COPING WITH ILL HEALTH IN A RICKSHAW PULLER'S HOUSEHOLD IN CHITTAGONG, BANGLADESH

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Abstract. The correlation between poverty and ill-health is undeniably strong. Ill-health reduces the earning capacity, and increases the risk of families with ill members to drift down the social and economic ladder. In this article, we present a simulation model of how a poor rickshaw puller in Bangladesh copes with illness, in particular tuberculosis (TB). We first analyze the various coping mechanisms that are set in motion when he starts to suffer from tuberculosis; the impact on household assets, income and food intake will be studied. The simulation model is then used to analyse the effects on his household of a specific health intervention, namely the Directly Observer Treatment Short Course (DOTS) treatment. It shown that DOTS offers positive improvements of the overall well-being of the household by restoring the working capacity of the rickshaw puller in one treatment course and minimizing lost income. Assets and food consumption would be preserved significantly more in the presence of DOTS, rendering the household both financially and physically less vulnerable. The probability of death of the sick rickshaw puller is also significantly reduced, improving household's welfare over the long run.

INTRODUCTION

It is estimated that there were 1.3 billion people in the world living in absolute poverty in 1993, well over a fifth of the earth's population (WHO, 1997a). The greatest incidence of poverty occurs in South Asia at a rate three times this average. In Bangladesh in particular, the percentage of the population below the absolute poverty line is estimated at 52% (Haq, 1997).

The correlation between poverty and ill health is undeniably strong. Ill health reduces the body's capacity to perform its normal tasks, rendering the sick unable or less able to work. Accordingly, their earnings tend to reduce just at the time that expenditure for medicine and medical care may become necessary. The ill, even among non-poor families, are at risk of drifting down the social and economic ladder. Between 1990 and 1994, 21% of previously non-poor households in Bangladesh are reported to have slipped into poverty as a result of health-related causes (Sen, 1996). The consequences are especially severe for the poor groups of society with little or no resources to fall back upon in hard times.

In this article we analyse how a rickshaw puller belonging to the poorer segments of society in Bangladesh, copes with illness, in particular tuberculosis (TB). We study especially how household assets, income and food intake is likely to be affected by the illness and by the costs of subsequent treatment. In the next section, we present a profile of the rickshaw puller's household, as these data are crucial in the methodology developed. In the second section, we discuss the various coping mechanisms set in motion when the rickshaw puller starts to suffer from tuberculosis. The third section comprises a further quantitative analysis of illness and coping, using a simulation approach. The simulation model is used subsequently to analyse the effects on the household of a specific health intervention, namely the introduction of the Directly Observer Treatment. Short Course (DOTS) treatment. It is examined to what extent this intervention contributes to better health and halts impoverishment.

A RICKSHAW PULLER'S HOUSEHOLD PROFILE

To examine the effect of ill health, and in particular tuberculosis, on a rickshaw puller's household, a simulation model was developed. The household lives in a Chittagong slum and belongs to the poorer segments of the population. The simulation methodology enables one to experimentally analyse consequences upon a rickshaw puller's household resulting from external events such as the occur-

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rence of illness and the implementation of health policy measures. It is a useful method in the absence of detailed data which would be time-consuming and costly to acquire. Instead, a set of assumptions are employed, using a combination of specific and aggregate data and expert opinion. Data from Bangladesh, and wherever possible specific to Chittagong slums, was used to build the model.

An important first stage was to specify a typical profile of a rickshaw puller's household in this area. The household data, presented in Table 1, reflect the conditions and experiences as described in recent area surveys, and are associated with full capacity to work of the rickshaw puller. The data also refer to averages or expected values. Let us mention immediately, however, that the demographic, nutrition and economic characteristics of the household should not be considered to be deterministic. In fact, in the next section, probability distributions for a number of variables and parameters will be introduced. The latter approach is adopted so as reflect that within the same professional group, living conditions are not necessarily equal and that, therefore, the impact of illness may differ across households.

COPING MECHANISMS AS A RESULT OF ILLNESS

We analyse the situation whereby the rickshaw puller contracts tuberculosis. As soon as the effects of ill health begin to threaten family income, a sequence of household coping mechanisms is set in motion. The initial response to the sudden necessity of a large medical expenditure is the sale of assets, as noted in Pryer (1989). Next, intra-household labor substitution is undertaken to preserve income, followed by consumption loans to maintain the household at a level of income needed to survive.

First then, the mother could take on an extra position as a servant, thereby increasing her income by one-third. The other dependents could also engage in income-generating activities. The grandmother could cook rice to be sold by the youngest daughter in the marketplace, and the son could beg or scavenge for food near his sister. It is further assumed that, before undertaking loans, the household will reduce its consumption to 1,600 calories a person a day, which is equivalent to the level of severest poverty (See Appendix D). Finally, consumption loans, though a last resort due to the extraordinarily high interest rates and short repayment periods (See Appendix E), would probably prove necessary to meet the income gap that remains after labor substitution and food reduction has occurred. This again is consistent with Pryer's study (1989), in which households dependent on casual labor accumulated large consumption loans to finance lost income when the breadwinner fell ill.

Modelling income formation (See Appendix A)

Rickshaw puller : The rickshaw puller's net monthly income, (The rickshaw puller considered does not own the rickshaw and pays a rent to the owner. The income considered is net of payment of rent to the rickshaw owner), YR, follows a normal distribution centered around a mean of 1,253.53 Tk/month,

Table 1
Household profile.

	Value of assets (in Tk)	Caloric consumption	Age	Occupation	Income (in Tk)
Family	3,600	2,122 per family member per day			
Family numbers					
Father			40	rickshaw puller	1,254
Mother			35	servant	501
Daughter			16	garment worker	532
Daughter			9	student	0
Son			4	none	0
Grandmother			55	home maker	0

Note : The currency in Bangladesh is the Taka (Tk) ; the exchange rate used in this paper was 43.6 = US$ 1 (August 1997).

and is defined as follows (Henceforth the capital letter F at the end of a symbol is associated with "full work capacity of the rickshaw puller" :

$$YR_t = (1-wr_t)YRF_t$$

where YRF = income associated with absence of illness and therefore full work capacity
wr = work reduction indicator
t = indicator of monthly period

The work reduction indicator has been defined as follows :
wr = 0 in the event of full work capacity
wr = 0.5 in the event of a 50% reduction in work capaity
wr = 1 in the event of total incapacity

It is further assumed that work reduction is only dependent upon the degree of illness experienced by the rickshaw puller.

Other family members : Income earned by other family members, YO_t, is defined as :

$$YO_t = YG_t + YD_t(wr_t)$$

where YG_t = garment worker's monthly income
YD_t = servant's monthly income

The *garment worker's* income is assumed to be fixed :

$$YG_t = 531.66 \text{ Tk for all } t$$

The incomes of the *servant* depend on the work capacity of the breadwinner. In the event of the rickshaw puller's full capacity to work ($wr_t = 0$), $YD_t = YDF_t$, the monthly income the servant earns from working in three homes averages 501.3 Tk a month.

Concerning the three *remaining dependents*, it is assumed that in the event of the breadwinner's full capacity to work (wr = 0), they do not make a contribution to family income.
Hence

$$YDEP_t = YDEPF_t = 0$$

Total family income : We are now able to define the model for total family income in the event of full work capacity:

$$YH_t = YR_t + YG_t + YD_t + YDEP_t$$

which, when the breadwinner is at full working capacity (wr = 0), becomes the following :

$$YHF_t = YRF_t + YGF_t + YDF_t$$

Coping with a drop in the rickshaw puller's income

As soon as the rickshaw puller's income drops, the servant adjust her activities in order to compensate, albeit partially, for the breadwinner's drop in income. Her income is adjusted upwards by 33% when wr > 0 as she assumes an extra position to compensate for her husband's lost income:

$$YD_t = YDF_{t*} (1 + 0.33)$$

The three remaining dependents recoup some of the lost family income through the activities described earlier, including selling cooked rice in the marketplace and begging. It is assumed that the average additional income from these activities amounts to 325 Tk/month (See Appendix B).

We can now formulate the net change in household income in the event of the breadwinner's illness, NCY as:

$$NCY_t = YH_t - YHF_t$$

The variable NCF becomes an important variable in the simulation model.

Coping with medical care expenditure

Medical expenses (M_t) are paid up front in the period incurred, with the full amount covered by the sale of assets, an assumption supported by Pryer (1989). Asset value (A_t) is modelled as a triangular distribution ranging from 2,600 to 4,600 Tk; the average is 3,600 which is based upon personal information from Currey (1997) and from Desmet and Bashir (1998). Asset basically comprise household items (such as beds, tables, chairs, watch, fan, radio) as well as some petty cash. Assets do not include the value of the rickshaw, as the rickshaw puller rents the vehicle from a rickshaw owner. Assets are assumed reduced in each period by the full amount of medical care purchase:

$$A_t = A_{t-1} - M_t$$

Coping with a reduction in food consumption : borrowing

Although there may be some occasional petty cash saving, we will assume that the savings rate for this household is basically zero so that all earned income is destined for consumption. Accordingly, if there is a drop in income such that $NCY_t < 0$, the household will reduce food consumption (FR) to compensate. In other words:

$$FR_t = NCY_t$$

However, we impose a natural limit to the extent of this food reduction, FR_t. The household is assumed unable to reduce food consumption below the extreme poverty level consumption of 1,600 calories a person a day. This translates into a minimum monthly household income (YH_{min}) of 1,701.94 Tk. If the net household income (after intra-household labor substitution and interest/principle payments for loans) fails to maintain the household at YH_{min}, a consumption loan (L) will be taken. We therefore write, that if

$$FR_t > YHF_t - YH_t$$

then

$$L_t = (YH_{min} - YH_t)$$

As only short term loans are available to poor Bangladeshi household, the life of each loan is assumed to be two periods. Accordingly, total debt (D) due payable in each period is

$$D_t = r_{t-1} L_{t-1} + (1 + r_{t-2}) L_{t-2}$$

where r refers to the interest rate. The latter varies according to the existence of an outstanding loan, L_{t-1}. It is assumed to be 25% for debt - free ($D_{t-1} = 0$) household and 40% otherwise.

Coping in subsequent periods

In subsequent periods, the household income equations are adjusted to reflect the presence of debt. The extra income from intra-household labor substitution will be necessary not only when the breadwinner is ill but as long as the household is in debt. Accordingly $YDEP_t$ will continue to be positive and $YD_t = 1.33\ YDF_t$ so long as either $wr_t > 0$ or $D_t > 0$. In other words:

$$YO_t = YG_t + YD_t(wr_t, D_t) + YDEP_t(wr_t, D_t)$$

The net change in income must further include the existence of outstanding loan and interest payments, D_t, as a direct component. Where food reduction and labor substitution do not suffice, the household will be forced to take out additional loans to make the debt payments that are due in each period. Accordingly,

$$L_t = YH_{min} - (YH_t + D_t)$$

There is no data on how long a poor household could continually refinance its debt, nor on the maximum amount of debt they might carry and still be eligible for further loans. It may be assumed however, that the presence of assets as collateral is an important consideration.

SIMULATING ILLNESS AND COPING

Basic assumptions

Simulation methodology (See, for instance, Budnick, *et al* (1977) for an excellent treatment of the simulation methodology) is used to analyse the behavior of the rickshaw puller's household and to predict the household's reaction to external events such as illness or public policy initiatives. The advantage of simulation is that one can relatively rapidly obtain solutions of relatively complex mathematical models. Moreover, in the present case, we have defined probability distributions to a number of variables and parameters. Through simulation, results are obtained that would be more difficult to obtain via an analytical solution.

We have first performed a simulation run covering twenty four months. As we attempt to simulate the current living conditions of a rickshaw puller's household, we refer to it as the "base case" simulation.

The following basic assumptions are made as to the illness of the rickshaw puller. At the onset of the 24 month period the rickshaw puller is infected with tuberculosis. The rickshaw puller will start a "conventional" treatment, but will relapse into two more bouts of disease cum treatment. Each treatment period lasts for three months subsequent to the month of onset of the disease or its relapse. At the end of his third bout (with episodes beginning in months 1, 10, and 19) of tuberculosis treatment, we consider that the rickshaw puller is cured (in this, he is among the 40% cured under conventional practice). However, he will never be fully restored to the level of health (*ie*, work capacity) he enjoyed

Table 2
Selected results of base case simulation.

Month	Expected value of assets at the end of the month (in Taka)	Food reduction		Additional income earned by other family members		Expected value of loans at the end of the month	
		Expected value (in Taka)	Probability of food reduction %	Expected value (in Taka)	Probability of income >0 %	Expected value (in Taka)	Probability of a loan %
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
4	2,944	464	100.0	475	100.0	326	64.6
13	2,290	505	99.8	474	100.0	1,322	73.4
22	1,634	543	100.0	475	100.0	12,539	79
24	1,634	414	96.0	453	97.2	24,687	66.6

before the illness, and he will find his work more demanding than before.

For further details regarding the assumptions with respect to the rickshaw puller's income, the dependent's income, work capacity, caloric requirements, interest rates and repayment periods, medical expenditures for conventional practice, the reader is referred to Appendices A, B, C, D, E, and F, respectively.

Simulation results

The model presented above is subjected to 500 iterations. A selection of results pertaining to months 4, 13, 22 and 24 is included in Table 2. Periods 4, 13 and 22 correspond to the end of the different bouts of treatment. Period 24 is included as it is important to study the impact on the rickshaw puller' s household economy at the end of two years.

The following conclusions can be drawn from Table 2:

(i) Having started from an initial expected value of assets of 3,600 Taka, assets reduce gradually (column 1), and at the end of the 24 month period, the expected value of asset is 1,634 Tk, which implies a reduction of 54.6% vis-à-vis the starting stock of assets. This leaves the family that much more vulnerable to future shocks.

(ii) Food reduction (column 2) between the reported months 4 to 22 varies between 464 and 414 Taka per month. The latter translate into a percentage food reduction of 20.3% and 18.1% vis-à-vis average total family income in the event of full capacity of the breadwinner (YHF). Although there are no longer medical expenses in the 24th month, food reduction continues. The latter is the result of a lower working capacity, and hence lower income, of the rickshaw puller which obliges the family to save on food.

One can also observe (column 3) that there is a very high probability that the household suffers a prolonged period of reduced food consumption putting them at greater risk for additional diseases and likely further stunting the growth and development of the youngest children. Extreme lethargy from caloric deprivation may also occur at the same time that increased activity is demanded of the five household dependents'. As we have not modelled a link between the other dependents' working capacity and their nutritional status, our results are likely to underestimate the efficiency of coping via the work effort of dependents', however.

(iii) In all periods portrayed, additional income (column 4) is earned by family members as one of the ways to cope with the immediate consequences of the breadwinner's illness. In other words, intra household labor substitution takes place. This labor substitution is important in that the average increase of income earned by family members is 43.8% (period 24) to 46% (periods 4 to 22) compared to original income earned. One can also see (column 5) that labor substitution is certain or almost certain throughout the 24 month period.

(iv) Concerning the value of loans (column 6), they tend to be small at first. However, debt will be building up, and more loans will become nescessary to cope in general but also to reimburse the accumulated loans and the accrued interest. Loans become significant as time passes. The probability for the household to engage in loans remains at a high 66.6% at the end of the 24 month period.

(v) Overall, coping mechanisms are set in motion as a result of poor health and inadequate medical care. They attempt to lessen the impact of ill health on well-being, especially through additional income from other members and loans. However. households suffer the loss of assets, further periods of under nutrition and debt (in some cases even after the work capacity of the breadwinner has been restored). Other considerations relate to the schooling of the youngest daughter. She will not attend school during these hard times, and is unlikely to return after nearly two years of absence. Thus, in effect, her father's illness puts an end to her education. The long term opportunity costs of this loss of education, though difficult to quantify, can be taken to be quite significant.

SIMULATING A HEALTH POLICY INITIATIVE : THE DOTS TREATMENT

Proper medical treatment for tuberculosis currently takes the form of DOTS (Directly Observed Treatment, Short-course) (DOTS has a few essential components: generation of political commitment, quality-controlled sputum microscopy for diagnosis and monitoring progress, uninterrupted drug supplies with buffer stocks, supervised ingestion of drug intake with prompt absentee retrieval and a standardized recording and reporting system). The drugs included in the six-month regime include isoniazid, rifampicin, pyrazinamide, streptomycin, and ethambutol (or, in Bangladesh, thiacetazone). Patients are observed taking each course of medicine to ensure cure. Non-DOTS often uses the same drugs, but lacks the critical services that make DOTS effective. Non-DOTS achieves a cure rate of only about 40%, compared to 87% with DOTS. A crucial element in the comparison is also that about 15% of those on non-DOTS die, while as few as 5% of those on DOTS die.

The danger of non-DOTS treatment is not only the heightened potential for a patient to develop multi-drug resistant, incurable, and ultimately fatal forms of tuberculosis, but also that he may infect others with his more dangerous strains. When a patient is not cured, he will infect on average between ten and fifteen other people each year (WHO, 1997b).

For the DOTS regimen, the marginal benefits to the patient in terms of feeling better are realized almost immediately, with the later months of drug administration conferring no noticeable improvement in this area. Indeed, within one month of starting DOTS, the patient is restored to virtually full work capacity. These last months remain critical however, for a reduced course may lead to recurrent episodes of multi-drug resistant tuberculosis and the spread of this new infection to others.

Cost of DOTS treatment and financing

The cost of drugs alone of the eight-month treatment of DOTS in Bangladesh is estimated at US$10-15 per patient (Almeida, 1997 personal communication) which was transtlated into a triangular distribution of 436-654 Tk in the model using the August 1997 exchange rate of 43.6 Tk to a dollar. The cost per cure ranges from US$50 to US$150. Drug costs constitute about 20% of the total; the rest of the costs are due to critical services forming the DOTS package.

Because every country is vulnerable to the consequences of poor tuberculosis treatment practices in other countries, the generosity of donors in providing for this initial wave of effective treatment in developing countries especially hard hit by tuberculosis is understandable. In a *first* policy simulation, therefore, we will assume that DOTS treatment is fully subsidized. We will next consider, however, that in the long run, a country like Bangladesh may have to divise policies for increased self-provision whereby some or all of the costs of the DOTS regime are to be borne by local society and patients. In a *second* policy simulation, it is assumed that patients pay the full cost of the DOTS drug treatment. Finally, in the *third* policy simulation we model the Bangladesh experience whereby patients pay part of the cost via a co-payment or "deposit". The deposit ranges from 0 to US$ 5, which will be translated into a triangular distribution of 0-218 Tk. In reality, it seems to be better to obtain this deposit at the time when the patient feels ill, even though it may seem more sustainable to the household to spread the payment across the eight month period. Indeed, it may have the benefit of motivating the patient to continue the treatment to "get his money's worth". He may also subjectively value the treatment more, having paid a deposit for it himself. Greater patient compliance, to the greater benefit of the whole society would result.

One important issue relates to the poor and their capacity and willingness to pay deposits. In a sense, non-DOTS competes with DOTS: In the case of DOTS a deposit would be paid at the start of the treatment, whereas payments for non-DOTS are encountered in initially smaller amounts ranging from as little as 43.6 Tk, and are further spread out over a number of recurrent episodes. The very poor, with the shorter time horizons of a hand-to-mouth existence, may find it harder to turn away from the initially cheaper treatment. In practice, however, patients too poor to pay are found to obtain part or all of the deposit from local community donations, sometimes obtained through the mosque. In addtion, education campaigns are necessary to convince not only people but especially private providers of TB treatment, that DOTS is better for patients and society.

Simulation results

In Table 3, we present selected results pertaining to the three policy simulations. Each policy simulation comprises 500 iterations. The results will be presented as differences or percentage differences with respect to the base case values; the reader is reminded that the base case simulation included conventional practice with regard to tuberculosis treatment.

The following comments can be made:

(i) Asset reduction

One can see to what extent the DOTS strategies minimize the loss of assets. It is clear that in the case of fully subsidized DOTS (policy simulation 1), there is no call on the family's assets, so that they get restored to the initial level of 3,600 Tk. In the case of full payment of DOTS drugs and of payment of the deposit, asset reduction is much less than in the base case. When we consider full payment of DOTS drugs (policy simulation 2), the expected value at the end of the 24th period becomes 2,509 Tk (=1,634+875), which implies that 70% of assets are preserved. In the case of the payment of the deposit (policy simulation 3), the expected value becomes 3,382 Tk (=1,634+1,748); on average therefore, 94% of original assets are intact. These findings contrast with the case of the conventional practice (the base case), where only 45.3% of the original assets are maintained.

It should be stressed here that, with regard to impact on assets, the benefits of DOTS lie not in being tremendously cheaper per episode, but in being significantly more effective so that further courses of treatment are not necessary. Households following conventional practice (non-DOTS) must purchase two additional courses in response to relapses, thereby running assets down quickly.

(ii) Food reduction

In the simulation model, food reduction was the primary response to lost income, but limited to a fixed maximum amount ensuring that the household will not, on average, fall below the severest poverty level of 1,600 calories/person/day. Only when this reduction and intra-household labor substitution fail to compensate for the rickshaw puller's lost income are loans undertaken.

The simulation results indicated that both the expected value and the probability of food reduction reduce drastically over the simulation period. Note that at the end of the 24 month period, expected food reduction drops to 18-26 Tk. These results can be explained by the fact that there is a high probability that the rickshaw puller, who follows the DOTS regimen, remains at full working capacity at the end of their first treatment course.

It is safe to say that above contrasts with what happens in the case of conventional therapy whereby the rickshaw puller will experience relapse, each more severe and longer lasting than the one before. Conventional therapy is therefore associated with steady withholding of food. Though data to transform this food reduction directly into specific health effects is lacking, it stands to reason that the well-being of the household will suffer far more under the base case or non-DOTS scenario.

Finally note that in the 4th month, expected food reduction was negative. The latter reflects that there is probability that the rickshaw puller's household increase its income and, hence, its food consumption, due to some "overcompensation". The latter can be easily explained by the fact that other dependents start to work and earn more than before as a reaction to the breadwinner's reduced income earning capacity.

(iii) Intra-household labor substitution

The family responds to reductions in the rickshaw puller's income with intra-household labor substitution. All members contribute to the best of their ability and efforts are sustained until both the breadwinner recovers and all outstanding loans have been repaid. Under the base case scenario, intra-household substitution occurs in all periods presented. The most obvious opportunity cost of this household response is the youngest daughter's cessation of her formal education. After nearly two years of continuous absence, and being age eleven at the end of the scenario, she is unlikely to return to school.

The effects of exhaustion from heightened economic activity (such as the servant's employment in an extra household and the elderly grandmother's labor to earn income) would prove much harder to quantify buy hardly less significant. Sustained periods of exhaustion would most certainly weaken the resistance of all family members to disease.

With DOTS treatment however, the probability is very high that the rickshaw puller recovers from his illness and does not relapse. During the period of recovery, however, additional income from family members is needed, although the probability that household members do engage in extra work has gone down significantly vis-à-vis the base case. We have assumed though that there does remain a probability (4%) that the rickshaw puller would not return to full capacity, because he discontinues treatment. In addition, there is a probability of 5% that the rickshaw puller would die from his illness. One can understand, therefore, that between periods 13 and 24, around 30% of families continue to engage in extra work. This also explains why there remains a probability of food reduction of 27-28.2% at the end of the simulation period. Still, with a high probability the rickshaw driver would see his normal working capacity restored. The youngest daughter would most likely return to school, which is an important indirect benefit of the DOTS strategies.

(iv) Loans

After one bout of tuberculosis under the DOTS treatment, most rickshaw pullers are restored to full working capacity, whereas the non-DOTS treatment leaves a legacy of relapses. One can see how loans evolve in the non-DOTS base case. At the end of the 24^{th} period, the average loan is more than six times the value of original assets. Throughout the simulation period, there remains a high probability of engaging into loans. However, the DOTS strategies drastically reduce the expected values of the loans. In addition, they significantly reduce the probabilities of taking loans, to 17-19% by the end of the simulation period.

(v) Full subsidy versus full payment of drugs and payment of a deposit

It is clear that full subsidization is the "best" scenario from the patient's point of view. One of the main advantages is that the family's assets are fully maintained. From a macroeconomic point of view, because of limits on public finance, cost-sharing may well have to be considered, however. Full payment of drug costs may still constitute a difficult burden for households, but especially devastating for those already at or below the absolute poverty line. A simple co-payment or deposit scheme would make the expenses more manageable and help to preserve assets. An important fraction of the assets would still be maintained. At the same time, there would be benefits in the form of regular uninterrupted ingestion of drugs, without which there is an important risk of death. Under full subsidization, these benefits might be reduced in exchange for fully preserving the household assets.

CONCLUSIONS

This paper illustrates, first, how crucial the breadwinner's health is for the livelihood of his family. It has also highlighted how families cope initially with the breadwinner's illness. Coping manifests itself through asset sales, food reduction, intra-household labor substitution and consumption loans. In certain ways, the family "survives" as a result. However, it should be considered that the already poor family has suffered a prolonged period of reduced food consumption putting them a greater risk for addtional diseases and likely further stunting the growth and development of the youngest children. Unfortunately, the lack of data on nutritional intake and consequences precludes any further attempts to model for its effects. In addition, the father's illness is likely to have ended his youngest daughter's schooling. The long term opportunity costs, though difficult to quantify, are nonetheless significant.

Moreover, the death rate among rickshaw pullers as a results of conventional practice against tuberculosis is significant. The consequences of death are likely to be considerable for the surviving family members, especially for women, in that they will experience economic stress over a long period subsequent to the breadwinner's death.

Secondly, we also demonstrated how essential it is for health policy makers at the national level to remain aware of living and coping strategies of poor families, in order to design suitable measures to reduce poverty and halt impoverishment. In this paper, we focussed on assessing the consequences of TB on a poor rickshaw puller's household. Apart from preventive measures against TB (among which suitable housing, better nutrition, and good economic

Table 3
Selected results of policy simulations.

Variable	Month	Base case	Differences vis-à-vis base case value		
			Policy simulation 1 *Fully subsidized DOTS*	Policy simulation 2 *Full payment of DOTS drugs by the patient*	Policy simulation 3 *Deposit by the patient*
Expected value of assets at the end of the month (in Tk)	4	2,944	+656	+111	+547
	13	2,290	+1,310	+219	+1,092
	22	1,634	+1,966	+875	+1,748
	24	1,634	+1,966	+875	+1,748
Expected value of food reduction (in Tk)	4	464	na	na	na
	13	505	-488	-484	-488
	22	543	-543	-509	-535
	24	414	-388	-390	-396
Probability of food reduction (in %)	4	100.0	-49.2	-48.4	-50.2
	13	99.8	-74.8	-73.0	-72.6
	22	100.0	-73.6	-74.6	-71.6
	24	96.0	-69.0	-68.8	-68.6
Expected additional income earned by other family members (in Tk)	4	475	-248	-239	-251
	13	474	-369	-362	-360
	22	475	-363	-368	-355
	24	453	-339	-344	-338
Probability of additional income > 0 (in %)	4	100.0	-50.6	-49.0	-51.0
	13	100.0	-69.4	-67.8	-68.2
	22	100.0	-69.2	-69.2	-69.2
	24	97.2	-69.2	-68.8	-66.4
Expected value of loans at the end of the month (in Tk)	4	326	-218	-288	-272
	13	1,322	-1,040	-1,107	-1,033
	22	12,539	-9,884	-10,551	-9,871
	24	24,687	-19,435	-20,757	-19,399
Probability of a loan (in %)	4	64.6	-52.2	-55.2	-51.2
	13	73.4	-56.8	-57.0	-56.2
	22	79.0	-62.0	-62.6	-62.2
	24	66.6	-49.0	-48.6	-47.6

Note : na means not 'applicable' and refers to the simulation rusult that the expected value of food reduction has become negative.

conditions in general), adequate treatment is imperative. It is the latter that we have modelled. We stated above that the DOTS treatment results in a high cure rate, and its effects have been simulated in the current study. DOTS offers positive improvements to the overall well-being of the household by restoring the working capacity of the rickshaw puller in one treatment course and minimizing lost income. Assets and food consumption would be preserved significantly more in the presence of these policies, rendering the household both financially and physically less vulnerable in the future. The death rate among the sick breadwinners is also significantly reduced, which should improve households' welfare over the long run.

Finally, the reader has observed that we have combined data and knowledge from various sources, and that we formulated specific hypotheses especially about the probability distributions. It is true that data and findings from larger sample sizes, perhaps from cohort studies, would improve both on the realism of the modelling and the results obtained. We may also have overestimated the efficiency of coping, because of insufficient information. For instance, if limits were imposed on debt accumulation, they would worsen the family's coping ability. Notwithstanding these caveats, we believe that the simulation model developed has allowed us to better assess the impact of illness and TB in particular, the various ways of coping among households, and the utility and need for effective health interventions. There would of course be the need to adjust it further to additional and/or new findings about behavior of poor households and their coping.

APPENDICES

Appendix A: Incomes

Data concerning the normal incomes of the rickshaw puller, servant, and garment factory worker came from the UNDP (1996) and was specific to Chittagong slums. Daily earnings were reported by sex as a range for the most common occupations of each slum. Daily averages were converted to monthly averages assuming twenty-six working days in a month.

The reported income is assumed to be net of rickshaw rental fees. The monthly sample standard deviation was found to be 471.83, and the distribution was assumed normal.

The three-job scenario is confirmed in Huq-Hassian (1995) and by Currey (1997, personal communication). Because her income derives from three separate sources with low job security, a triangular distribution centered upon this average was assumed appropriate. The average and distribution were tentatively approved by Currey (1997, personal communication).

The average computed above was used in the model as a fixed value upon the advice of Currey (1997, personal communication) and the knowledge that this formal employment would command a set monthly wage.

The ten observations that included *rickshaw puller's* incomes are included below :

Slum	Daily income range	Daily average	Monthly average	Overall average
Abdul	15-80 Tk	47.5 Tk	1,235 Tk	48.21 Tk/day
Badsha Miar	5.75-38.5 Tk	22.125 Tk	575.25 Tk	or
Hossain Shanhebs	70-100 Tk	85 Tk	2,210 Tk	1,253.53 Tk/month
Erfan	30-80 Tk	55 Tk	1,430 Tk	
Relly	50-60 Tk	55 Tk	1,430 Tk	
East Mathabari	15-50 Tk	32.5 Tk	845 Tk	
Ambagan	30-50 Tk	40 Tk	1,040 Tk	
Barisal	50 Tk	50 Tk	1,300 Tk	
Bastuhara	60-80 Tk	70 Tk	1,820 Tk	
Jhowtala	20-30 Tk	25 Tk	845 Tk	

The ten observations that included *servant's* incomes are included below :

Slum	Daily income range	Daily average	Overall average
Abdul	5-20 Tk	12.5 Tk	17.85 Tk/day
Hossain Shahebs	20-30 Tk	25 Tk	or
Erfan	15-20 Tk	17.5 Tk	464.1 Tk/month
Relly	30-40 Tk	35 Tk	
East Mathabari	15-20 Tk	17.5 Tk	
North Mathabari	15-20 Tk	17.5 Tk	
Ambagan	10-15 Tk	12.5 Tk	
Barisal	20-30 Tk	25 Tk	
Bastuhara	4-8 Tk	6 Tk	
Jhowtala	10 Tk	10 Tk	

The six observations that included *garment worker's* incomes are included below :

Slum	Daily income range	Daily average	Overall average
Abdul	5-20 Tk	12.5 Tk	20.45 Tk/day
Badsha Miar	13.46-26.9 Tk	20.19 Tk	or
Hossain Shahebs	20-30 Tk	25 Tk	531.66 Tk/month
Erfan	15-20 Tk	17.5 Tk	
Relly	30-40 Tk	35 Tk	
Ambagan	10-15 Tk	12.5 Tk	

A 1993 study by Desmet and Bashir (personal communication) on slums in Dhaka found the monthly income of rickshaw pullers to be 1,326 Tk, that of servant to be between 488 and 537 Tk, and that of garment workers to be 636 Tk. (Desmet and Bashir, 1997, personal communication).

Appendix B: Other dependent's income

The income earnings of dependents was more problematic to model. Huq-Hussain (1995) described several home-based activities which would be suitable for the grandmother and youngest daughter to undertake together, such as cooking rice for sale in the marketplace. The son could simultaneously beg or scavenge. The scenario was confirmed by Rahman (1997, personal communication), Currey (1997, personal communication), and Desmet and Bashir (1997, personal communication).

The combined income from these activities is assumed to average 325 Tk/month, following a triangular distribution from 260 to 390 Tk/month (Rahman, 1997, personal communication; Currey, 1997, personal communication).

Appendix C: Tuberculosis work capacity

Workers with tuberculosis are less productive in the beginning and end stages of each disease episode, with an almost certain total loss of produc-

The probabilities below are associated with the "base case simulation" or conventional practice:

Month/Period	P(wr=1)	P(wr=0.5)	P(wr=0)
1	0.10	0.50	0.40
2	0.50	0.40	0.10
3	0.70	0.30	0
4	0.70	0.30	0
5	0.50	0.40	0.10
6	0.10	0.50	0.40
7	0.01	0.095	0.895
8	0.03	0.085	0.885
9	0.05	0.075	0.875
10	0.20	0.50	0.30
11	0.60	0.40	0
12	0.80	0.20	0
13	0.80	0.20	0
14	0.60	0.40	0
15	0.20	0.50	0.30
16	0.13	0.135	0.735
17	0.13	0.135	0.735
18	0.13	0.135	0.735
19	0.30	0.50	0.20
20	0.70	0.30	0
21	0.90	0.10	0
22	0.90	0.10	0
23	0.70	0.30	0
24	0.30	0.50	0.20

From periods 8 to 24, the probabilities P(wr = 1), P(wr = 0.5) and P(wr = 0) are equal to 0.09, 0.0 and 0.91 respectively.

In the case of DOTS treatment, we have applied the set of probabilities below :

Month/Period	P(wr=1)	P(wr=0.5)	P(wr=0)
1	0.10	0.50	0.40
2	0.50	0.40	0.10
3	0.04	0.0	0.96
4	0.04	0.0	0.96
5	0.04	0.0	0.96
6	0.04	0.0	0.96
7	0.04	0.0	0.96

tivity when the disease is at its worst. It has been estimated in India that "in urban areas, one or two months is taken for the diagnosis of the disease from the day symptoms start. Most of the urban patients stated that they could not perform their routine work for a period of three months". (Ramana, personal communication in Dholakia, 1997).

In the model, the work reduction of the rickshaw puller due to illness is denoted as full (1) partial (0.5), or no reduction (0). Based on the information contained in WHO (1997b) and from Almeida (1997, personal communication), the probabilities for a rickshaw puller for operating in each stage were assigned for each month of the simulation where he falls ill at the start of the first month and receives conventional treatment. Also note that the probabilities presented below take account of the fact that by the end of the first year about 10% of patients die, whereas about 15% will have died by the end of the second year.

It should be noted that the death rate is 5% whereas 4% of the patients discontinue treatment for various reasons (such as no interest to pursue the treatment, and absence). We have assumed that both the deaths and interruption of treatment occur as from the 8th period on. Note also that 4% of patients fail to attain smear negative status, and that this is recognized at 5 months after the start of the treatment (by means of a sputum examination); in the simulation model, recognition of smear negative status is in the seventh period. These patients promptly start a re-treatment regimen, and we have accepted that they do not experience another failure.

Appendix D: Caloric requirements

The Bangladesh Bureau of Statistics recognizes the absolute poverty line at 2,122 calories per person per day (Sen, 1996) which is the minimum caloric requirement recommended by FAO-WHO for South Asia (World Bank, 1987). They further consider 1,600 calories per person per day, or 75% of the absolute poverty line, as the cut-off mark for severest poverty. Accordingly, it is assumed in our simulation model that the household will respond to reduced income by reducing consumption to this level but no further, financing the remaining income deficit by loans to maintain themselves at 1,600 calories a person a day.

At Sen's valuation of 2,122 calories at 12.54 Tk a day, and considering a month of 30 days, this translates into a monthly income requirement of a six-member household of 2,257.2 Tk. When average caloric intake is reduced to 1,600 calories a day in bad times, this translates into a minimum income of 1,701.94 Tk.

A 1993 study by Desmet and Bashi (1997, personal communication) and Bahir (1997) placed the Taka value of 2,122 calories at 14.83 where 40 Tk = US$1.

Appendix E: Interest rates and repayment periods

We consider that interest rates for small loans will range from 15-60%. In addition, repayment periods are extremely short. This was incorporated by modelling the life of loans at two months. At this time, it may be necessary to undertake further loans to cover these payments. In the event of no outstanding loans, the interest rate is assumed to be 25%. This rate is assumed raised to 40% if the family carries debt from previous periods. This derives from a scenario provided by Currey (1997) and was confirmed by Rahman (1997, personal communication).

Appendix F: Medical expenditure under conventional practice

The rickshaw puller will not seek care at the onset of his disease, postponing doing so until he begins go cough blood in the second month. At this time he sees either a folk doctor or a certified

The above is summarized in the table below :

Months	Palliative care (Tk)	X-rays (Tk)	Curative care (Tk)	Total expenditure (Tk)
1, 10, 19	0	0	0	0
2, 11, 20	43.6	0	0	43.6
3, 12, 21	0	43.6-261.6	0	43.6-261.6
4, 13, 22	0	0	412.02-549.36	412.02-549.36
5, 14, 23	0	0	0	0
6, 15, 24	0	0	0	0
7, 16	0	0	0	0
8, 17	0	0	0	0
9, 18	0	0	0	0

physician and is first given palliative treatment for a couple of weeks, costing approximately 43.6 Tk for the entire period. This and all monetary estimates are based upon dollar costs in India, as related by Almeida (1997, personal communication), and were converted to Taka at the August 1997 exchange rate of 43.6 Tk/US$.

As his suffering continues, he will return to his doctor for a diagnosis necessitating between 1 and 3 X-rays at 43.6-87.2 Tk each, which translates into a total charge of 43.6-261.6 Tk. At this time he will also receive a prescription for more drugs than necessary and for a longer course than necessary, at a daily cost of approximately 19.62 Tk. He will feel relief ater a few weeks and, with very little personal incentive to continue to spend money on the drugs, will stop treatment. It is assumed that he will purchase the prescribed drugs for between three and four weeks at a total cost of 412.02-549.36 Tk. This was modelled as a regular triangular distribution.

Between one and five months later (at an average length of three months as represented in our model) he will relapse and the cycle will be repeated, complete with X-rays, just as before.

The total cost for each episode will average 655.09 Tk.

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