Health Status of Filipino Children: Biologic and Subjective Measures Used in the Quality Improvement Demonstration Study (QIDS)

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Background

Public policy makers and payors want evidence that demonstrates the impact of health policy on health outcomes. Traditional determinants, such as cost, utilization, staffing levels, insurance coverage and even mortality rates do not provide adequate information on the impact of high level policies on the actual health outcomes of a population. These structural measures are too weak to make reliable inferences because they are either too distal or confounded by utilization. Typical outcome measures such as mortality rates, though concrete and important, are too rare and too long term to relate to policy effects in the near term.

Two alternative approaches for assessing health status appear to overcome these problems. The first are self-reported subjective health status measures such as General Self Reported Health status (GSRH) and/or self-reported Health Related Quality of Life (HRQOL). The second approach is objective clinical measures, or biomarkers, that provide specific clinical information on a particular disease state.

Self-reported subjective health measures

Self reported health measures have been attractive in large population based surveys and are rapidly gaining favor in individual health assessments because of their ability to predict important health outcomes (DeSalvo, 2005; Idler and Benyamini, 1997). They include single and multi-item measures that ask individuals to rate their own overall health or answer a variety of questions targeting multiple aspects of functionality or well-being. One study found that a multi-item measure of self-rated health successfully predicted health care utilization in older adults (Balkrishan and Anderson, 2001). Another demonstrated that the General Self Reported Health Status measure (GSRH), a single-item measure, is as stable and reliable as multi-item measures in predicting mortality and utilization (Desalvo et al, 2005; Desalvo et al, 2006). Others have demonstrated the predictive power of self reported health for future morbidity (Ferraro et al, 1997; Shadbolt, 1997) and functional decline (Kaplan et al, 1993; Mor et al, 1994).

The TAPQOL is another subjective measure, used to assess the health of children, developed by researchers at the Leiden University Medical Centre and TNO Prevention Health. The TAPQOL is a Health Related Quality of Life (HRQOL) tool specifically designed for use with children. Like other HRQOL tools it attempts to capture several of the many facets of well-being. The TAPQOL is reliable, stable and valid tool for both infants and toddlers (Bunge, 2005).

Biomarkers
Clinicians have relied on objective health measures to measure certain health functions. While routinely collected in the physician's office, they have more limited use in population-based surveys and in developing countries due to obvious logistic and resource constraints.

Self Reported Health compared to Biomarkers
Self-reported measures are often not considered to be as robust as objective clinical measures. Despite the widespread use of both there is limited information comparing the two, particularly in children. One study in adults living in rural Bangladesh compared self reported measures to body mass index (BMI) and observable disability on activities of daily living (ADL) and suggested that self-reported measures were as robust as BMI and better than ADL in predicting mortality (Kuhn, et al 2004). Another study found self rated health to be significantly associated with multiple clinical measures but reported that self reported health was a better overall predictor of diverse aspects of well being (Goldman et al, 2003). The TAPQOL, in particular has not been compared with biomarkers.

We wondered how well subjective health status measures compared with objective measures in young children. In addition, we recognized that subjective measures would necessarily be reported by a parent rather than the child and, thus, also wanted to ascertain the relative usefulness was of the two approaches in a young population.

Predicting health status and outcomes in young children is critical in developing country settings where limited resources necessitate the easy identification of high-risk individuals and the assessment of policy impact. And because policy is concerned with both those that are sick and getting care and those that may become ill and potentially use care, measuring the health status of both those receiving care and in the general population (who might be at risk) is important.

Methods

Setting
Beginning in 2003, we initiated the Quality Improvement Demonstration (QIDS) Project in collaboration with the Philippine government. This ongoing natural experiment evaluates the impact of two broad-based health sector reforms on the health status of children living in a geographical area covering about one-third of the Philippines. These health reforms are focused on improving the physical and cognitive health outcomes of children between the ages of 6 months and 5 years. There are two interventions:

expanded insurance coverage and bonus payments to providers who provide high quality care.

Sample Frame

Eleven provinces, located in the centrally located Visayas Region of the country, were non-randomly selected for participation in the project. From within these provinces 30 district level hospitals were identified. Children using the facilities and living in the surrounding population constituted the sample frame. Children admitted to these facilities were serially sampled until a total of 3000 children (100 per facility) were identified. Half of these children (1500) were diagnosed with either an acute respiratory illness (pneumonia) or diarrhea. These 1500 children were followed home where a second assessment of their health status was determined. For the general population, a random sample of children was identified using enumeration from the national census frame in the catchment areas of each of the 30 hospitals. Again 1500 children were assessed with 50 sampled per district catchment area.

We sampled the parents of children between the ages of 6 months and five years at the time of their hospital stay (or household interview in the case of random households). No more than one child per household was enrolled in either group or in the study as a whole. In the population-based group, the youngest child at least 6 months old from each selected household was selected for enrollment. In the hospital-based group, only the first child from any given household admitted to the hospital during the study period was eligible for enrollment. All study participation was strictly voluntary. Parents of guardians of all children provided written informed consent prior to enrollment.

Subjective health status measures were obtained through interviews conducted by trained interviewers using a standardized protocol in one of three local dialects spoken in the region. Parents were the target of the survey and answered questions covering a variety of domains aimed at understanding the overall health status of children.

Objective health status measures were obtained by trained medical personnel using a standardized protocol. Children were weighed, measured and had blood drawn. Trained medical technologists collected blood using established clinical procedures for obtaining venous samples. Blood draws occurred on the day of discharge for hospital-based subjects and during the home visit for population-based subjects and samples were drawn for four different blood tests for each child.

Field Personnel

The licensed medical technologists (MTs) were trained collectively and then performed the parental interviews, anthropometric measurements, blood draws, and laboratory analysis. Physicians supervised the field MTs. A clinical Pathologist supervised the entire study team making planned and unannounced visits to the field to directly observe the MTs. MTs were accompanied by psychologists who performed the developmental testing in all household visits.

Health Status Measures

The subjective and objective health status measures used included the General Self Reported Health Status (GSRH), the Toddler and Preschool Quality of Life (TaPQOL), height, weight, blood hemoglobin, blood C-Reactive Protein, blood lead levels, and Red Blood Cell Folate.

Data Collection Instruments

Subjective Health Assessments

General Self Reported Health (GSRH) is a recognized measure of population level self-reported health status (Idler and Benyamini, 1997). It is commonly captured as part of the widely-used 36-item Medical Outcomes Study Short Form-36 (SF-36) (Ware, 1992). The most widely-used version of GSRH is generally the phrasing "How would you rate your health?" It is brief and easier to administer than multi-item measures of self-rated health and has strong predictive validity that is as robust as the SF36 physical component score (PCS) (DeSalvo 2005; DeSalvo 2006; DeSalvo et al, 2005). It is also correlated with health system quality (Peabody et al, 2005).

The TAPQOL is a measure developed by researchers at the Leiden University Medical Centre and TNO Prevention Health that measures the physical, social, cognitive, and emotional quality of life of preschool children on 12 different domains (Fekkes, et al, 2000). The TAPQOL is a reliable, stable and valid tool for infants as well as toddlers (Bunge, 2005).

The instrument also included other information about socioeconomic background, health care utilization patterns and insurance coverage.

Anthropometrics

Height was measured using stiff measuring tapes, taken lying down for children under 2 years of age and standing up for older children. Weight was measured with 25 kg Salter scales designed for field use, or with standing hospital scales in patient exit surveys. Weight and height were measured in each child twice during the survey visit and the mean values for each measure were used.

Blood tests

All blood tests were conducted using venous blood samples. Blood was drawn in the hospital for patients about to be discharged or in the home for the household population. One EDTA and one plain tube were collected. Tubes were transported the same day to a provincial level lab where hemoglobin and CRP testing was performed and samples were prepared for lead and folate analysis and stored at appropriate temperatures. Lead and folate samples were shipped twice weekly to a centralized lab in Manila where lead analysis was performed and frozen samples were forwarded to a lab in Singapore for analysis.

Hemoglobin levels were tested using the Hemocue ® Blood Hemoglobin Photometer. On the same day as blood drawing, at the provincial level lab, medtechs took 50ul of

fresh whole blood from the EDTA tube and pipetted onto a clean glass slide. From there it was drawn into the Hemocue microcuvette using capillary action as directed in the Hemocue manual. Each Hemocue machine comes with a control cuvette which was checked before each testing session to assure the machine was in within expected parameters.

CRP levels were tested using a semi-quantitative latex agglutination test manufactured by Concept Diagnostics. On the same day as blood drawing whole blood in the plain tube was spun in a centrifuge to separate the serum. 50ul of serum was then mixed with latex agglutination reagent and checked against positive and negative controls. Positive samples were further tested by serial dilution to get semi-quantitative results.

Blood lead levels were obtained from venous samples that were analyzed at a central laboratory using the LeadCare® Analyzer (ESA Inc., Chelmsford, Mass.). On the same day of blood draw, 50 ul of whole blood from the EDTA tube was pipetted into the treatment reagent vial. This was stored in refrigeration and shipped on ice to the central lab in Manila. Shipments were sent at least twice weekly and always within 5 days of blood draw. Shipments were sent in the early morning hours and upon arrival in Manila were hand carried to the laboratory, where they were tested the same day as they were received. Tests were completed on the LeadCare Analyzer by a licensed medical technician, with positive and negative controls run during each testing session.

Red Blood Cell Folate was measured using the Architect system by Abbott laboratories. On the day of blood draw, hematocrit was calculated and whole blood samples from the EDTA tube were transferred to a cryovial and frozen for transport within 5 days of blood draw. Upon receipt in Manila they were stored in the freezer and reshipped to Singapore weekly. Upon receipt in Singapore samples were tested the same day by licensed medical technologists as per the manufacturer's specifications.

Data Entry

Baseline data were collected throughout 2004. The data were checked for completeness and accuracy, coded and keyed by project staff at the University of the Philippines in Manila using double keyboard entry on a Microsoft Access® platform. After entry, the dual entries were checked for discrepancies due to coding error and all discrepancies were corrected by reference to the original survey forms. Data were then subjected to internal consistency checks, logic checks, and range checks; inconsistent data were corrected whenever possible using the original paper surveys. Discrepant and inconsistent data that could not be resolved were excluded from the analysis data set.

Analysis

Given the ordinal nature of the dependent variable, we used an ordered probit model. This was done in two stages. First, because of the non-random nature of the follow-home sample (chosen by virtue of being a follow up interview on a family interviewed at hospital discharge) we used a two stage model beginning with a Heckman model to predict the probability that a child would be hospitalized given their age, whether they were urban dwellers, whether they had insurance coverage, and the level of the mother's

educational attainment. This produced an Inverse Mills Ratio which was introduced into the ordered probit model in the second stage with the biomarkers as additional independent variables.

The distribution of responses to the GSRH are reported in Table 1 along with results of the t-tests and variance ratio tests. Table 2 includes descriptive statistics of the biomarkers used in the models. Table 3 shows the change in biomarkers over time. Table4 shows the results of the Heckman model and the ordered probit. In Table 5 we demonstrate the magnitude of the effect by showing the predicted proportions in each category of self-rated health for the significant biomarkers from the ordered probit model.

Separate regression models were done between each of the domains of the TAPQOL and the biomarkers. Descriptive statistics for the TAPQOL are presented in Table 6 and regression results in Table 7.

STATA version 8 was used to do the various analyses.

Results

Forty percent of randomly sampled respondents replied that their child's health status was excellent or very good (see Table 1). Thirty-four percent among those exits that were *screened in* and interviewed again in a follow-home interview 4-6 weeks later replied that their child's health status was excellent or very good. However, only 20% of those interviewed again 4-6 weeks later as follow-homes rated their child's health as excellent or very good.

Results of the t-tests and Variance tests (also shown in Table 1) indicate that the differences in the GSRH between the random and exit populations are significant, as are the differences between the random and the follow home (except for those rated in good health). The group means for exits versus follow homes did not differ significantly except for those children whose health is rated as excellent, very good, or good.

The objective health test for four biomarkers in the household sample show a mean lead level of 9.40, just below the CDC cut-off for lead toxicity of 10.0; a mean red blood cell folate of 206.76; that 5 percent of all children sampled at the household level had positive CRP and that the mean hemoglobin level was 11.9 (See Table 2).

Twenty nine percent of children had elevated lead and the same proportion had insufficient hemoglobin. Five percent had elevated C-Reactive protein (CRP), indicating current or recent infection. Fourteen percent were folate deficient.

Table 4 shows the change in biomarkers over time for those children interviewed in the hospital at exit (discharge) and again at follow home 4-6 weeks later. Only hemoglobin and CRP were repeated at follow home. Both of these measures show improvement that is statistically significant. While only 77% had normal hemoglobin levels at discharge,

this had increased to 82% at follow-home. Conversely, although only 78% had negative CRP at discharge, this proportion increased to 94% at follow home.

GSRH

To compare the biomarkers to the subjective health status as measured by the GSRH we first pooled the household sample and weighted it appropriately, to account for the nonrandom sample of the follow-homes (who were chosen specifically because of a prior hospitalization). In our two-stage model, we used a Heckman model to first predict the probability that a given child would be hospitalized given their age, health insurance coverage, whether they were urban dwellers and their mother's educational level. Age and urban residence were significant. This procedure produces an Inverse Mills Ratio that corrects for the selection bias. The Inverse Mills Ratio was then included in an ordered probit model with GSRH as the dependent variable and the biomarkers as the independent variables (see Table 4).

When we compared the GSRH to the objective health measures, hemoglobin, CRP, folate plus weight for height in model, each objective measure was independently correlated with the subjective measure of health ($p<.05$). Only lead levels were not correlated.

To understand the magnitude of the effect we then looked at the distribution of predicted probability of GSRH to determine whether GSRH could be used as a targeting variable (See Table 5). We divided the children into five quintiles based on their objective test and compared this with the five self-reported health measures.

In Table 5 the critical values for hemoglobin, folate and weight for height are in the first quintiles. Table 5 shows that only 18% of those with the lowest hemoglobin levels would get a health rating of fair or poor, as would 21% of the lowest weight for height, 17% with the lowest folate levels, and 26% of those with positive CRP. By contrast 32% of those with a negative CRP reported their health status as excellent or very good.

TAPQOL

Average TAPQOL scores for the household sample on each of the 12 domains are presented in Table 6. As is seen here, scores tended to be high, and in general, slightly higher in the random population that the follow-homes, with the exception of skin, problem behavior, and anxiety.

We performed regressions on each TAPQOL domain against our biomarkers. (See Table 7). The different TAPQOL domains correlated less well than the GSRH with the objective health status measures except for hemoglobin which was correlated with 6 of 12 domains ($p</=.05$). Folate and weight for height each correlated with 2 of 12 domains ($p<.05$), CRP only with the stomach domain ($p<.05$), and lead with none of the TAPQOL domains. Five of the TAPQOL domains had no significant correlations with any biomarker.

Discussion

We reported the subjective and objective health status measures on a large population of children as part of a social policy experiment in the Philippines. Overall we found a high correlation between subjective and objective health status measures. There are a number of reasons why we suspect that there is a high degree of correlation. Many factors go into how a mother report's her child's health status on a self-reported measure such as the GSRH. Undoubtedly, a mother is able to assess overall characteristics such as weight, height, energy level, feeding and sleeping patterns, etc. She also likely observes clinical measures that are related to biomarkers and that also have some observable manifestation to the mother, for example acute illness and a positive CRP. In addition a mother can take into account information about current or past illnesses and hospitalizations. Finally a mother can observe change in health status associated with recent health related events.

The differences in response to the GSRH (described in Table 1) illustrate how some of these factors interact. Understandably, mothers whose children have not been hospitalized are more likely to give their child an excellent or very good health rating, than those interviewed at hospital discharge or 4-6 weeks after. The strong predictive nature of the biomarkers on overall health status for most measures is another illustration of these interactions.

More interestingly, mother's are more likely to give their child an excellent or very good rating at discharge than they are when interviewed again as a follow home 4-6 weeks later in spite of the fact that their biomarkers actually improve. Several factors may explain this. In the 4-6 weeks between that discharge and our 2nd interview, several things may have happened to decrease the likelihood that the mother will give her child an excellent or very good rating. For, one, she may have assimilated the information of her child having been ill enough to be hospitalized more fully into her conception of the child's health status. Next she may now be more aware that the child has lost weight, has less energy, or is in other ways still recovering. Finally the child may have relapsed, or deteriorated or remain ill in a less than fully recovered state thereby reducing the mother's likelihood of giving the child an excellent or very good heath rating.

The results of the model show that mothers' ratings of their children's health have an associated clinical basis in the GSRH for all biomarkers except lead. The case of lead can be explained by the chronic nature of lead poisoning.

These findings suggest that GSRH as reported by mothers for their children are useful and similar to the findings of self reported health measures that have been found in adults.

However, since only 18% of those with the lowest hemoglobin levels would get a health rating of fair or poor, as would 21% of the lowest weight for height, 17% with the lowest folate levels, and 26% of those with positive CRP, using only GSRH to identify clinical risk may not be advisable. On the other hand biomarkers are useful for identifying specific disease states but not overall health. In a broad population study where you want

an overall assessment of health status and do not have the resources to collect expensive biomarkers, the GSRH may be a useful screening device to economize on biomarkers which are expensive and difficult to collect.

TAPQOL

The multiple domains of the TAPQOL, while perhaps more descriptive of health related quality of life, were less correlated in the regression analysis against biomarkers. Some strong correlations do exist, particularly for hemoglobin, indicating that the mother's subjective rating with this instrument draws on a clinically measurable reality.

Comparative Utility of Biomarkers

One way to assess the utility of these measures is to rank the difficulty and cost of administering the various biomarkers. These can then be ranked with their correlation with the subjective measure. Our ranking of the measures we used is shown in Table 8. Biomarkers with high affordability have low cost supplies readily available in the Philippines. The most expensive ones required imported reagents and expensive, highly specialized equipment. Biomarkers with high ease of collection are those that could be collected or performed accurately at the household or hospital level. Our most difficult test included multiple steps requiring complicated logistical and transport arrangements such as the sending of frozen blood samples to another country. Unfortunately these rankings do not provide a single clear answer as to which biomarkers should be collected.

Both available resources and objectives must be considered. Folate, which is highly correlated with subjective measures but expensive and difficult to collect, might be better included only after using the GSRH as a screening tool. To illustrate, our estimate in Table 5 suggests that if we were to perform folate tests only for children whose mothers rated their health as poor, fair, or good, we would only have to perform the test on 68% of the population and would only miss 6 children with low folate for every 100 children screened. On the other hand, lead, which is more expensive, moderately difficult, and correlates less well with biomarkers, might be chosen for the additional, otherwise undetected information that it adds to a child's health picture, particularly considering the insidious effects on children's well-being. Since it does not correlate with GSRH, it is not possible to predict the outcome of using GSRH as a screening device to decide which children to test for lead.

Conclusions

We conclude that GSRH as reported by the mother or other guardian about a child's health is correlated with biomarkers. This correlation is somewhat disturbed with incidence of acute illness, e.g. hospitalization. Mother's assessments seem to integrate the hospitalization into their rating only some time after discharge when biomarkers are already improving.

The TAPQOL is weakly correlated with biomarkers except for hemoglobin, which correlates with half of the TAPQOL domains.

The correlation between objective and subjective measures offers potential for using GSRH as a screening tool to economize on the collection of biomarkers. In a large population survey with limited resources, one could use the GSRH as a screening question to determine a sub-sample on which to collect biomarkers. Because of the high correlation this could effectively reduce the sample needed while still capturing those most likely to suffer from a given clinical condition. It would be important however, to only use the GSRH as a screening tool for biomarkers known to correlate with it.

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Table 1. Current Subjective Health Status Rating by Respondent

	Means					t Test	Variance Ratio Test	t Test	Variance Ratio Test	t Test	Variance Ratio Test
	Random	Follow Home	Exits			Random vs Follow Home		Follow Home vs Screened In		Random vs Exit	
			All	SO*	SI**						
Excellent	0.020	0.003	0.007	0.004	0.010	0.000	0.000	0.024	0.000	0.000	0.000
Very Good	0.382	0.195	0.339	0.351	0.325	0.000	0.000	0.000	0.000	0.005	0.245
Good	0.472	0.608	0.477	0.480	0.473	0.000	0.386	0.000	0.419	0.697	0.983
Fair	0.111	0.162	0.147	0.137	0.156	0.000	0.000	0.704	0.615	0.001	0.000
Poor	0.014	0.031	0.028	0.026	0.031	0.002	0.000	0.977	0.910	0.003	0.000

*SO= Screened Out Exit - not followed home

**SI=Screened In Exit - followed home 4-6 weeks after discharge

Table 2. Means and Standard Deviations of Biomarkers

Mean baseline health outcomes					
Outcome Measure	*Normal Range*	*Obs*	*Mean**	*Standard Deviation***	*Percent not normal****
Lead	<10	2860	9.40	8.69	29
Folate	>100	2463	206.76	127.55	14
CRP Negative	Negative	2945	0.95	.23	5
Hemoglobin	>10.4	2942	11.9	1.54	29
Weight for height	varies by age	2906	0.13	.05	

*weighted (using pweight) **unweighted

***Not normal refers to values below the normal range, positive values for CRP.

Table 3. Change in Biomarkers Over Time

	Proportion of the sample with:	
	Normal Hemoglobin	CRP Negative
Exit (Screened in only)	0.77	0.78
Follow Home	0.82	0.94
p-value for test in difference of means	0.003	0.000

Table 4: Two-stage (Heckman) Ordered Probit model of GSRH

Selection Equation	Dependent Variable: Follow home=1	
Independent Variables	Coef.	P>z
Child's age in years	-0.301	0.000
Urban	0.155	0.003
Has PhilHealth coverage	0.066	0.218
Mother is college graduate	-0.132	0.081
Constant	0.589	0.000
Number of Observations	2855	
Pseudo R^2	0.0564	
Ordered Probit	Dependent Variable: GSRH	
Independent Variables	Coef.	P>z
Weight/height	-10.964	0.000
Weight/height squared	19.779	0.000
Lead	-0.005	0.101
Folate	-0.002	0.000
Folate squared	0.000	0.004
CRP negative	-0.434	0.000
Hemoglobin	-0.041	0.013
Inverse Mills Ratio	-0.263	0.022
Number of Observations	2124	
Pseudo R^2	0.02	

Table 5. Predicted Proportions Over Self-Reported Health Status Categories by Quintiles of Selected Covariates.

		Poor	Fair	Good	Very Good	Excellent
Hemoglobin	1st quintile*	0.02	0.16	0.55	0.26	0.01
	2nd quintile	0.02	0.14	0.54	0.29	0.01
	3rd quintile	0.02	0.13	0.53	0.31	0.02
	4th quintile	0.01	0.12	0.53	0.32	0.02
	5th quintile	0.01	0.11	0.52	0.35	0.02
Weight for Height	1st quintile*	0.03	0.18	0.56	0.23	0.01
	2nd quintile	0.02	0.15	0.55	0.27	0.01
	3rd quintile	0.01	0.13	0.54	0.30	0.01
	4th quintile	0.01	0.11	0.52	0.34	0.02
	5th quintile	0.01	0.09	0.50	0.38	0.02
Folate	1st quintile*	0.02	0.15	0.55	0.27	0.01
	2nd quintile	0.02	0.13	0.54	0.30	0.01
	3rd quintile	0.02	0.13	0.54	0.30	0.01
	4th quintile	0.01	0.12	0.53	0.32	0.02
	5th quintile	0.01	0.11	0.52	0.34	0.02
CRP	Positive*	0.04	0.22	0.55	0.18	0.00
	Negative	0.01	0.13	0.53	0.31	0.01

Table 6. Average TAPQOL Scores

Scale	ALL		FH		RANDOM	
	N	%	N	%	N	%
Sleeping	2,946	88.9	1464	85.6	1,482	92.2
Appetite	2,939	88.6	1466	86.2	1,473	91.0
Lungs	2,953	88.5	1474	83.9	1,479	93.2
Stomach	2,947	84.4	1472	80.6	1,475	88.1
Skin	2,961	94.9	1481	95.0	1,480	94.8
Problem Behavior	2,930	71.6	1462	73.0	1,468	70.2
Anxiety	2,956	81.3	1468	82.0	1,488	80.6
Positive Mood	2,971	91.0	1479	89.7	1,492	92.3
Liveliness	2,952	90.5	1467	89.4	1,485	91.5
Motor	1,803	97.9	710	97.3	1,093	98.3
Social Functioning	1,725	92.7	696	91.6	1,029	93.5
Communication	1,763	90.1	694	88.6	1,069	91.1

Range: 0-100

Table 7. Regression Results for TAPQOL Domains with Significant Correlations to Biomarkers.

TAPQOL Domain	Sleep		Lungs		Stomach		Skin	
Biomarker	Coef.	P value	Coef.	P value	Coef.	P value	Coef.	P value
Hemoglobin	**1.018602**	**0.001**	**1.392157**	**0.000**	**1.26023**	**0.000**	**0.407786**	**0.050**
Folate	-0.00142	0.682	0.003185	0.339	0.001314	0.717	0.000941	0.682
Lead	-0.08895	0.115	-0.06672	0.218	0.101584	0.086	-0.05016	0.180
CRP negative	4.029475	0.052	2.151837	0.280	**4.89284**	**0.026**	1.096083	0.428
Weight for Height	6.24769	0.530	-2.23676	0.815	-9.08521	0.383	**-24.9017**	**0.000**
Constant	77.12375	0.000	74.974	0.000	68.21279	0.000	93.22091	0.000

TAPQOL Domain	Motor		Social		Problem Behavior	
Biomarker	Coef.	P value	Coef.	P value	Coef.	P value
Hemoglobin	**0.422708**	**0.015**	**1.494531**	**0.001**	0.276272	0.498
Folate	**-0.00452**	**0.026**	-0.00494	0.361	**-0.00909**	**0.043**
Lead	-0.01574	0.592	0.133397	0.104	-0.10266	0.160
CRP negative	1.908283	0.108	0.830735	0.790	2.313895	0.387
Weight for Height	6.121925	0.208	10.12051	0.455	**-33.5159**	**0.009**
Constant	91.8221	0.000	72.72984	0.000	72.70615	0.000

Table 8. Ranking of Biomarkers by Cost, Difficulty, and Correlation.

Biomarker	Affordability of Collection*	Ease of Collection*	Correlates with GSRH	Correlates with Tapqol
Weight for Height	High	High	High	Med
Hemoglobin	High	High	High	High
CRP	Med	Low	High	Low
Lead	Low	Med	Low	Low
Folate	Low	Low	High	Med