Arsenic Anticipation: A Perceived Problem and Preventive Solution

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Abstract

Arsenicosis in Nepal continues to be a prevalent health concern. Household filters show great promise in reducing not only arsenic quantities but biological pathogens and other contaminants as well. One continuing problem is finding who is most at risk (not all tubewells are contaminated, or contaminated equally) and using economically feasible methods of encouraging adoption and maintenance of the household filters. Arsenic contaminated water can look and smell clean, meaning that people may not be more likely to utilize a filter simply because arsenic poisoning exists. This paper attempts to test whether populations who anticipate a high risk of arsenic poisoning are likely to utilize a filter, without regard for actual measured arsenic levels. We will use the results to recommend policy that is feasible as well as effective, using empirically supported cause and effect relationships. Mitigation and prevention of arsenic poisoning is a major cause in many locations around the world, ranging from our focus country of Nepal to Bangladesh, Mexico, USA, Argentina and more. We hope that this paper will inform data driven solutions that will set Nepal ahead as a leader in economical solutions to groundwater-arsenic contamination problems.

Literature Review

The use of tubewells in Nepal has counteracted the relative scarcity of drinking water in rural areas where it is economically infeasible to deliver water to homes through a publicly funded water supply (Gao, 2000). However, tubewells can be contaminated with biological pathogens as well as minerals such as arsenic and iron. Shrestha et all (2003) detailed the relative severity of the problem, finding that in the Terai region of Nepal, 90% of citizens are at risk of utilizing tubewells with arsenic levels above the WHO guideline. Point of extraction filters are a seemingly efficient way of handling the problem because many citizens benefit from a single filter, but are inefficient in the sense that the water quality is still below the WHO standard for both biological and mineral contaminants even after filtering (Sagara, 2000). Household filters such the Kanchan Arsenic Filter show a reduction of 80 to 99% of various contaminants including biological pathogens and arsenic, and because of their relatively simple mechanics and ingredients, 83% of users continue to utilize the filters a year after initial adoption (Ngai, 2007). However, arsenicosis disproportionately affects the poor and less educated, who often suspect that their water isn't contaminated because it appears clear and smells fresh (Adhikari, 2005). Further, rigorous testing is difficult in the rural and mountainous regions of Nepal where citizens are most at risk. Accordingly, we have identified that, given the range of affordable and effective modern filters available, the arsenic prevention problem is now best understood as an information and decision making problem.

Hypothesis

In areas where rigorous testing of actual arsenic levels is difficult or impossible, the perception of danger from arsenic-contaminated water is positively correlated with citizen's adoption and continued use of modern household arsenic filters in Nepal.

Table 1: Variables

Variable	Definition	N	Mean	SD	Max	Min
Modern Filter	respondent uses Kanchan, Sono, or Candle Filter	200	0.125	0.3315488	1	0
Perception of Arsenic	1 if answered they suspected arsenic in their tubewell 0 if answered something else	200	0.29	0.4549007	1	0
Age	the age in years of the respondent	200	31.735	8.273271	55	18
Level of Education	the amount of education 1 if No formal schooling, 2 if Grades (1-5), 3 if Grades (6-8), 4 if Grades (9-12), 5 if Bachelors, 6 if Masters or other professional degrees	199	1.758794	1.181555	6	1
Wealth Index	an index of ownership of items	200	4.945	1.669103	11	0

Methods and Models

The models we utilized to predict the use of a modern filter (Sonos, Kanchan, or Candle) primarily depend on the perception that arsenic exists in the water of the respondent. With perception of arsenic as our primary independent variable, we attempt to describe the choice to adopt a modern filter with three models.

Model 1

The first merely used the perception of arsenic as the only independent variable, and is run as a logistic regression.

$$Modern\ Filter_t * = 1[\beta_0 + \beta_1 Perception\ of\ Arsenic_t + u_t]$$

Model 2

Model 2 is also run as a logistic regression and assumes that there are more variables that describe the use of the modern filters, and adds age, as a control, as well as education and wealth.

$$Modern\ Filter_t * = 1[\beta_0 + \beta_1 Perception\ of\ Arsenic_t + \beta_2 Age_t + \beta_3 Level\ of\ Education_t + \beta_1 Wealth_t + u_t]$$

In this we look to describe more variation of the adoption with the level of education of the respondent as well as their level of wealth. The level of education changes the ability of the respondent to account for the potential risk of arsenic and can affect their intensity to adopt. The wealth variable aims to look at the likelihood that the respondent has enough disposable income to afford a modern filter. Age can also effect the intensity, but acts as a control in this instance for changes in perception and knowledge based upon the generation effects or cohort differentiation.

Model 3

The third model (Model 3) takes into account that it is highly likely that the perception of arsenic being in the respondent's water is an endogenous variable. It contains the same variables as Model 2, but in a different format.

1 $Perception\ of\ Arsenic_t = f\,[\,Knowledge\ About\ Arsenic_t, Heard\ from\ Media_t\,]$

2 $Modern\ Filter_t * = 1[\beta_0 + \beta_1 Perception\ of\ Arsenic_t + \beta_2 Age_t + \beta_3 Level\ of\ Education_t + \beta_1 Wealth_t + u_t]$

This model is run with the command on Stata, as a two-step linear regression with instruments to control for endogeneity within the primary independent variable. The first model in this endogeneity regression takes into account the instruments of knowledge about arsenic, and whether the respondent to the survey has heard about the issue of arsenic presence through media coverage. It looks at perception of arsenic as a function of these two new additional variables. This function allows for the endogeneity to be controlled by these instruments in the second model, which is regressed again. This second step regression is displayed with the final variables identified as modern filters, age, education and wealth, but this time with a uniformly comparable standard error and controlled for endogeneity and as an ordinary least squares regression, unlike the previous two logistic regressions.

Table 2: Effect of Perception on the Use of a Water Filter

	Model 1	Model 2	Model 3
Perception of Arsenic	0.951**	1.177**	0.352***
	(-0.437)	(-0.459)	(-0.116)
Age		0.05	0.004
		(-0.037)	(-0.004)
Education		0.357	0.047*
		(-0.233)	(-0.027)
Wealth Index		0.239*	0.028*
		(-0.143)	(-0.015)
Constant	-2.295***	-5.919***	-0.333**
	(-0.292)	(-1.443)	(-0.152)
Pseudo-R2	0.031	0.094	
BIC	156.670	163.04	
AIC	150.073	146.548	
RSS			22.367
N	200.000	200	200

Standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01

Results

Our models show that the perception of arsenic in the water taken from the respondent's tubewell does in fact have a statistically significant impact on the decision making process and whether or not a respondent chooses to adopt a modern filter (Sonos, Kanchan, or Candle).

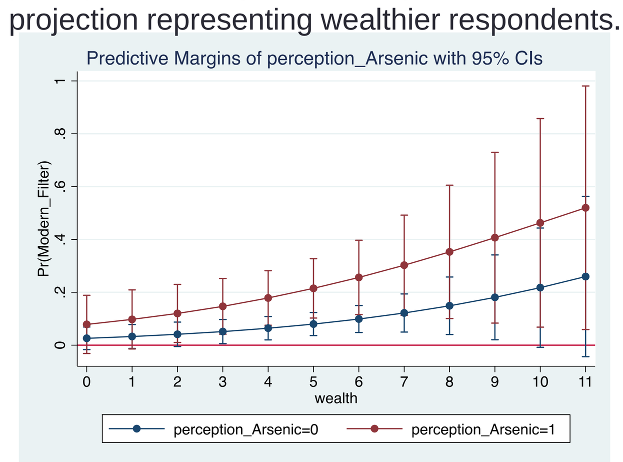
Model 1

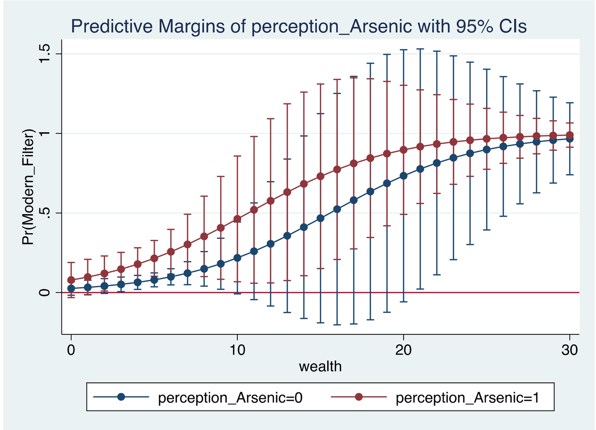
The first model we see plainly that the primary variable that is defined as the perception of arsenic being in he respondent's tubewell, is in fact statistically significant when regressed as the lone variable. When you regress the perception variable without any other variables the significance is measured at better than .05, with a relatively low pseudo R2 .031of and an AIC at 150.073.

Model 2

In the second model, which is our main model, there is a higher pseudo R2 at .094, and a lower AIC of 146.548, which proves that it is a better model at describing the the intensity of the choice to use a modern filter or not. The new variables of age, education, and wealth, do help describe the prediction of the choice better, but only wealth is a significant variable. This is because wealthier individuals are more likely to adopt a modern filter to remove arsenic from their water. Perception is even more significant than before, almost better than one percent with a p value reading of .010.

In the plots below we see the marginal effect of wealth on probability of adoption of a modern filter, with the perception dummy variable equal to 1 in red and 0 in blue for the length of our measured index as well as a projection representing wealthier respondents.





In the first plot we see that as wealth grows, the gap between the lines of perception grow, which indicates that as you become wealthier the perception variable becomes more important. Comparing this to projected effect of wealth, we see that around a wealth index of 30 the lines meet and perception doesn't seem to play a role as to adopt a filter or not. This is because a filter is likely to be used regardless of arsenic perception when the cost of a filter is relatively insignificant.

Model 3

In this model we have to acknowledge that our primary variable of perception has an endogeneity issue and because of this our third model looks to control for that endogeneity with instruments through a two step regression process, as discussed in the methods and models. In this after controlling for media coverage and education on the topic of arsenic, perception is still found as a significant variable. This allows for the first two models to be accepted and adds to the robustness of the explanatory power of the perception variable although it does have endogeneity.

Conclusion

The models included in this study prove that the sampled populations in Nepal are more likely to adopt modern filters if they perceive an arsenic problem exists. The use of perceived rather than measured arsenic proves that media coverage and individual knowledge of arsenic are important in determining the use of a filter, even when age, education, and wealth are accounted for. Although the model explains just nine percent of the decision, marginal impacts in this type of issue are important. If increased filter use can be attained through perception changes, that would be a great gain for a program that, as of the time of the survey, only had 12.5% of the population using a filter.

The Sono and Kanchan filters are proven to be cheap and accessible methods of removing of arsenic from water and thus reducing the rate and severity of arsenic poisoning. It is our recommendation to utilize various media in a general knowledge campaign aimed at educating people in high-risk areas about the affect of arsenic poisoning on their health. This will prove to be a successful, cost effective method in improving adoption of the Sono, Kanchan, and Candle filters.

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