1.19 (i.e. otherwise we would need to include point D in the equation). Thus, we can decrease C up to 7%.