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Kawanda Foster Date

The Association Between Acute Phase Proteins and transferrin Receptor Levels in Non-Pregnant Women in Papua New Guinea

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2007

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An abstract of
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Abstract

The Association Between Acute Phase Proteins and transferrin Receptor Levels in Non-Pregnant Women in Papua New Guinea

By Kawanda Foster

Background: Iron deficiency is an important global public health issue. Creating a strategy to address this problem can be difficult due to extraneous variables in populations that affect the condition. For example, inflammation is important to consider when diagnosing iron deficiency because the presence of inflammation overestimates iron deficiency measurements. Two acute phase proteins known as alpha-1-acid glycoprotein (AGP) and C-reactive protein (CRP) are common biomarkers of inflammation. The five indicators used to diagnosis this condition are hemoglobin concentration, zinc protoporphyrin, mean cell volume, transferrin receptor (TfR) concentration, and serum ferritin concentration.

Objective: The purpose of this study was to determine if TfR is affected by inflammation in Papua New Guinea and if a relationship exists between elevated TfR and elevated CRP, and elevated TfR and elevated AGP. The study focused on non-pregnant women aged 15 to 49 who participated in the National Micronutrient Survey of 2005.

Methods: A complex cross sectional study design, which took into account stratification, clustering, and sample weights, was utilized for this study. A two-stage, 100-cluster, proportional to population size (PPS) survey was conducted. Data on 746 women were used during the analysis. Survey logistic modeling techniques were implemented to assess the relationships between TfR, CRP, and AGP.

Results: The unadjusted POR for CRP and TfR was 1.42 (0.74,2.71). This ratio was not significant. The unadjusted POR between AGP and TfR was 1.99 (1.28, 3.10). This ratio was significant. After adjusting the model for relevant covariates and interaction terms, the POR for CRP and TfR, in the rural setting, was 2.54 with a p-value of 0.0112. The POR for AGP and TfR, in the rural setting, the POR was 2.90 with a p-value less than 0.0001.

Conclusions: The results of this study support the alternative hypothesis that there is an association between elevated CRP and elevated TfR and elevated AGP and elevated TfR. Life in a rural or urban setting is a effect modifying factor when using CRP and TFR to look at the relationship between inflammation and iron deficiency. These findings differ from the established notion that TfR levels are not affected by inflammation. In this population, women living in rural settings who have inflammation have a higher prevalence of iron deficiency.

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This work is dedicated to my beloved family.

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I. Introduction

Background

Iron is an essential nutrient for humans. Specifically, it serves important metabolic functions as a cofactor for several enzymes and is a major component of oxygen transporters within the body.[1] Iron imparts biological function through its incorporation into proteins and enzymes such as hemoglobin, myoglobin, and cytochrome c.[2] The majority of functional iron is contained in hemoglobin, with smaller quantities found in myoglobin and cytochrome c.[3] Defined as the state in which there is insufficient iron to maintain normal physiological function of body tissues such as the brain, blood, and muscles, iron deficiency can have detrimental affects on human health.[4] Iron deficiency is the most prevalent micronutrient deficiency disorder in the world.[2]

The following sources contribute to the ability of the body to meet iron requirements: oral ingestion of iron, storage of iron, and recycling of iron from the breakdown of aging red blood cells. Consequently, if iron needs exceed available iron supplies, iron deficiency results.[5] Stored iron is the pool of iron in the body that is not being used by tissues. During periods of iron deficiency, resulting from insufficient dietary intake of iron, the pool of stored iron acts as a buffer to maintain normal physiological functions. Absolute iron deficiency occurs when there is no storage iron. It is most common in young children, pregnant women, and premenopausal women. Conditions contributing to the development of absolute iron deficiency include inadequate diet, menstrual blood loss, peptic ulcers, celiac disease, and *Helicobacter pylori* infection.[6]A phenomenon called functional iron deficiency can result if sufficient iron supplies are present but the transportation of iron to target tissues is impaired.[4]

Functional iron deficiency is most commonly caused by the release of cytokines (cell-to-cell signaling protein molecules) during inflammation caused by infectious diseases. A small peptide hormone known as hepcidin mediates this process.[4]

As previously mentioned, iron deficiency is the most common global nutritional deficiency disorder. In addition to affecting children and women in developing countries, it is significantly prevalent in industrialized countries. One of the most problematic health outcomes associated with iron deficiency is anemia, most commonly referred to as iron deficiency anemia. It is estimated that two billion people are affected by anemia worldwide.[7] Iron is a crucial building block for red blood cell production. Therefore, when iron levels are not sufficient, the body is not able to properly manufacture red blood cells and anemia results. Iron deficiency anemia can also result from chronic blood loss.[3] The severity of iron deficiency anemia is exacerbated by infectious diseases including malaria, HIV/AIDS, schistosomiasis, tuberculosis, and hookworm infection.[7]

Iron deficiency can cause delay of normal infant motor function, increased risk of morbidity in children, preterm pregnancies, impairment of mental function and memory in teens and young adults.[8] Another important public health concern of iron deficiency is the impairment of work capacity of adults and populations. This is important because it can translate to crippling economic consequences for developing nations.[7]

Oxygen transportation in hemoglobin is facilitated by iron in the form of heme. Through the donation or acceptance of an electron, dietary iron exists in either a reduced ferrous (Fe^{2+}) or an oxidative ferric (Fe^{3+}) state.[3] Before ferric iron can be absorbed by cells, it must be reduced to ferrous iron by an enzyme known as Fe-reductase. Absorption occurs in the small intestine across enterocyte cells (intestinal cells) with the

help of a transporter known as divalent metal transporter (DMT1).[5] During states of iron deficiency, expression of Fe-reductase and DMT1 is increased. The opposite is true for times of iron overload. The total amount of ferrous iron that can be absorbed from the duodenum is 1-2mg/day.[5] Ferrous iron is then oxidized back to its ferric form by Fe-oxidase hephaestin in the cell membrane. Ferroportin, a transmembrane protein, facilities the transport of ferric iron across the cell membrane. Hepcidin (a small peptide hormone) inhibits the release of ferric iron from ferroportin. Thus, the expression of hepcidin decreases during states of iron deficiency and increases during iron overload.[5] Once released into blood plasma, ferric iron complexes with a protein called transferrin. This forms the transferrin-iron complex. This complex travels first to the liver then to the spleen where it binds to transferrin receptors (TfR) on hepatocytes (liver cells) and macrophages (white blood cells). Iron is stored in hepatocytes and macrophages as ferritin until released by ferroportin for transport to target organs and/ or alternative storage.[5] Controlled homeostasis of iron is crucial. An excess accumulation of iron in hepatocytes can cause pathologic damage known as hemochromatosis; while a deficiency of iron leads to anemia and other metabolic dysfunctions.

Our bodies are equipped with various defenses to fight infectious including innate and natural immunity. An example of an innate defense mechanism is the acute phase response. In the acute phase response, pattern recognition molecules initiate a set of immediate inflammatory responses when a microbial pathogen is recognized.[9] The intensity of an acute phase response is dependent upon the type of pathogen, host genetic factors, and the balance between pro and anti-inflammatory cytokines present. Intensity can then be detected in the blood.[10] Germ cell encoded proteins are able to recognize

these microbial pathogens due to shared molecular structures, a system host response then results. Clinically, signs of an acute phase response include fever, leukocytosis, change in vascular permeability, increase in metabolic responses, and enhancement of nonspecific host defenses.[9] Cytokines, specifically types Il-6 and Il-1, function in controlling the production of acute phase proteins. Acute phase protein concentrations increase rapidly after infection in order to provide protection against microorganisms. These activated host defenses are advantageous because they contribute to the isolation and destruction of microbial pathogens as well as activation of tissue repair processes.[9]

In order to effectively recognize pathogens of various origins and structures, acute phase proteins recognize carbohydrate or lipid molecules on the pathogen. Host proteins that recognize these microbial structures are known as pattern recognition molecules. These molecules initiate the inflammatory responses that comprise the acute phase response.[9] Two pattern recognition molecules related to iron deficiency are alpha-1-acid glycoprotein (AGP) and C-reactive protein (CRP).

In this study, the exposure variables of interest are AGP and CRP. Research has shown that these acute phase proteins play an important role in detection of iron deficiency, particularly when serum ferritin is the diagnostic tool.[11] Correctly diagnosing and assessing the prevalence of iron deficiency in at risk populations is challenging because certain iron status indicators are influenced by inflammation.[12] Simultaneous measurements of both biomarkers of inflammation are recommended for accurate assessment due to behavioral differences. For example, AGP reaches its maximum concentration forty-eight hors after infection while CRP rises quickly after the onset of infection and begins to decline twenty-four to forty-eight hours after onset.[12]

The outcome being addressed in this study is iron deficiency. In the assessment of iron deficiency, the five indicators used to diagnosis this condition are hemoglobin concentration, zinc protoporphyrin, mean cell volume, transferrin receptor concentration, and serum ferritin concentration.[4] Each iron status indicator was chosen as a test based on its biological functions and significance. Hemoglobin is a red blood cell protein that contains iron and transports oxygen.[13] Its concentration is important in measuring anemia, and anemia is closely linked with iron deficiency. However, the usage of hemoglobin concentration is not always ideal because of its low sensitivity and specificity.[14] Measurement of zinc protoporphyrin is a diagnostic tool for iron deficiency because when iron levels are low, zinc is inserted into the protoporphyrin molecule instead of iron. Its presence is then detected in red blood cells by fluorimetry.[4] A common sign of iron deficiency anemia is red blood cell size. When red blood cells are smaller than usual, or microcytic, that is an indication of iron deficiency. Thus, mean cell volume is used to identify iron deficiency.[4] Serum transferrin receptor levels are related to red blood cell development, or erythropoiesis, and iron demand. During times of insufficient iron, serum transferrin receptor levels decline. Thus, it can be used to detect iron deficiency. [4]

Serum ferritin measures the amount of storage iron in the absence of infection. Serum ferritin levels of less than 12 μg/L (for those under five years of age) or 15 μg/L (for those over five years of age) indicate iron deficiency.[11] Ferritin is a hollow protein shell composed of twenty-four subunits that surround an iron core that contains about four thousand iron atoms. Thus, ferritin concentration is positively correlated with the bodily iron storage size.[15] Normal ferritin concentration fluctuates based on age and sex.

Concentrations are typically high at birth, decrease during infancy, increase again at one year of age, and then steadily increase into adulthood. Males typically have higher serum ferritin concentrations than females.[15] Unlike hemoglobin, ferritin levels are not affected by residential elevation above sea level or smoking habits. However, because ferritin is a positive acute phase protein, concentrations increase during inflammation. This rise in ferritin levels in the presence of inflammation masks the presence of iron deficiency. As a result, ferritin levels can independently assess iron deficiency only during the absence of infection and inflammation.[11] The elevation of ferritin during states of inflammation reflects increased total body iron storage, but these stores are sequestered and not available for use. It is believed that this sequestration of iron during inflammation developed as a defense mechanism to prevent pathogens from using the body's iron.[16] Thus, only using ferritin levels would not be an appropriate test for areas greatly affected by infectious diseases.[15] Ferritin is typically measured in serum or plasma using an enzyme-linked immunosorbent assay (ELISA).[15]

The iron deficiency indicator measured in this study was serum transferrin receptor concentration. As previously mentioned, iron is carried by serum transferrin and transported to cells via transferrin receptors. Transferrin serves three main purposes in relation to iron. Firstly, it maintains ferric iron in a soluble form under physiologic conditions. Secondly, it facilitates regulated iron transport and cellular uptake. Lastly, it maintains ferric iron in a redox-inert state to prevent formation of toxic free radicals.[17] Free radicals are atoms, molecules, or ions that contain an unpaired electron. Transferrin receptors are also an indirect defense against systemic infections because they deprive pathogens of extracellular iron, which is essential for their growth.[17] The term soluble, or

serum, transferrin receptors (sTfR) refer to transferrin receptors that have been shed during the recycling process and appear in a soluble form.[18] Although transferrin receptor is a cell membrane protein, small quantities circulate in the blood (sTfR after shedding.[19] Serum transferrin receptor concentrations can be quantified using immunoassays and detected in plasma in addition to serum. Transferrin receptor concentrations are in negative feedback with iron concentrations. Thus, when iron concentration is low, transferrin receptor concentration increases in an effort to import and transport more iron into cells.[20] Consequently, iron deficiency is associated with high concentrations of transferrin receptor in serum. Unlike serum ferritin levels, serum transferrin receptor levels are not thought to increase during inflammation. Research has shown that AGP and CRP have a greater effect on serum ferritin levels than serum transferrin receptor levels.[21] Additionally, soluble transferrin receptor levels are not greatly affected by pregnancy.[19] Thus; it can be used in situations where ferritin use is not appropriate.[18]

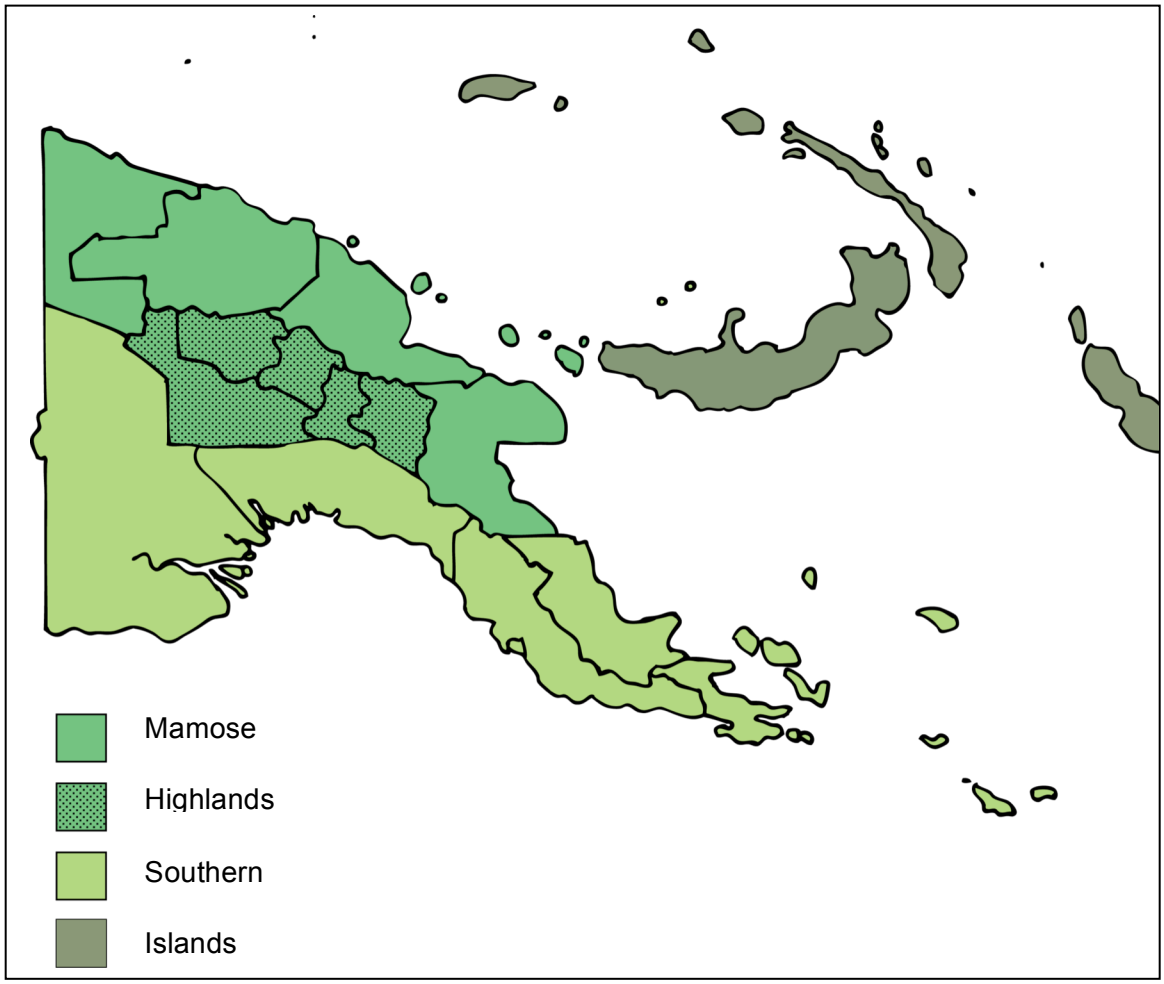
Due to ferritin's shortcomings in the presence of inflammation, an alternative method to utilize ferritin concentrations was constructed by researchers. It is known as the serum transferrin receptor (sTfR)-ferritin index and is the ratio of sTfR to log-ferritin. The combination of ferritin and transferrin receptor measurements in order to diagnose iron deficiency has high sensitivity and is a useful test.[22] The sTfR-ferritin index is best for situations in which ferritin amount is at intermediate levels of (45 to 99 ng/dL) in patients with inflammation.[23] An important of using the index is that it controls for differences in body weight, which can affect serum ferritin levels.[24]

The subjects of interest in this study are non-pregnant women of childbearing age. In the developed world, the greatest prevalence of iron deficiency occurs in

premenopausal women. This occurrence is due to an inadequate consumption of dietary coupled with iron loss during menstruation.[2] The average woman has approximately 40mg/kg of iron stored within her body. This storage amount is maintained by daily iron absorption amounts of 1-2 mg of iron per day.[5] About 1 to 2 mg of iron is lost per day, in women, through stool and another 1-2 mg is lost daily during menstruation. Pregnancy adds additional iron demands for the fetus.[5] Female athletes may also experience an elevated risk of iron deficiency because hepcidin, the peptide hormone that inhibits iron absorption, may rise in response to physical activity.[2] Thus, given the processes that women of reproductive age undergo, the maintenance of iron level for women is a major concern. The recommended daily allowance (RDA) for iron in women varies based on age. For women aged 1 to 13 the RDA is 7 to 10mg/day, for ages 14 to 18 the RDA is 15mg/day, for ages 19 to 50 the RDA is 18mg/day, and for ages 51 and over the RDA is 8 mg/day.[5]

Papua New Guinea Background Information

MAP OF PAPUA NEW GUINEA SHOWING PROVINCIAL BORDERS AND SURVEY REGIONS[25]



Papua New Guinea (PNG) is the largest Pacific Island Nation in the Western Pacific Island of New Guinea. PNG occupies the eastern half of the Island of New Guinea in addition to multiple larger volcanic islands and six hundred small, scattered islands in the Bismarck and Solomon Seas.[25] With a land area of 462,840 kilometers squared, Papua New Guinea borders Irian Jaya (an Indonesian province) and seas of the Solomon Islands and Australia. In terms of geographical features, PNG is extremely

diverse. In addition to its rugged surface features and high altitudes, it contains offshore volcanic islands, coral atolls, lowland forests, swamps, dry savannah, and alpine forests.[25]

Travel and migration within PNG is extremely difficult due to cost and lack of proper infrastructure—especially in rural areas. As a result, PNG must utilize coastal shipping and domestic air services rather than road transport. Approximately a third of the population lives below the poverty line and eighty-five percent live in rural areas. Papua new Guinea is composed of twenty provinces and eighty-nine districts that are grouped into four regions—Southern, Highlands, Mamose, and Islands.[25] The differences between regions, due to geographical and economical barriers, manifest themselves in comparing nutrition status between the regions. For example, in the Papua New Guinea National Nutrition Survey of 1983, great variation, in the extent of protein-energy malnutrition (PEM), among children under five years old in different regions was observed. Furthermore, within provinces there was considerable variation between districts.[25] In Papua New Guinea malnutrition is a major cause of poor health outcomes. While documentation on the nutritional status of children has been well documented in PNG, the nutritional status of adult women is not as well documented.[25] The Papua New Guinea Micronutrient survey was conducted in 2005 to determine the prevalence of various micronutrient disorders including iron deficiency. Non-pregnant women aged 15 to 49 were a target group in the survey.

II. Methods

Null Hypothesis:

There are no associations between: 1) elevated C-reactive protein (CRP) levels and elevated transferrin receptor (TfR) levels, 2) between elevated α-1 acid glycoprotein (AGP) levels and elevated transferrin receptor levels (TfR), in non-pregnant women of 15-49 years of age in Papua New Guinea.

Study Design:

The Papua New Guinea nutritional survey utilized a two-stage, 100-cluster, proportional to population size (PPS) survey. Stratification by region (Southern, Highlands, Mamose, and Islands) was done in order to obtain national and regional estimates. Twenty households were randomly selected within each cluster using standard mapping, numbering, and segmentation methodologies. The decision to stratify on region was based on the following assumptions: 1) The regions may experience wide differences in nutrition outcome due to the diversity of the landscape, agriculture, and cultural practices. 2) Intervention programs will need to be introduced on the region level. Thus, region-specific estimates will be needed to identify the regions in need. 3) Not all nutritional interventions in Papua New Guinea are implemented nationwide. There are concerns that there could be significant regional variations.

The sample size was determined using standard statistical procedures. The final number of households included in the sample was 1600. Nationally, 1677 non-pregnant women aged 15-49 were included in the sample. In every second household anemia, iron deficiency, BMI, urinary iodine and malarial load were measured in all non-pregnant

women of childbearing age. The final sample size for assessing TfR status among women aged 15 to 45 years old was 850.

During the first stage of sampling, a list of all census units in PNG was used to select 25 primary sampling units (PSUs) for each region. No census unit was selected more than once. If the census unit selected had fewer than 25 households the next nearest census unit was selected and combined with the original census unit. The 100 randomly selected PSUs are located in all 20 provinces and in 75 of the 87 districts in PNG: 16 districts in the Southern region, 24 in the highlands regions, 23 in the Mamose region, and 12 in the Islands region. In the second stage of sampling, each PSU survey team worked with local leaders and the community to create a household listing of all households in the selected PSU. Twenty households were randomly selected from the overall list. PSUs with more than 250 households were split into segment. A segment was chosen at random, and twenty households were chosen randomly within that segment. In each selected household, all eligible persons in the target group were asked to participate in the survey. A household was defined as a group of people who share common cooking pot and household resources, such as bedding and food. Members of a household were not necessarily relatives by blood or marriage.

Ethical and technical considerations were reviewed and approved by the Department of Health in Port Moresby. The right of individuals to choose to participate or not participate was ensured and respected. Informed consent (see appendix) was obtained from all participating women. Consent was taken verbally and marked on the top of the participant form by the interviewer, and participants were informed that they were free to refuse at any point during the survey.

Data Collection

There were six survey teams that consisted of a team leader, one interviewer and anthropometry assistant, one anthropometrist, and one laboratory technician. Focal persons were identified and assigned by the Department of Health to assist teams in each district. Focal persons provided the teams with assistance in locating the correct primary sampling unit, helping the team access the PSU, collecting the specimens and data collection forms completed in the PSU and transporting them to Port Moresby. They also provided an essential link in the communication between the survey supervisor located in Port Moresby and team members and helped trouble shoot any problems in the field. Individuals from the survey task force and Centers for Disease Control and Prevention (CDC) assisted with training, implementation, and data collection. The survey teams completed a two-week training program. The training was coordinated by technical advisors form the CDC, the University of Papua New Guinea, and the Department of Health. The training covered various topics including survey methodology, team composition, team and individual responsibilities, field procedures, selection of households and eligible participant, interview techniques, questionnaire administration, anthropometry, and blood, urine, stool and salt sample collection and storage, and transport guidelines. Data collection forms were created after consultation with national and international organizations providing nutrition and health services to the population of Papua New Guinea. The training concluded with a two-day pilot survey conducted in Hanuabada village in Port Moresby. Village leaders were contacted and the survey procedure was explained to them. Once the village leaders granted permission, a list was made of all households in the census unit. Upon arrival at the selected households, the

team leader usually accompanied by community leaders or representatives explained to the head of household the purpose and procedures of the survey (see appendix I) and the household was selected. The head of household was defined as the person in the household who makes the major decisions for all the household members, such as financial expenditures, schooling, medical care and food.

Before proceeding with individual interviews, informed consent was obtained from each participant. Where possible the interviews were conducted in Pidgin. When that was not possible, and none of the team members had experience in the local language, a local translator was used. This was a main reason for keeping the data collection form very simple. Blood, and urine samples were taken from the women. Height and weight was also measured. The blood was used to assess transferrin receptor, CRP, and AGP. Survey workers asked each woman of reproductive age questions regarding night blindness, whether they used tobacco, their last pregnancy and information about that child, such as the child's birth weight. Women who had given birth during the past three years prior to the survey were asked to recall the birth weight of their last-born child.

Women's ages were self-reported. Height was measured to the nearest 0.1 cm using a Shorr board with the adult extension piece attached. Seca Uniscales were used to measure weights. Capillary blood was collected via finger puncture from the middle or ring finger using semi-automated lancets with 2.25mm needles. The blood was then collected into a microtainer; each participant submitted approximately 250 to 500 microliters of blood. After using the blood to test hemoglobin and to prepare malaria sticks, the remainder blood was transferred to dried bloodspot (DBS) cards. These dried

bloodspot cards were then sent to a laboratory at SEAMEO-TROPMED RCCN-UI in Jakarta for testing of TfR, CRP, and AGP.

The main exposure variables of interest are AGP and CRP and the outcome of interest is iron deficiency (TfR). Relevant covariates of interest for this study are: age, education level, previous pregnancy, region of residency, body mass index (BMI), and urban/rural.

Data Analysis

Data analysis was conducted using SAS v. 9.3 (SAS Institute Inc., NC, USA). Proc SurveyFreq and Proc Surveylogistic were used to account for the complex study design and need to conduct weighted analysis. Stratification was performed based on regions and sampling weights were attached to the region according to population size. Clustering was also taken into account. A significance level of 5% was used for all significance analyses. Cutoffs to define inflammation and iron deficiency and their level of public health significance were based on WHO and CDC recommendations (Table 1).

The Papua New Guinea National Micronutrient Survey collected data on 850 women aged 15 to 49 years old. Observations were excluded if age was missing, if the participant was pregnant, if TfR value was missing, and if both CRP and AGP values were missing. After exclusions, the study sample size was 746. Table 1 shows the cutoffs for the main exposures and outcome variable. Inflammation in relation to CRP is defined as having a blood concentration greater than 5mg/L. Inflammation in relation to AGP is defined as having a blood concentration greater than 1 g/L. Iron deficiency is defined as having a blood concentration level greater then 8ug/dL. The definitions and classifications of the study covariates are described in Table 2. Table 3 shows simple

descriptive statistics for the exposures, outcome, and covariates. For comparison purposes, weighted and unweighted frequencies are given. Crude prevalence odds ratios between TfR and the exposure variables are given in Table 4. In order to characterize the prevalence of iron deficiency and inflammation among the sub-groups of the study population, prevalence tables were constructed. Tables 5, 6, and 7 show the prevalence and prevalence odds ratios between TfR, CRP, AGP and the study covariates.

Logistic Regression Data Analysis

In order to assess the relationship between elevated CRP and elevated TfR and between elevated AGP and elevated TfR logistic regression analysis was conducted. Specifically, the goal was to find the most appropriate final model for each relationship when considering variable significance, interaction, confounding, precision, and collinearity.

Initially, all possible two-way interaction terms were entered into the model and a likelihood ratio test was performed to detect interaction. The model that includes the exposure variable, the covariates, and the two-way interaction terms is known as the full model. In order to support the results of the likelihood ratio test, a backwards elimination approach was used on the full model (see appendix II). This involves running the full model and continuing to drop insignificant interaction terms until only significant interaction terms remain or no interaction terms remain.

Once the backwards elimination procedure was completed, the resulting model (known as the gold standard model) was used to assess confounding and precision. Before assessing confounding, it was decided a priori that all significant covariates and covariates part of interaction terms would remain in the full model. Given those

guidelines, all resulting possible subset models of the gold standard model were analyzed to assess confounding and precision. Tables of prevalence odds ratios were formulated for each relationship. To determine confounding, a ten percent rule was used. This rule states that any prevalence odds ratio estimate greater or smaller than ten percent of the gold standard POR estimate is affected by confounding and is not an appropriate model to use. After confounding is determined, the best or final model is chosen by confidence interval ratio precision. The model with the smallest confidence interval ratio is considered the most precise and the best model.

Collinearity diagnostics were performed on the final models. Possible collinearity problems were assessed by examining condition indices and variance decomposition proportion (VDPs) values from the inverse of the information matrix. If there are any condition indices greater than 30 then collinearity is indicated. To confirm or deny this indication, VDPs are examined. For condition indices greater than 30, the corresponding VDPs are examined in order to find two or more variables with VDP values greater than 0.5 then the source of the collinearity is found. The collinearity matrix was produced using a SAS macro called "Collin_2011" originally created by Mathew Zack.

III. Results

Descriptive Statistics

The demographical composition of the study population included women mostly aged 20 to 29 (36.8%), most women lived in the highlands region (40.1%), the majority had a highest level education of primary school (45.9%), most lived in a rural community style (75.9%), most had a normal BMI (72.0%), most had a previous pregnancy (70.7%), most had normal CRP levels (90.1%), most had normal AGP levels (77.4%), and most had normal TfR levels (80.7%). For women with elevated CRP, the prevalence of elevated TfR is 24.69%. For women with elevated AGP, the prevalence of elevated TfR is 28.47%.

Crude associations between CRP and TfR and between AGP and TfR are shown in Table 4. For CRP and TfR the POR was 1.42 (0.74,2.71). Thus, the odds of having elevated TfR levels is 1.42 times higher among women with elevated CRP than women with normal CRP levels. However, this ratio was not significant. The crude POR between AGP and TfR was 1.99 (1.28, 3.10). Thus, compared to women with normal AGP levels, women with elevated AGP were 1.99 times more likely to have elevated TfR levels. This relationship was significant.

Table 5 shows the prevalence of elevated CRP amongst the sub-populations in the data set. A significant prevalence odds ratio was observed when comparing those with normal BMI to those with an underweight BMI (POR=0.45, 95%CI=0.21, 0.97). No other significant comparisons were found.

Table 6 shows the prevalence of elevated AGP amongst the sub-populations in the data set. A significant prevalence odds ratio was found when comparing ages 20-29 to

15- 19 (POR=0.52, 95%CI=0.33, 0.82), ages 30-39 to 15-19 (POR=0.36, 95%CI= 0.22, 0.59), ages 40-49 to 15-19 (POR=0.50, 95%CI=0.28, 0.89), southern region inhabitants to island region inhabitants (POR=1.85, 95%CI=1.01,3.36), and women who had experienced a previous pregnancy to those who had not (POR=0.52, 95%CI=0.35, 0.76).

Table 7 shows the prevalence of elevated TfR amongst the sub-populations in the data set. A significant prevalence odds ratio was found when comparing ages 20-29 to 15-29 (POR=0.51, 95%CI=0.31, 0.85), ages 30-39 to 15-19 (POR=0.47, 95%CI=0.27, 0.80), ages 40-49 to 15-19 (POR=0.47, 95%CI=0.26, 0.86), highlands region inhabitants to islands region inhabitants (POR=0.11,95%CI=0.05,0.27), and women who had experienced a previous pregnancy to those who had not (POR=0.54, 95%CI=0.37, 0.79).

Association Between Elevated CRP and Elevated TfR

The full model for the association between elevated CRP and elevated TfR was the following:

$$TfR = \beta_0 + \beta_1 CRP + \beta_2 AGE + \beta_3 EDU + \beta_4 REGION + \beta_5 COMMUNITY + \beta_6 BMI + \beta_7 EVERPREG + \beta_8 (CRP*AGE) + \beta_9 (CRP*EDU) + \beta_{10} (CRP*REGION) + \beta_{11} (CRP*COMMUNITY) + \beta_{12} (CRP*BMI) + \beta_{13} (CRP*EVERPREG).$$

Table 8a shows result of the likelihood ratio test (chunk test) for the relationship between CRP and TFR. A cutoff value of 12.59, for 6 degrees of freedom, was used for the test. A final value of 16,921.07 was obtained. This value is tremendously higher than the designated cutoff value. Backwards elimination procedure was performed to determine which interaction term(s) were significant. After a series of runs, it was determined that the interaction term involving CRP and community was significant. Table 8b shows the

results of this process. The CRP/Community interaction term had a p-value of 0.0113. Thus, the gold standard model was the following:

$$TfR = \beta_0 + \beta_1 CRP + \beta_2 AGE + \beta_3 EDU + \beta_4 REGION + \beta_5 COMMUNITY + \beta_6 BMI + \beta_7 EVERPREG + \beta_8 (CRP*COMMUNITY)$$

The covariates region, community, and ever pregnant must remain in the model due to significance and inclusion in an interaction term. There were eight other possible models given that restriction. Table 8c shows those models. Four out of the eight models were eligible to be compared for precision. After considering confounding, the most precise model (using confidence interval ratios) was the gold standard model. Thus the gold standard model was chosen to be the final model as well. The final model had a POR of 2.416 (95% CI=1.192, 4.897) and a confidence interval ratio of 4.108. Table 8d shows chi-square statistics and p-values for all variables in the final model. Collinearity diagnostics demonstrated that there were no collinearity problems in the final model.

Association Between Elevated AGP and Elevated TfR

The full model for the association between elevated AGP and elevated TfR was the following:

$$TfR = \beta_0 + \beta_1 AGP + \beta_2 AGE + \beta_3 EDU + \beta_4 REGION + \beta_5 COMMUNITY + \beta_6 BMI + \beta_7 EVERPREG + \beta_8 (AGP*AGE) + \beta_9 (AGP*EDU) + \beta_{10} (AGP*REGION) + \beta_{11} (AGP*COMMUNITY) + \beta_{12} (AGP*BMI) + \beta_{13} (AGP*EVERPREG)$$

Table 9a shows result of the likelihood ratio test (chunk test) for the relationship between AGP and TFR. A cutoff value of 12.59, for 6 degrees of freedom, was used for the test. A final value of 13,272.3 was obtained. This value is tremendously higher than the designated cutoff value. Backwards elimination procedure was performed to determine which interaction term(s) were significant. After a series of runs, it was determined that

the interaction term involving AGP and community was significant. Table 9b shows the results of this process. The AGP/Community interaction term had a p-value of 0.0383. Thus, the gold standard model was the following:

$$TfR = \beta_0 + \beta_1 AGP + \beta_2 AGE + \beta_3 EDU + \beta_4 REGION + \beta_5 COMMUNITY + \beta_6 BMI + \beta_7 EVERPREG + \beta_8 (AGP*COMMUNITY)$$

The covariates region and community must remain in the model due to significance and inclusion in an interaction term. There were sixteen other possible models given that restriction. Table 9c shows those models. Fifteen out of the sixteen models were eligible to be compared for precision. After considering confounding, the most precise model (using confidence interval ratios) was the following:

$$TfR = \beta_0 + \beta_1 AGP + \beta_2 REGION + \beta_3 COMMUNITY + \beta_4 EVERPREG + \beta_5 BMI \beta_6 (AGP*COMMUNITY)$$

The final model had a POR of 1.806 (95% CI=1.806, 4.559) and a confidence interval ratio of 2.525. Table 9d shows chi-square statistics and p-values for all variables in the final model. Collinearity diagnostics demonstrated that there were no collinearity problems in the final model.

Stratified Prevalence Odds Ratios

Table 10 shows the adjusted prevalence odds ratios for the relationship between elevated CRP and TfR and between elevated AGP and elevated TfR. Each variable is stratified to show the difference in prevalence in each community style. The PORs for the urban communities were not significant for CRP or AGP. However, the rural PORs were significant. For CRP in the rural communities, the POR was 2.54 with a p-value of 0.0112. For AGP in the rural communities, the POR was 2.90 with a p-value less than 0.0001.

IV. Discussion

Prevalence of Elevated CRP, AGP, and TfR

When making two-way comparisons of the study participants we found that there is a significant difference in CRP when comparing women of normal BMI to women of underweight BMI. Women who are underweight are 2.22 times more likely to have elevated CRP levels than women who are normal weight. There does not appear to be any other significant BMI relationships in regards to elevated AGP or elevated TfR. When considering age, there are significant age relationships for elevated AGP and TfR. For AGP, the prevalence of elevated AGP for women aged 15-19 is 1.92 times higher than women aged 20-29, 2.78 times higher than women aged 30 to 39, and 2.00 times higher than women aged 40 to 49. For TfR, the prevalence of elevated TfR for women aged 15-19 is 1.96 times higher than women aged 20-29, 2.13 times higher than women aged 30-39, and 2.13 times higher than women aged 40-49. The high prevalence of elevated AGP and TfR may result from some underlining biological or behavioral factor related to that age group. A significant relationship between history of pregnancy was observed for elevated AGP and TfR. Women with no history of pregnancy were 1.93 times more likely to have elevated AGP and 1.85 times more likely to have elevated TfR than women with a history of pregnancy. In regards to residential region, elevated AGP was 1.85 times more prevalent in the southern region than the islands region. Elevated TfR was 9.09 times more prevalent in the islands region than the highlands region. No significant relationships for elevated CRP, AGP, and TfR were observed for education or community style comparisons.

Association Between Elevated CRP and Elevated TfR

The results of this study demonstrate that there is a statistically significant relationship between elevated CRP and elevated TfR in women when controlling for age, region, education, community, BMI, and history of pregnancy. With p-values of 0.5103, 0.9331, and 0.3555 age, education, and BMI, respectively, were not significant factors in the relationship between CRP and TFR, but made the point estimate more precise thus they remained in the model. Our results demonstrate that the relationship between CRP and TfR differs based on community style, so community remained in the model in order to maintain model hierarchy. Residential region, and history were significant factors in assessing the relationship. This conclusion is different from what was initially seen when we looked at the crude association between CRP and TfR. For the crude association, the POR was 1.42 and was not significant. However, after including significant covariates, confounders, and interaction terms, we see that among rural inhabitants, prevalence of elevated TfR is 2.54 times higher in women with elevated CRP than women with normal CRP. No significant relationship between elevated CRP and TfR was found in women living in urban settings.

Association Between Elevated AGP and Elevated TfR

The results of the study analysis demonstrates that there is a significant association between elevated AGP and elevated TfR in Papua New Guinean women when controlling for history of pregnancy, BMI, region, and community. BMI was not a significant factor in the relationship (p-value=0.1963) but was kept in the model because it made the final point estimate more precise. History of pregnancy (p-value=0.002) and region (p-value= <0.0001) were both significant factors in the association. Interaction

was detected based on community style. Women in rural communities with elevated AGP levels had an elevated TfR prevalence that was 2.90 times greater than rural women with normal AGP concentration. In the urban settings, the prevalence of elevated TfR was not significantly different between the two groups of women.

Summary

Iron deficiency is an important global public health issue. Creating a strategy to address this problem can be difficult due to extraneous variables in populations that affect the condition. For example, inflammation is important to consider when diagnosing iron deficiency because the presence of inflammation overestimates iron deficiency measurements. Furthermore, if cross-country comparisons are the goal, it can be difficult due to inflammation differences. The purpose of this thesis was to determine if TfR is affected by inflammation in Papua New Guinea. Papua New Guinea is unique because a common ancestry connects the inhabitants, but culturally different groups formed due to geographical and economical differences. The study focused on non-pregnant women aged 15 to 49 and aimed to investigate the relationship between elevated acute phase proteins and elevated transferrin receptor levels. The results of this study support the alternative hypothesis that there is an association between elevated CRP and TfR and elevated AGP and TfR. Life in a rural or urban setting is a effect modifying factor when using CRP, AGP, and TFR to look at the relationship between inflammation and iron deficiency. Using the previous mentioned cutoffs, in this population, women living in rural settings who have inflammation have a higher prevalence of iron deficiency. In only the rural settings, the results show that inflammation is connected to iron deficiency. These findings are interesting because they are contrary to established beliefs that

inflammation does not affect TfR levels. The study demonstrates that this phenomenon can occur in some settings. In order to learn more about these relationships, this knowledge can be used to research women living in rural settings to discover why elevated TfR is more prevalent. Additionally, the results support the practice of using inflammation to monitor and diagnose iron deficiency due to their close relationship. Considering inflammation when diagnosing iron deficiency can increase sensitivity and specificity of tests. Knowing that this relationship exists is beneficial from a public health prospective because it can be used when developing public health programs and deciding which populations to target.

Strengths and Limitations

A major strength of this study was the methodology and ability to account for the complex study design including stratification, cluster design, and sample weights. A great deal of consideration was taken to properly train the data collectors and to incorporate local figures in order to obtain accurate data. The dataset size is another strength. No issues of too few observations occurred when stratifying the data to look at small sub-groups within the whole dataset. Additionally, the main exposures and outcome variables were determined based on laboratory confirmed test rather than relying on participant knowledge and or recollection—which can introduce bias. Furthermore, no collinearity was observed amongst the selected variables. This a study advantage because the presence of collinearity can bias point estimates. The collaborative nature of the study was is another strength. In the spirit of global health, multiple organizations contributed to the planning and implementing of the study, which is preferred when tackling global issues.

A cross-sectional study design was implemented. This is a limiting factor due to the inherent nature of cross-sectional studies being incapable of inferring directionality or causality. Thus, it can be difficult to apply conclusions to problems because the conclusion does not give causality. Furthermore, though we observed an association between elevated acute phase proteins and elevated transferrin receptor levels, we are not able to pinpoint the origin of the relationship. Measurements for the outcome of interest, exposures of interest, and covariates of interest were taken by study facilitators; thus, information bias may have been introduced due to human error. Also, the point estimate used was the prevalence odds ratio. Although the POR is useful in characterizing relationships, a prevalence risk ratio would be more ideal because prevalence odds ratios always overstate the prevalence risk. Thus, caution must be taken when interpreting the prevalence odd ratios that were obtained. Lack on analysis of socioeconomic factors is another limitation of the study. Collecting information on wealth and social status is very difficult and subjective in this population. Therefore, researchers were not able to obtain this information.

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25. National Nutrition Survey Papua New Guinea, 2005

TABLES

Tabel 1: Biochemical Cutoffs and Indicators for Inflammation and Iron Deficiency,National Micronutrient Survey, Papua New Guinea 2005		
Condition	**Indicator**	**Cutoff***
Inflammation	C-Reactive protein	> 5 mg/L
Inflammation	Alpha-1-acid Glycoprotein	>1g/L
Iron Deficiency	Transferrin Receptor (TfR)	> 8ug/dL

* Cutoffs are for the target group of non-pregnant women aged 15 to 49.

Table 2: Description of Covariates used in the Study Analysis, National Micronutrient Survey, Papua New Guinea 2005	
Variable	Description
Age	Age Categories: 15 to 19 years 20 to 29 years 30 to 39 years 40 to 49 years
Region	PNG Region of Residence: Southern Highlands Momase Islands
Urban/Rural	Urban or Rural
Education	Highest Level of Education: No School Elementary School Primary School Secondary School & Higher
BMI	Body Mass Index: Underweight Normal Overweight
Ever Pregnant	History of Pregnancy: Yes No

Table 3: Demographic Characteristics among Non-Pregnant Women Ages 15 to 49, National Micronutrient Survey, Papua New Guinea 2005			
Characteristic	**N**	**Unweighted %**	**Weighted%**
TfR[1]			
Elevated	176	23.59	19.34
Normal	570	76.41	80.66
CRP[1]			
Elevated	76	10.19	9.93
Normal	670	89.81	90.07
AGP[1]			
Elevated	167	22.39	22.58
Normal	579	77.61	77.42
Age			
15 to 19	133	17.83	18.16
20 to 29	274	36.73	36.80
30 to 39	203	27.21	27.63
40 to 49	136	18.23	17.40
Education			
No School	157	21.87	25.98
Elementary	75	10.45	10.97
Primary	347	48.33	45.91
Secondary & Higher	139	19.36	17.14
BMI			
Underweight	48	6.51	5.28
Normal	517	70.15	72.03
Overweight	172	23.34	22.69
Ever Pregnant			
Yes	532	71.31	70.65
No	214	28.69	29.35
Region			
Southern	244	32.71	19.74
Highlands	173	23.19	40.05
Momase	168	22.52	26.70
Islands	161	21.58	13.51
Urban/Rural			
Urban	184	24.66	20.50
Rural	562	75.34	79.50

[1]Cutoffs: TfR > 8ug/dL CRP > 5mg/L AGP >1g/L

Table 4: Crude Associations Between Exposures and Outcome of Interest in Non-Pregnant Women Ages 15 to 49, National Micronutrient Survey, Papua New Guinea 2005

Association	N	POR (95% CI)	X^{2*}	P-Value**
TfR and CRP[1]	746	1.42 (0.74,2.71)	1.20	0.2743
TfR and AGP[1]	746	1.99 (1.28, 3.10)	9.97	0.0016

*Rao-Scott Chi-Square Value **Significance level of 0.05

[1] Cutoffs: TfR > 8ug/dL CRP > 5mg/L AGP >1g/L

Weighted analysis to account for complex survey design

Table 5: Prevalence of Elevated CRP Among Non-Pregnant Women Ages 15 to 49 With Respect to Covariates, National Micronutrient Survey, Papua New Guinea 2005

Covariate	N	Elevated CRP Prevalence (%)	Crude POR (95% CI)
TfR[1]			
Elevated	176	12.67	1.42 (0.75, 2.69)
Normal	570	9.27	1.00 Ref
AGP[1]			
Elevated	167	31.33	11.92 (6.16, 23.07)*
Normal	579	3.69	1.00 Ref
Age			
15 to 19	133	8.87	1.00 Ref
20 to 29	274	9.85	1.12 (0.41, 3.09)
30 to 39	203	11.80	1.37 (0.52, 3.62)
40 to 49	136	8.22	0.92 (0.35, 2.45)
Education			
No School	157	7.93	1.00 Ref
Elementary	75	17.85	2.52 (0.94, 6.80)
Primary	347	9.98	1.29 (0.61, 2.74)
Secondary & Higher	139	8.78	1.12 (0.42, 2.98)
BMI			
Underweight	48	17.22	1.00 Ref
Normal	517	8.53	0.45 (0.21, 0.97)*
Overweight	172	11.90	0.65 (0.27, 1.57)
Ever Pregnant			
Yes	532	10.34	1.17 (0.63, 2.18)
No	214	8.95	1.00 Ref
Region			
Southern	244	8.99	0.66 (0.30, 1.44)
Highlands	173	10.40	0.77 (0.39, 1.54)
Momase	168	8.33	0.61 (0.31, 1.17)
Islands	161	13.04	1.00 Ref
Urban/Rural			
Urban	184	10.45	1.08 (0.57, 2.04)
Rural	562	9.79	1.00 Ref

Weighted analysis to account for complex survey design

* Significant association (alpha=0.05)

[1]Cutoffs: TfR > 8ug/dL CRP > 5mg/L AGP >1g/L

Table 6: Prevalence of Elevated AGP Among Non-Pregnant Ages 15 to 49 Women With Respect to Covariates, National Micronutrient Survey, Papua New Guinea 2005

Covariate	N	Elevated AGP Prevalence (%)	Crude POR (95% CI)
TfR[1]			
Elevated	176	33.25	1.99 (1.28, 3.08)*
Normal	570	20.03	1.00 Ref
CRP[1]			
Elevated	76	71.26	11.92 (6.16, 23.07)*
Normal	670	17.22	1.00 Ref
Age			
15 to 19	133	34.95	1.00 Ref
20 to 29	274	21.84	0.52 (0.33, 0.82)*
30 to 39	203	16.37	0.36 (0.22, 0.59)*
40 to 49	136	21.13	0.50 (0.28, 0.89)*
Education			
No School	157	22.58	1.00 Ref
Elementary	75	21.56	0.94 (0.44, 2.01)
Primary	347	21.32	0.93 (0.60, 1.45)
Secondary & Higher	139	28.21	1.35 (0.74, 2.46)
BMI			
Underweight	48	32.67	1.00 Ref
Normal	517	20.85	0.54 (0.24, 1.23)
Overweight	172	23.68	0.64 (0.27, 1.50)
Ever Pregnant			
Yes	532	19.03	0.52 (0.35, 0.76)*
No	214	31.15	1.00 Ref
Region			
Southern	244	27.11	1.85 (1.01, 3.36)*
Highlands	173	24.28	1.59 (0.89, 2.83)
Momase	168	19.64	1.21 (0.66, 2.23)
Islands	161	16.77	1.00 Ref
Urban/Rural			
Urban	184	24.80	1.17 (0.73, 1.88)
Rural	562	22.01	1.00 Ref

Weighted analysis to account for complex survey design

* Significant association (alpha=0.05)

[1] Cutoffs: TfR > 8ug/dL CRP > 5mg/L AGP >1g/L

Table 7: Prevalence of Elevated TfR AmongNon-Pregnant Women Ages 15 to 49 With Respect to Covariates, National Micronutrient Survey, Papua New Guinea 2005

Covariate	N	Elevated TfR Prevalence (%)	Crude POR (95% CI)
CRP[1]			
Elevated	76	24.69	1.42 (0.75, 2.69)
Normal	670	18.75	1.00 Ref
AGP[1]			
Elevated	167	28.47	1.99 (1.28, 3.08)*
Normal	579	16.68	1.00 Ref
Age			
15 to 19	133	29.65	1.00 Ref
20 to 29	274	17.73	0.51 (0.31, 0.85)*
30 to 39	203	16.50	0.47 (0.27, 0.80)*
40 to 49	136	16.50	0.47 (0.26, 0.86)*
Education			
No School	157	14.45	1.00 Ref
Elementary	75	23.27	1.80 (0.81, 3.98)
Primary	347	20.71	1.55 (0.94, 2.54)
Secondary & Higher	139	19.66	1.45 (0.72, 2.92)
BMI			
Underweight	48	21.47	1.00 Ref
Normal	517	21.11	0.98 (0.46, 2.09)
Overweight	172	13.19	0.56 (0.24, 1.27)
Ever Pregnant			
Yes	532	16.36	0.54 (0.37, 0.79)*
No	214	26.50	1.00 Ref
Region			
Southern	244	30.34	1.03 (0.53, 1.99)
Highlands	173	4.62	0.11 (0.05, 0.27)*
Momase	168	27.98	0.91 (0.47, 1.76)
Islands	161	29.81	1.00 Ref
Urban/Rural			
Urban	184	13.67	0.60 (0.31, 1.18)
Rural	562	20.80	1.00 Ref

Weighted analysis to account for complex survey design

* Significant association (alpha=0.05)

[1]Cutoffs: TfR > 8ug/dL CRP > 5mg/L AGP >1g/L

Table 8a: Assessment of Interaction for the Association Between CRP[1] and TFR[1] in Non-Pregnant Women Ages 15 to 49 Using the Likelihood Ratio Test, National Micronutrient Survey, Papua New Guinea 2005

Model Type	-2 Ln Value		
Reduced	892323.65		
Full	875402.58		
LRT=(-2 LnRed) - (-2LnFull)		Degrees of Freedom	X^2 Cutoff Value
16921.07		6	12.59

Weighted analysis to account for complex survey design

[1]Cutoffs: TfR > 8ug/dL CRP > 5mg/L

Table 8b: Assessment of Interaction for the Association Between CRP[1] and TFR[1] in Non-Pregnant Women Ages 15 to 49 Using the Backward Elimination Approach National Micronutrient Survey, Papua New Guinea 2005

Model Assessed	Least Significant Term	P-Value*
Full Model	CRP*EDU	0.8544
Dropped Edu Interaction Term	CRP*AGE	0.7540
Dropped Age Interaction Term	CRP*EVERPREG	0.9124
Dropped Everpreg Interaction Term	CRP*REGION	0.1668
Dropped Region Interaction Term	CRP*BMI	0.1969
Dropped BMI Interaction Term	-	-
With Only Urban/Rural Interaction Term	-	0.0113

Weighted analysis to account for complex survey design

* Significant association (alpha=0.05)

[1]Cutoffs: TfR > 8ug/dL CRP > 5mg/L

Table 8c: Assessment of Confounding for the Association Between CRP[1] and TFR[1] in Non-Pregnant Women Ages 15 to 49, National Micronutrient Survey, Papua New Guinea 2005					
V's in the Model	**POR**	**≤ 10% GS?**	**95%CI**	**CI Width**	**CI Ratio**
All (Gold Standard)	2.416	--	1.192, 4.897	3.705	4.108
Region, Everpreg, Urban/Rural, Age,	2.178	Yes	1.071, 4.428	3.357	4.134
Region, Everpreg, Urban/Rural BMI,	2.414	Yes	1.163, 5.008	3.845	4.306
Region, Everpreg, Urban/Rural Edu,	2.159	No	1.073, 4.343	3.270	4.048
Region, Everpreg, Urban/Rural, Age, BMI	2.426	Yes	1.172, 5.021	3.849	4.284
Region, Everpreg, Urban/Rural, Age, Edu	2.152	No	1.082, 4.281	3.199	3.957
Region, Everpreg, Urban/Rural, BMI, Edu	2.418	Yes	1.192, 4.905	3.713	4.115
Region, Everpreg, Urban/Rural	2.170	No	1.056, 4.458	3.402	4.222
None	1.916	No	0.976, 3.761	2.785	3.853

Weighted analysis to account for complex survey design

[1]Cutoffs: TfR > 8ug/dL CRP > 5mg/L

Table 8d: Analysis of Variables in Final Model Used to Assess the Relationship Between CRP[1] and TfR[1] in Non-Pregnant Women Ages 15 to 49, National Micronutrient Survey, Papua New Guinea 2005			
Variable	**DF**	**Wald Chi-Square**	**P-Value***
CRP	1	5.9941	0.0144
AGE	3	2.3118	0.5103
REGION	3	33.7699	<.0001
EDUCATION	3	0.4342	0.9331
URBAN/RURAL	1	2.8381	0.0921
BMI	2	2.0683	0.3555
EVERPREG	1	3.8583	0.0495
CRP*URBAN/RURAL	1	6.4129	0.0113

Weighted analysis to account for complex survey design

* Significant association (alpha=0.05)

[1]Cutoffs: TfR > 8ug/dL CRP > 5mg/L

Table 9a: Assessment of Interaction for the Association Between AGP[1] and TFR[1] in Non-Pregnant Women Ages 15 to 49, Using the Likelihood Ratio Test National Micronutrient Survey, Papua New Guinea 2005

Model Type	-2 Ln Value		
Reduced	879423.05		
Full	866150.8		
LRT=(-2 LnRed) - (-2LnFull)		**Degrees of Freedom**	**X^2 Cutoff Value**
13272.3		6	12.59

Weighted analysis to account for complex survey design

[1]Cutoffs: TfR > 8ug/dL AGP >1g/L

Table 9b: Assessment of Interaction for the Association Between AGP[1] and TFR[1] in Non-Pregnant Women Ages 15 to 49 Using the Backward Elimination Approach, National Micronutrient Survey, Papua New Guinea 2005

Model Assessed	Least Significant Term	P-Value*
Full Model	AGP*EVERPREG	0.8690
Dropped Everpreg Interaction Term	AGP*REGION	0.7498
Dropped Region Interaction Term	AGP*BMI	0.6292
Dropped BMI Interaction Term	AGP*EDU	0.6031
Dropped EDU Interaction Term	AGP*AGE	0.5575
Dropped Age Interaction Term	-	-
With Only Urban/Rural Interaction Term	-	0.0383

Weighted analysis to account for complex survey design

* Significant association (alpha=0.05)

[1]Cutoffs: TfR > 8ug/dL AGP >1g/L

Table 9c: Assessment of Confounding for the Association Between AGP[1] and TFR[1] in Non-Pregnant Women Ages 15 to 49, National Micronutrient Survey, Papua New Guinea 2005						
V's in the Model	**POR**	**≦ 10% GS?**	**95%CI**		**CI Width**	**CI Ratio**
All (Gold Standard)	2.757	--	1.697	4.479	2.782	2.639
Region, Urban/Rural, Age	2.709	Yes	1.699	4.319	2.620	2.542
Region,Urban/Rural, Edu	2.744	Yes	1.683	4.472	2.789	2.657
Region, Urban/Rural, BMI	3.065	No	1.924	4.883	2.959	2.538
Region, Urban/Rural, Everpreg	2.711	Yes	1.704	4.311	2.607	2.530
Region, Urban/Rural, Age, Edu	2.599	Yes	1.607	4.204	2.597	2.616
Region, Urban/Rural, Age, BMI	2.758	Yes	1.712	4.443	2.731	2.595
Region, Urban/Rural, Age, Everpreg	2.687	Yes	1.686	4.285	2.599	2.542
Region,Urban/Rural, Edu, BMI	2.919	Yes	1.801	4.730	2.930	2.627
Region, Urban/Rural, Edu, Everpreg	2.632	Yes	1.621	4.272	2.651	2.635
Region, Urban/Rural, BMI, Everpreg	2.869	Yes	1.806	4.559	2.754	2.525
Region, Urban/Rural, Age, Edu, BMI	2.767	Yes	1.708	4.483	2.775	2.625
Region, Urban/Rural, Age, Edu, Everpreg	2.596	Yes	1.600	4.212	2.611	2.632
Region, Urban/Rural. Edu, BMI, Everpreg	2.774	Yes	1.710	4.503	2.793	2.634
Region, Urban/Rural, Age, BMI, Everpreg	2.863	Yes	1.795	4.566	2.771	2.543
Region, Urban/Rural	2.863	Yes	1.786	4.591	2.805	2.571
None	2.416	Yes	1.474	3.960	2.485	2.686

Weighted analysis to account for complex survey design

[1]Cutoffs: TfR > 8ug/dL AGP >1g/L

Table 9d: Analysis of Variables in Final Model Used to Assess the Relationship Between AGP[1] and TfR[1] in Non-Pregnant Women Ages 15 to 49, National Micronutrient Survey, Papua New Guinea 2005

Variable	DF	Wald Chi-Square	P-Value*
AGP	1	19.8948	<.0001
EVERPREG	1	14.1152	0.0002
BMI	2	3.2564	0.1963
REGION	3	36.694	<.0001
URBAN/RURAL	1	1.4908	0.2221
AGP*URBAN/RURAL	1	3.9728	0.0462

Weighted analysis to account for complex survey design

* Significant association (alpha=0.05)

[1]Cutoffs: TfR > 8ug/dL AGP >1g/L

Table 10: Adjusted Associations Between Exposures and Outcome of Interest in Non-Pregnant Women Ages 15 to 49, National Micronutrient Survey, PNG 2005

Association	N	POR (95% CI)	X^{2*}	P-Value**
CRP and TfR For Urban Residents	169	0.20 (0.03, 1.42)	2.5816	0.1081
CRP and TfR For Rural Residents	540	2.54 (1.24, 5.22)	6.4349	0.0112
AGP and TfR For Urban Residents	179	1.09 (0.43, 2.76)	0.0299	0.8626
AGP and TfR For Rural Residents	558	2.90 (1.81, 4.64)	19.6562	<.0001

Weighted analysis to account for complex survey design

*Wald Chi-Square Value **Significance level of 0.05

[1]Cutoffs: TfR > 8ug/dL CRP > 5mg/L AGP >1g/L

-CRP and TFR association is adjusting for age, region, education, BMI, and ever pregnant

-CRP and AGP association is adjusting for region, BMI, and ever pregnant

APPENDIX I
SURVEY DATA COLLECTION FORMS

Cluster Number ☐☐☐ Household Number ☐☐

HOUSEHOLD QUESTIONNAIRE TEAM CODE ☐

"We would like to talk to you about your household, that is all the people who usually sleep and eat here."

"Mipela i laik toktok long yu long haus bilong yu. Dispela em olgeta pipel husat i save slip na kaikai hia."

Read the survey consent form and ask for verbal consent. If consent is not obtained then move on to the next household. If there are no adult household members present in the household schedule another visit when an adult household member will be present.

VERBAL CONSENT OBTAINED FROM ADULT HOUSEHOLD MEMBER Yes ☐ No ☐

1. Day/Month/Year of interview: ☐☐ ☐☐ ☐☐☐☐ Day Month Year	
2. Census Unit	
3. Ward	
4. LLG	
5. District	
6. Province	
7. Region	
8. HOW MANY PEOPLE NORMALLY LIVE IN THIS HOUSEHOLD? **HAMAS PIPEL I SAVE STAP LONG DISPELA HAUS?** *(People who usually eat and sleep in the household)*	☐☐

9. ARE THERE ANY WOMEN BETWEEN THE AGES OF 15 AND 49 YEARS WHO USUALLY LIVE IN THIS HOUSEHOLD? **I GAT SAMPELA MERI WE KRISMAS BILONG OL I STAP NAMEL LONG 15 NA 49 YIAS I SAVE STAP LONG DISPELA HAUS?**	Yes ..... No ..... 2⇨Q.12 Refused ..... Don't know ..... 9 ⇨Q.12	
10. HOW MANY WOMEN BETWEEN 15 AND 49YEARS LIVE IN THIS HOUSEHOLD? **HAMAS MERI I GAT KRISMAS NAMEL LONG 15 NA 49 YIAS I SAVE STAP LONG DISPELA HAUS?**	☐	
11. COULD YOU PLEASE TELL ME THE NAME AND AGE OF EACH WOMAN AGED 15 TO 49 YEARS WHO LIVES IN THIS HOUSEHOLD EVEN IF THEY ARE NOT HERE RIGHT NOW? **PLIS INAP YU TOKIM MI NEM NA KRISMAS BILONG OL WAN WAN MERI I SAVE STAP LONG DISPELA HAUS NA I GAT KRISMAS NAMEL LONG 15 NA 49 YIAS, MASKI OL I NO STAP LONG HAUS NAU?**	Name Age (Years) 1._____ ☐☐ 2._____ ☐☐ 3._____ ☐☐ 4._____ ☐☐ 5._____ ☐☐	
12. ARE THERE ANY MEN AGED 18 YEARS AND OLDER WHO USUALLY LIVE IN THIS HOUSEHOLD? **I GAT SAMPELA MAN KRISMAS BILONG OL EM 18 NA MOA I SAVE STAP LONG DISPELA HAUS?**	Yes ..... No ..... 2⇨Q.15 Refused ..... Don't know ..... 9⇨Q.15	
13. HOW MANY MEN 18 AND OLDER LIVE IN THIS HOUSEHOLD? **HAMAS MAN WANTAIM KRISMAS NAMEL LONG 18 NA MOA I STAP LONG DISPELA HAUS?**	☐	
14. COULD YOU PLEASE TELL ME THE NAME AND AGE OF EACH MAN AGED 18 YEARS AND OLDER WHO LIVES IN THIS HOUSEHOLD EVEN IF THEY ARE NOT HERE RIGHT NOW? **PLIS INAP YU TOKIM MI NEM NA KRISMAS BILONG WAN WAN MAN I GAT 18 KRISMAS NA MOA, MASKI OL I INO STAP LONG HAUS NAU.**	Name Age(Years) 1. _____ ☐☐ 2._____ ☐☐ 3._____ ☐☐ 4._____ ☐☐ 5._____ ☐☐	

15. ARE THERE ANY CHILDREN AGED 6 MONTHS TO 5 YEARS WHO USUALLY LIVE IN THIS HOUSEHOLD? **I GAT SAMPELA PIKININI I GAT KRISMAS NAMEL LONG 6-PELA MUN NA 5-PELA KRISMAS I STAP LONG DISPELA HAUS?**	Yes ..... No ..... Refused ..... Don't know	2⇨Q.18 9⇨Q.18
16. HOW MANY CHILDREN BETWEEN 6 MONTHS TO 5 YEARS LIVE IN THIS HOUSEHOLD? **HAMAS PIKININI I GAT KRISMAS NAMEL LONG 5-PELA MUN NA 5-PELA YIA I STAP LONG DISPELA HAUS?**	☐	
17. COULD YOU PLEASE TELL ME THE NAME AND AGE OF EACH CHILD AGED 6 MONTHS TO 5 YEARS WHO LIVES HERE EVEN IF THEY ARE NOT HERE NOW? **PLIS NINAP YU TOKIM MI LONG NEM NA KRISMAS BILONG WAN WAN PIKININI I GAT KRISMAS NAMEL LONG 5-PELA MUN NA 5-PELA KRISMAS I SAVE STAP LONG DISPELA HAUS. M ASKI OL I NO STAP LONG HAUS NAU, BAI YU GIVIM NEM NA KRISMAS BILONG OL.** *(Check the clinic book or other document for confirmation of names and ages)*	Name Age in: Years Months 1._____ ☐ ☐☐ 2._____ ☐ ☐☐ 3._____ ☐ ☐☐ 4._____ ☐ ☐☐ 5._____ ☐ ☐☐	
18. What type of house is this? *(Observation: Use your own judgment. Do not ask the respondent the answer to this question)*	High cost house ..... Low cost house ..... Flat ..... Duplex ..... Domestic quarters ..... Dormitory ..... Makeshift ..... Traditional ..... Self-help high cost ..... Self-help low cost ..... Other (specify) ..... Don't know	
19. WHAT IS THE MAIN SOURCE OF DRINKING WATER FOR MEMBERS OF YOUR HOUSEHOLD?	Piped into yard or plot ..... Piped into neighborhood (communal) ..... Public well ..... Well in yard	

YUPELA LONG HAUS I SAVE KISIM WARA BILONG DRING WE? *(If necessary confirm this visually)*	Spring River/stream Pond/lake/dam Communal tank Rainwater Tanker-truck, vendor Refused Other (specify) Don't know
20. WHAT KIND OF TOILET FACILITY DOES YOUR HOUSEHOLD USE? **WANEM KAIN TOILET YUPELA I YUSIM**?	Flush to sewage system or septic tank Pour flush latrine (water seal type) Improved pit latrine (e.g., VIP) Traditional pit latrine Open pit Bucket No facilities or bush/field/beach Overhang latrine Refused Other (specify) Don't know
21. HOW OFTEN DO YOU LISTEN TO THE RADIO? **HAMAS TAIM YU SAVE HARIM REDIO?**	I never listen to the radio Every day Every week Occasionally Other (specify)

This next section should be completed by the female head of the household or another person in the household familiar with the salt, flour, oil, sugar and rice used in the household.

"WE ARE INTERESTED IN THE TYPES OF FOOD THAT PEOPLE EAT IN PAPUA NEW GUINEA. I WILL BE ASKING TO SEE THE SALT, FLOUR, OIL, SUGAR AND RICE, AND THEIR PACKAGES, THAT YOU HAVE IN THE HOUSE TODAY. YOU MIGHT WANT TO COLLECT THESE ITEMS BEFORE WE BEGIN THIS PART OF THE INTERVIEW."
"MIPELA I GAT INTRES LONG OL KAIN KAIKAI WE OL PIPEL BILONG PNG I SAVE KAIKAIM. BAI MI ASKIM LONG LUKIM SOL, FLAUA, OIL, SUGA, RAIS, NA OL PEKET BILONG OL BIPO YUMI STATIM DISPELA HAP BILONG ASKIM."

SALT MODULE *If two or more types of salt are available in the household record information on the two main types of salt used in the household.*		
22. DO YOU HAVE ANY SALT CURRENTLY IN YOUR HOUSEHOLD NOW? **YU GAT SAMPELA SOL LONG HAUS BILONG YU NAU**?	Yes No Don't know	2 ⇨ Q. 40

23. *If Yes ASK* "MAY I SEE A SAMPLE OF EACH TYPE OF SALT YOU HAVE IN THE HOUSEHOLD" **"INAP MI LUKIM SEMPOL LONG OL KAIN SOL YU GAT LONG HAUS BILONG YU"** *(If there is more than one type of salt record the information for just one type of salt here. Record the information for another type of salt in the Type 2 salt module beginning with question 31.)* *(Observe the type of salt used and circle the appropriate answer)*	Fine table salt ..... Cooking salt ..... Traditional salt ..... Sea water used for cooking ..... Refused ..... Other (specify) ..... Don't know	4 ⇨ Q.31
24. *If you DO NOT see the original salt bag or package ask* "COULD I PLEASE SEE THE ORIGINAL SALT BAG OR PACKAGE?" **"PLIS INAP MI LUKIM SOL BEK O PEKET SOL I BIN STAP LONG EN?"**	Yes, original salt bag or package observed ..... No, original salt bag or package not observed	2 ⇨Q. 29
25. Write the name of the brand of salt written on the package	Brand name _____	
26. Observe the country where the salt is produced	Papua New Guinea..... Australia..... India..... China…..... Thailand…. ..... Other (specify) ..... Don't know.....	
27. Observe the country where the salt is packaged	Papua New Guinea..... Australia..... India..... China…..... Thailand…. ..... Other (specify) ..... Don't know.....	
28. Observe – Is the salt iodized?	Yes..... No or not stated on label..... Don't know.....	
29. MAY I ASK WHERE YOU GOT THE SALT FROM? **INAP MI ASKIM YU WE YU BIN KISIM DISPELA SOL?**	Purchased from a shop..... Purchased from a vendor ..... Mined/collected from the rock..... Other (specify) ..... Don't know.....	
30. MAY I TAKE A SAMPLE OF THIS SALT TO THE LABORATORY TO TEST FOR IODINE CONTENT?	Salt sample collected..... Salt sample not collected.....	

Salt Type 1 Label

INAP MI KISIM SEMPOL LONG DISPELA SOL I GO LONG LEBORETORI LONG TESTIM SAPOS EM MI GAT AIDIN LONG EN? *(Collect the required amount of salt and replace the salt you have taken with 1 packet of iodized salt)*		
TYPE 2 SALT ***If there is a second type of salt used in the household record the information here***		
31. DO YOU HAVE ANY OTHER TYPE OF SALT CURRENTLY IN YOUR HOUSEHOLD NOW? **YU GAT OL SAMPEAL NARAPELA SOL LONG HAUS BILONG YU NAU?**	Yes..... No ..... Don't know	2 ⇨ Q.40
32. *If Yes ask* "MAY I SEE THIS SALT" **"INAP MI LUKIM DISPELA SOL?"** *(Observe the type of salt used and circle the appropriate answer)*	Fine table salt ..... Cooking salt ..... Traditional salt ..... Sea water used for cooking ..... Refused ..... Other (specify) ..... Don't know	
33. *If you DO NOT see the original salt bag or package ask* "COULD I PLEASE SEE THE ORIGINAL SALT BAG OR PACKAGE?" **"PLIS INAP MI LUKIM SOL BEK O PEKET SOL I BIN STAP LONG EN?"**	Yes, original salt bag or package observed.. No, original salt bag or package not observed	2 ⇨ Q.38
34. Write the name of the brand of salt written on the package	Brand…… ……	
35. Observe the COUNTRY where the salt is produced	Papua New Guinea..... Australia..... India ..... China….. Thailand…. ..... Other (specify) ..... Don't know.....	

36. <u>Observe</u> the country where the salt is packaged	Papua New Guinea..... Australia..... India..... China…..... Thailand…. ..... Other (specify) ..... Don't know.....
37. <u>Observe</u> – Is the salt iodized?	Yes..... No or not stated on label..... Don't know.....
38. MAY I ASK WHERE YOU GOT THE SALT FROM? **INAP MI ASKIM YU WE YU BIN KISIM DISPELA SOL?**	Purchased from a shop..... Purchased from a vendor ..... Mined/collected from the rock..... Other (specify) ..... Don't know.....
39. MAY I TAKE A SAMPLE OF THIS SALT TO THE LABORATORY TO TEST FOR IODINE CONTENT? **INAP MI KISIM SEMPOL LONG DISPELA SOL I GO LONG LEBORETORI LONG TESTIM SAPOS EM MI GAT AIDIN LONG EN?** *(Collect the required amount of salt and replace the salt you have taken with 1 packet of iodized salt)*	Salt sample collected..... Salt sample not collected..... Salt Type 2 Label

FLOUR MODULE

If two or more types of flour are available in the household record information on the flour most frequently consumed in the household.

40. DID YOU HAVE FLOUR IN THE HOUSEHOLD TODAY? **YU GAT WIT FLAUA LONG HAUS TEDE?**	Yes …… …….. No …… …… ..... Don't know.....	2 ⇨ Q.49
41. WHERE DID YOU GET THIS FLOUR? **YU BIN KISIM FLAUA WE?**	Shop ..... Other (specify)..... Don't know.....	8 ⇨ Q.49
42. PLEASE SHOW US SAMPLES OF THE FLOUR YOU BOUGHT IN THE SHOP?	Whole meal flour ..... White flour (Plain).....	

PLIS SOIM MIPELA SEMPOL BILONG OLGETA WIT FLAUA YU BAIM LONG STOA *(Observe and circle the type of flour used)*	White (Self Raising)..... Don't know.....	
43. *If you DO NOT see the original bag or package the flour came in* *ASK* "COULD I PLEASE SEE THE ORIGINAL BAG OR PACKAGE THE FLOUR CAME IN?" **"PLIS INAP MI LUKIM PEKET FLAUA I BIN STAP INSAIT LONG EM NA YU BAIM?"**	Yes, bag observed ..... No, bag not observed……..... No label ..... Mothers Choice ..... 3 Roses. ..... Flame.. ..... Other (specify) _____ ..... Don't know.....	2 ⇨ Q.48
44. *Observe the brand written on the flour package and circle appropriate answer*		
45. *Observe the country where the flour is produced*	Papua New Guinea ..... Australia ..... India..... Other (specify) _____ ..... Don't know.....	
46. *Observe the country where the flour is packaged*	Papua New Guinea ..... Australia ..... India..... Other (specify) _____ ..... Don't know.....	
47. *Observe- Is the flour fortified with vitamins or minerals?*	Not fortified or not stated on label ..... Fortified with iron ..... Fortified with folic acid ..... Fortified with iron and folic acid ..... Fortified with other vitamins/minerals (specify)..... Enriched with vitamins and minerals ..... Don't know.....	
48. DO YOU OR OTHERS FROM THIS HOUSEHOLD BUY BREAD THAT IS ALREADY MADE (NOT FROM YOUR OWN DOUGH)? **YU O OL NARAPELA LONG DISPELA HAUS I SAVE BAIM BRET WE OL I**	Yes ..... No ..... Don't know	

BEKIM PINIS (I NO DISPELA YU YET I MEKIM)		
OIL MODULE *If two or more types of oil are available in the household record information on the cooking oil most frequently consumed in the household.*		
49. DO YOU HAVE ANY OIL IN THE HOUSEHOLD NOW? **YU GAT OIL LONG HAUS NAU?**	Yes ..... No …….... .. Don't know.....	2 ⇨ Q.57
50. WHERE DID YOU GET THIS OIL? **YU BIN KISIM WE?**	Shop ..... Other (please specify) ..... Don't know.....	8 ⇨ Q.57
51. PLEASE SHOW US SAMPLE OF THE OIL YOU BOUGHT FROM THE SHOP? **PLIS, SOIM MIPELA SEMPOL LONG OLGETA OIL YU BAIM LONG STOA.** *(Observe and circle the type of oil used)*	Observation not possible……..…… ..... Vegetable oil…..……..... ..... Sunflower oil…… ..... Cooking oil..... Coconut oil ..... Palm oil..... Peanut oil ..... Canola oil ..... Olive oil..... Soy bean…..…….. ..... Other (specify) _____ ..... Don't know..... 9	
52. If you DO NOT see the original container the oil came in or package ask "COULD I PLEASE SEE THE ORIGINAL CONTAINER OR PACKAGE THE OIL CAME IN?" **"PLIS INAP MI LUKIM ORIJINEL KONTENA O PEKET OIL I KAM LONG EN?"**	Yes, original container observed ..... No, original container not observed	2 ⇨ Q.57
53. Write the name of the brand of oil written on the package	No label or no brand..... Brand _____ ___	9 ⇨ Q.57
54. Observe the country where the oil is produced	Papua New Guinea ..... Australia ..... Other (specify) _____ ..... Don't know.....	

55. *Observe the* country *where the oil is packaged*	Papua New Guinea ..... Australia ..... Other (specify) _____ ..... Don't know……..	
56. Observe – Is the oil fortified with with vitamin A?	Yes ..... No or not stated on label ..... Don't know.....	
SUGAR MODULE *If two or more types of sugar are available in the household record information on the sugar most frequently consumed in the household.*		
57. DO YOU HAVE SUGAR IN THE HOUSEHOLD NOW? **YU GAT SUGA LONG HAUS NAU?**	Yes…… No……	2⇨Q.65
	Don't know.....	
58. WHERE DID YOU GET THIS SUGAR? **YU BIN KISIM DISPELA SUGA WE?**	Shop ..... Other (please specify)	8⇨Q.65
	Don't know.....	
59. PLEASE SHOW US SAMPLE OF THE SUGAR YOU BOUGHT IN THE SHOP? **PLIS, SOIM SEMPOL LONG OLGETA SUGA YU BIN BAIM LONG STOA.** (*Observe and circle type of sugar used)*	Observation not possible…… ..... White sugar….. Brown sugar……..... Dont know	
60. If you DO NOT see the original bag or package the sugar came in *ASK* "COULD I PLEASE SEE THE ORIGINAL BAG OR PACKAGE THE SUGAR CAME IN?" **"PLIS INAP INAP MI LUKIM ORIJINEL BEK O PEKET SUGA I KAM LONG EN?"**	Yes, bag observed ..... No, bag not observed	2⇨Q.65
61. Observe the brand written on the sugar package and circle appropriate answer	No label ..... 4 Roses ..... Ramu..... CSR..... Other (specify) _____ ..... Don't know.....	
62. Observe the country where the sugar is produced	Papua New Guinea .... Australia…… …….. ..... Other (specify) _____ ..... Don't know…… …	

63. *Observe the country where the sugar is packaged*	Papua New Guinea .... Australia…… ……. ..... Other (specify) _____..... ..... Don't know…… ….....	
64. *Observe- Is the sugar fortified with vitamins or minerals?*	Not fortified or not stated on label ..... Fortified with vitamin A ..... Fortified with other vitamins/minerals (specify)..... Don't know.....	
RICE MODULE *IF TWO OR MORE TYPES OF RICE ARE AVAILABLE IN THE HOUSEHOLD RECORD INFORMATION ON THE RICE MOST FREQUENTLY CONSUMED IN THE HOUSEHOLD.*		
65. DO YOU HAVE RICE IN THE HOUSEHOLD NOW? **YU GAT RAIS NAU LONG HAUS BILONG YU?**	Yes …… ..... No …… ..... Don't know..... ..	2 ⇨ END
66. WHERE DID YOU GET THIS RICE? **YU BIN KISIM DISPELA RAIS WE?**	Shop ..... Self grown ..... Other (specify)..... Don't know.....	3 ⇨ END 8 ⇨ END
67. PLEASE SHOW US A SAMPLE OF THE RICE YOU BOUGHT IN THE SHOP? **PLIS, SOIM MIPELA OL SEMPOL LONG OL RAIS YU BAIM LONG STOA.** (*Observe and circle type of rice used))*	Observation not possible…… ..... White rice…..…… ..... Brown rice……... Don't know.....	
68. *If you DO NOT see the original bag or package the rice came in* ASK "COULD I PLEASE SEE THE ORIGINAL S BAG OR PACKAGE THE RICE CAME IN?" **"INAP MI LUKIM ORIJINEL BEK O PEKET RAIS I KAM LONG EN"?**	Yes, bag observed ..... No, bag not observed.....	2 ⇨ END
69. *Write the brand written on the rice package*	No label or no brand..... Brand _____ ___	9 ⇨ END
70. *Observe the country where the rice is produced*	Papua New Guinea .... Australia…… ……..... India..... China ..... Thailand..... ……	

	Other (specify) _____..... ..... Don't know…….....
71. Observe the country where the rice is packaged	Papua New Guinea .... Australia…… …….. India..... China ..... Thailand..... …… Other (specify) _____..... ..... Don't know…….....
72. Observe- Is the rice fortified with vitamins or minerals?	Not fortified or not stated on the label ..... Fortified with iron ..... Fortified with riboflavin..... Fortified with niacin..... Fortified with iron, riboflavin and niacin ..... Fortified with various vitamins and minerals ..... Enriched with vitamins and minerals ..... Don't know.....

CHILD ONLY HH – Proceed to child (primary care taker data collection form) if there are eligible children (6 months to 5 years of age). If there are no eligible children in the household thank the respondent for his or her time and move on to the next house.

CHILD, MEN AND WOMEN HH – Proceed to the women, children and men data collection forms where applicable. If there are no eligible women, children or men in the household then thank the respondent and move on to the next house.

Data Entry Information Panel

(To be completed by the data entry clerks)

First Data entry clerk ID number		Second Data entry clerk ID number	

Cluster Number ☐☐☐ Household Number ☐☐ Woman's Line Number ☐

WOMEN (15-49 YEARS)

Label

TEAM CODE ☐

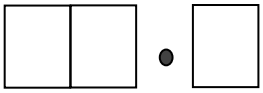
VERBAL CONSENT OBTAINED FROM ELIGIBLE WOMAN Yes ☐ No ☐

1.	*Woman's name:*	
2.	*Woman's age*	☐☐
3.	WHAT IS YOUR HIGHEST GRADE OF EDUCATION COMPLETED? **YU PINISIM WANEM GRET LONG SKUL?** *(0= No school completed 1-3=Elementary School 4-8= Primary School 9-12=Secondary school)*	Highest grade completed ☐☐ Refused ..... Other (specify) ..... Don't know .....
4.	DID YOU SLEEP UNDER A MOSQUITO NET LAST NIGHT? **YU BIN SLIP ANINIT LONG MOSKITO NET O TAUNAM LONG LAS NAIT?**	Yes ..... No ..... Refused ..... Don't know .....
5.	HOW MANY MOSQUITO NETS DOES YOUR HOUSEHOLD HAVE? **HAUS BILONG YU I GAT HAMAS TAUNAM?**	Number of nets ☐☐
6.	DO YOU SMOKE? **YU SAVE SMOK TU?**	Yes ..... No ..... 2⇨Q.8 Refused ..... Don't know ..... 9⇨Q.8
7.	HOW MANY STICKS DO YOU SMOKE PER DAY? **HAMASPELA STIK SIMUK YU SAVE SMOKIM INSAIT LONG WANPELA DE?**	Number per day ☐☐
8.	HAVE YOU EVER BEEN PREGNANT? **YU BIN GAT BEL TU?** *(Should be asked by female or with female present.)*	Yes ..... No ..... 2⇨Q.17 Refused .....

	Don't know	9⇨Q.17
9. HAVE YOU GIVEN BIRTH TO A CHILD IN THE LAST 3 YEARS? **INSAIT LONG LASPELA TRIPELA YIA, YU BIN KARIM WANPELA PIKININI TU?** (*This includes both live births and still births BUT NOT miscarriages*) *(Ask for meri book if available)*	Yes ..... No ..... Refused ..... Don't know	 2⇨Q.17 9⇨Q.17
10. WHEN YOU WERE PREGNANT WITH YOUR LAST CHILD, DID YOU RECEIVE IRON TABLETS? **TAIM YU BIN BEL LONG LASPELA PIKININI BILONG YU, YU SAVE KISIM AIN TABLET?** *(Show an example of the iron tablet)*	Yes ..... No ..... Refused ..... Don't know	 2⇨Q.12 9⇨Q.12
11. WHO DID YOU RECEIVE THE IRON TABLETS FROM? **YU BIN KISIM OL AIN TABLET LONG HUSAT?**	Health centre ..... Health workers on patrol ..... VBA ..... VHV ..... Refused ..... Other (specify) ..... Don't know	
12. WAS YOUR LAST BORN CHILD WEIGHED AT BIRTH? **OL BIN SKELIM LASPELA PIKININI BILONG YU TAIM YU KARIM?**	Yes ..... No ..... Refused ..... Don't know	 2⇨Q.15 9⇨Q.15
13. WHAT WAS THIS CHILD'S WEIGHT ***WANEM MAK LONG WEIT O HEVI BILONG EM?*** *(Record weight from baby book/health card, if available.)*		
14. Write down where information on the birth weight was obtained from.	From recall ..... From clinic book ..... Other (specify).....	
15. WHEN YOU WERE PREGNANT WITH YOUR LAST CHILD, DID YOU HAVE DIFFICULTY SEEING DURING THE DAY? **TAIM YU BIN BEL WANTAIM LASPELA PIKININI BILONG YU, YU BIN GAT HEVI LONG LUKLUK LONG SAN?**	Yes ..... No ..... Refused ..... Don't know	
16. WHEN YOU WERE PREGNANT WITH YOUR LAST CHILD DID YOU HAVE ANY DIFFICULTY SEEING AT DUSK? **TAIM YU BIN BEL WANTAIM LASPELA PIKININI BILONG YU, YU BIN GAT HEVI LONG**	Yes ..... No ..... Refused ..... Don't know	

LUKLUK TAIM EM I LAIK TUDAK?		
17. ARE YOU CURRENTLY PREGNANT? **YU GAGT BEL NAU?** *(If YES end the interview. DO NOT take anthropometric measurements or urine or blood samples)*	Yes ..... No ..... Refused ..... Don't know	1⇨END
Weigh and measure each woman after all questionnaires have been completed. **DO NOT** measure any woman with casts, heavy bandages or disabilities that prevent them being measured. **DO NOT** measure women who are pregnant.		

ANTHROPOMETRY MODULE	
18. Woman's weight	
19. Woman's height	
20. *Circle result for height measurement*	Measured ..... Refused ..... Other (specify) ..... Unable .....
CHECK Are there any other women in the household who are eligible for measurement? *If not, pass the data collection form on to the laboratory technician.*	

SPECIMEN COLLECTION MODULE **Do NOT take urine or blood samples from pregnant women**	
21. Was urine sample collected from this woman?	Yes ..... No ..... Refused ..... Other (specify).....
22. *Ask* "WE WOULD LIKE TO TAKE SOME OF YOUR BLOOD FROM YOUR FINGER, FOR TESTING. IS THIS OK? **"MIPELA I LAIK KISIM SAMPELA BLUT LONG PINGA BILONG YU LONG KARIMAUT TES. EM I ORAIT WANTAIM YU?**	Yes ..... No ..... Refused ..... Other (specify) .....
23. Write down the hemoglobin level *(If the Hb is 7 or less then write the result in the space provided and also on a*	

referral sheet and on a referral slip for the health center)	
24. *Was finger stick blood sample collected from this woman?*	Yes ..... Not available ..... Refused ..... Other (specify).....
25. Approximately how many microlitres of finger stick blood were collected from this woman.	☐☐☐
FOR NCD CLUSTERS ONLY	
26. Was a venous blood sample collected from this woman?	Yes ..... Not available ..... Refused ..... Other (specify) .....
27. Approximately how many milliliters of venous blood were collected from this woman	☐☐

THANK *the participant for their cooperation*
CHECK *that all the data collection form has been completed correctly*
CHECK *that the identification numbers are at the top of each page.*

Data Entry Information Panel

(To be completed by the data entry clerks)

First data entry clerk ID number		Second data entry clerk ID number	

APPENDIX II
BACKWARDS ELIMINATION & MODELING SAS CODE AND SAS OUTPUT

Association Between CRP and TfR

```
*****************************************;
*Program: H:\Thesis\CRP TfR Modeling     *;
*Date: 04\22\2013                        *;
*Programmer: Kawanda Foster              *;
*                                        *;
*Purpose: This program was used to       *;
*assess the relationship between CRP and *;
*TfR to determine a proper model         *;
*****************************************;


*Performing Chunk Test;
***********************************;

*REDUCED MODEL;
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= CRPCAT AGECAT REGION2 EDUCATE UR BMICAT
EVERPREG/TECHNIQUE=NEWTON;
RUN;

*FULL MODEL;
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= CRPCAT AGECAT REGION2 EDUCATE UR BMICAT
EVERPREG CRPCAT*AGECAT CRPCAT*REGION2 CRPCAT*EDUCATE CRPCAT*UR
CRPCAT*BMICAT CRPCAT*EVERPREG/TECHNIQUE=NEWTON;
RUN;

/*INTERACTION!*/


*PERFORMING BWE;
***********************************;
*FULL MODEL;
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
```

```
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= CRPCAT AGECAT REGION2 EDUCATE UR BMICAT
EVERPREG CRPCAT*AGECAT CRPCAT*REGION2 CRPCAT*EDUCATE CRPCAT*UR
CRPCAT*BMICAT CRPCAT*EVERPREG/TECHNIQUE=NEWTON;
RUN;


*DROPPING EDUCATE INTERACTION;
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= CRPCAT AGECAT REGION2 EDUCATE UR BMICAT
EVERPREG CRPCAT*AGECAT CRPCAT*REGION2 CRPCAT*UR
CRPCAT*BMICAT CRPCAT*EVERPREG/TECHNIQUE=NEWTON;
RUN;

*DROPPING AGE INTERACTION;
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= CRPCAT AGECAT REGION2 EDUCATE UR BMICAT
EVERPREG CRPCAT*EVERPREG CRPCAT*REGION2 CRPCAT*UR
CRPCAT*BMICAT/TECHNIQUE=NEWTON;
RUN;

*DROPPING EVERPREG INTERACTION;
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= CRPCAT AGECAT REGION2 EDUCATE UR BMICAT
EVERPREG CRPCAT*REGION2 CRPCAT*UR
CRPCAT*BMICAT/TECHNIQUE=NEWTON;
RUN;

*DROPIING REGION INTERACTION;
```

```
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= CRPCAT AGECAT REGION2 EDUCATE UR BMICAT
EVERPREG CRPCAT*UR CRPCAT*BMICAT/TECHNIQUE=NEWTON;
RUN;

*DROPIING BMI INTERACTION;
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= CRPCAT AGECAT REGION2 EDUCATE UR BMICAT
EVERPREG CRPCAT*UR/TECHNIQUE=NEWTON;
RUN; *KEEP UR INTERACTION TERM;

*THUS, AFTER ASSESING FOR INTERACTION, THERE IS ONLY ONE SIGNIFICANT
INTERACTION BETWEEN CRP AND UR.
THE GOLD STANDARD MODEL IS MODEL TFRCAT (EVENT='1')= CRPCAT AGECAT
REGION2 EDUCATE UR BMICAT EVERPREG CRPCAT*UR;


*Assessing Confounding;
*****************************************************;

/*Gold Standard*/
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= CRPCAT AGECAT REGION2 EDUCATE UR BMICAT
EVERPREG CRPCAT*UR/TECHNIQUE=NEWTON;
CONTRAST 'POR FOR ID COMPARING INF TO NOINF' CRPCAT 1/ESTIMATE=BOTH;
RUN;

/*Model 1*/
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
```

```
MODEL TFRCAT (EVENT='1')= CRPCAT AGECAT REGION2 UR
EVERPREG CRPCAT*UR/TECHNIQUE=NEWTON;
CONTRAST 'POR FOR ID COMPARING INF TO NOINF' CRPCAT 1/ESTIMATE=BOTH;
RUN;

/*Model 2*/
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= CRPCAT REGION2 UR BMICAT
EVERPREG CRPCAT*UR/TECHNIQUE=NEWTON;
CONTRAST 'POR FOR ID COMPARING INF TO NOINF' CRPCAT 1/ESTIMATE=BOTH;
RUN;

/*Model 3*/
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= CRPCAT REGION2 UR EDUCATE
EVERPREG CRPCAT*UR/TECHNIQUE=NEWTON;
CONTRAST 'POR FOR ID COMPARING INF TO NOINF' CRPCAT 1/ESTIMATE=BOTH;
RUN;

/*Model 4*/
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= CRPCAT AGECAT REGION2 UR BMICAT
EVERPREG CRPCAT*UR/TECHNIQUE=NEWTON;
CONTRAST 'POR FOR ID COMPARING INF TO NOINF' CRPCAT 1/ESTIMATE=BOTH;
RUN;

/*Model 5*/
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= CRPCAT AGECAT REGION2 UR EDUCATE
EVERPREG CRPCAT*UR/TECHNIQUE=NEWTON;
CONTRAST 'POR FOR ID COMPARING INF TO NOINF' CRPCAT 1/ESTIMATE=BOTH;
RUN;
```

```
/*Model 6*/
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= CRPCAT BMICAT REGION2 UR EDUCATE
EVERPREG CRPCAT*UR/TECHNIQUE=NEWTON;
CONTRAST 'POR FOR ID COMPARING INF TO NOINF' CRPCAT 1/ESTIMATE=BOTH;
RUN;

/*MODEL 7*/
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= CRPCAT REGION2 UR
EVERPREG CRPCAT*UR/TECHNIQUE=NEWTON;
CONTRAST 'POR FOR ID COMPARING INF TO NOINF' CRPCAT 1/ESTIMATE=BOTH;
RUN;


/*MODEL 8*/
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
MODEL TFRCAT (EVENT='1')= CRPCAT CRPCAT*UR/TECHNIQUE=NEWTON;
CONTRAST 'POR FOR ID COMPARING INF TO NOINF' CRPCAT 1/ESTIMATE=BOTH;
RUN;



*Final Model;

PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
WHERE UR=1;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= CRPCAT AGECAT REGION2 EDUCATE UR BMICAT
EVERPREG CRPCAT*UR/TECHNIQUE=NEWTON;
CONTRAST 'POR FOR UR 1' CRPCAT 1/ESTIMATE=BOTH;
RUN;

PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
```

```
STRATA REGIONS;
WHERE UR=0;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= CRPCAT AGECAT REGION2 EDUCATE UR BMICAT
EVERPREG CRPCAT*UR/TECHNIQUE=NEWTON;
CONTRAST 'POR FOR UR 0' CRPCAT 1/ESTIMATE=BOTH;
RUN;
```

CRP/TfR Full Model Output

The SURVEYLOGISTIC Procedure

Model Information

Data Set	WORK.PNGMOD	
Response Variable	TFRCAT	
Number of Response Levels	2	
Stratum Variable	REGIONS	
Number of Strata	4	
Cluster Variable	cluster_	CLUSTER_NO
Number of Clusters	94	
Weight Variable	smplwts	smplwts
Model	Binary Logit	
Optimization Technique	Newton-Raphson	
Variance Adjustment	Degrees of Freedom (DF)	

Variance Estimation

Method	Taylor Series
Variance Adjustment	Degrees of Freedom (DF)

Number of Observations Read	746
Number of Observations Used	709
Sum of Weights Read	1133211
Sum of Weights Used	1085711

Response Profile

Ordered Value	TFRCAT	Total Frequency	Total Weight
1	0	542	877558.72
2	1	167	208152.30

Probability modeled is TFRCAT=1.

Class Level Information

Class	Value	Design Variables		
AGECAT	**1**	0	0	0
	2	1	0	0
	3	0	1	0
	4	0	0	1
EDUCATE	**1**	0	0	0
	2	1	0	0
	3	0	1	0
	4	0	0	1
BMICAT	**1**	0	0	
	2	1	0	
	3	0	1	

region2	**1.00**	1	0	0
	2.00	0	1	0
	3.00	0	0	1
	4.00	0	0	0

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	1061191.4	875458.58
SC	1061196.0	875586.37
-2 Log L	1061189.4	875402.58

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	185786.814	27	<.0001
Score	165037.103	27	<.0001
Wald	120.0872	27	<.0001

Type 3 Analysis of Effects

Effect	DF	Wald Chi-Square	Pr > ChiSq

CRPCAT	1	0.4745	0.4909
AGECAT	3	1.4044	0.7045
region2	3	26.5797	<.0001
EDUCATE	3	0.2374	0.9713
UR	1	2.8183	0.0932
BMICAT	2	0.5459	0.7611
EVERPREG	1	3.1772	0.0747
CRPCAT*AGECAT	3	1.7133	0.6340
CRPCAT*region2	3	5.1184	0.1633
CRPCAT*EDUCATE	3	0.7795	0.8544
CRPCAT*UR	1	9.2592	0.0023
CRPCAT*BMICAT	2	3.3739	0.1851
CRPCAT*EVERPREG	1	0.1526	0.6960

Analysis of Maximum Likelihood Estimates

Parameter		**DF**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
Intercept		1	-0.3288	0.5797	0.3217	0.5706
CRPCAT		1	-1.2834	1.8632	0.4745	0.4909
AGECAT	**2**	1	-0.3683	0.3678	1.0026	0.3167
AGECAT	**3**	1	-0.3865	0.4532	0.7274	0.3937
AGECAT	**4**	1	-0.5218	0.4666	1.2502	0.2635
region2	**1.00**	1	0.1087	0.3606	0.0909	0.7630
region2	**2.00**	1	-2.3653	0.5323	19.7423	<.0001
region2	**3.00**	1	0.0327	0.3447	0.0090	0.9245

EDUCATE	**2**	1	0.0938	0.3808	0.0607	0.8053
EDUCATE	**3**	1	0.1571	0.3278	0.2296	0.6318
EDUCATE	**4**	1	0.1620	0.4165	0.1512	0.6974
UR		1	-0.5314	0.3165	2.8183	0.0932
BMICAT	**2**	1	0.1311	0.3767	0.1212	0.7278
BMICAT	**3**	1	-0.0443	0.4349	0.0104	0.9189
EVERPREG		1	-0.5542	0.3109	3.1772	0.0747
CRPCAT*AGECAT	**2**	1	-1.0203	1.1765	0.7521	0.3858
CRPCAT*AGECAT	**3**	1	-0.0468	1.5329	0.0009	0.9756
CRPCAT*AGECAT	**4**	1	-0.5226	1.4312	0.1334	0.7150
CRPCAT*region2	**1.00**	1	1.7746	1.0717	2.7421	0.0977
CRPCAT*region2	**2.00**	1	0.5876	1.1282	0.2713	0.6025
CRPCAT*region2	**3.00**	1	-0.3847	1.1683	0.1084	0.7420
CRPCAT*EDUCATE	**2**	1	0.9616	1.3942	0.4757	0.4904
CRPCAT*EDUCATE	**3**	1	0.0748	1.1950	0.0039	0.9501
CRPCAT*EDUCATE	**4**	1	0.4302	1.3837	0.0967	0.7559
CRPCAT*UR		1	-3.5965	1.1819	9.2592	0.0023
CRPCAT*BMICAT	**2**	1	2.2061	1.4160	2.4274	0.1192
CRPCAT*BMICAT	**3**	1	1.2067	1.6951	0.5068	0.4765
CRPCAT*EVER		1	0.3065	0.7845	0.1526	0.6960

PREG

Association of Predicted Probabilities and Observed Responses

Percent Concordant	72.2	**Somers' D**	0.455
Percent Discordant	26.7	**Gamma**	0.460
Percent Tied	1.1	**Tau-a**	0.164
Pairs	90514	**c**	0.728

CRP/TfR Gold Standard/Final Model Output

The SURVEYLOGISTIC Procedure

Model Information

Data Set	WORK.PNGMOD	
Response Variable	TFRCAT	
Number of Response Levels	2	
Stratum Variable	REGIONS	
Number of Strata	4	
Cluster Variable	cluster_	CLUSTER_ NO
Number of Clusters	94	
Weight Variable	smplwts	smplwts
Model	Binary Logit	
Optimization Technique	Newton-Raphson	
Variance Adjustment	Degrees of Freedom (DF)	

Variance Estimation

Method	Taylor Series
Variance Adjustment	Degrees of Freedom (DF)

Number of Observations Read	746
Number of Observations Used	709
Sum of Weights Read	1133211
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Response Profile

Ordered Value	TFRCAT	Total Frequency	Total Weight
1	0	542	877558.72
2	1	167	208152.30

Probability modeled is TFRCAT=1.

Class Level Information

Class	Value	Design Variables		
AGECAT	**1**	0	0	0
	2	1	0	0
	3	0	1	0
	4	0	0	1
EDUCATE	**1**	0	0	0
	2	1	0	0
	3	0	1	0
	4	0	0	1

BMICAT	**1**	0	0	
	2	1	0	
	3	0	1	
region2	**1.00**	1	0	0
	2.00	0	1	0
	3.00	0	0	1
	4.00	0	0	0

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	1061191.4	886593.90
SC	1061196.0	886666.92
-2 Log L	1061189.4	886561.90

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	174627.491	15	<.0001
Score	154478.530	15	<.0001
Wald	84.5197	15	<.0001

Type 3 Analysis of Effects

Effect	DF	Wald Chi-Square	Pr > ChiSq
CRPCAT	1	5.9941	0.0144
AGECAT	3	2.3118	0.5103
region2	3	33.7699	<.0001
EDUCATE	3	0.4342	0.9331
UR	1	2.8381	0.0921
BMICAT	2	2.0683	0.3555
EVERPREG	1	3.8583	0.0495
CRPCAT*UR	1	6.4129	0.0113

Analysis of Maximum Likelihood Estimates

Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-0.5802	0.5996	0.9361	0.3333
CRPCAT		1	0.8823	0.3604	5.9941	0.0144
AGECAT	**2**	1	-0.4396	0.3430	1.6423	0.2000
AGECAT	**3**	1	-0.3556	0.4485	0.6287	0.4278
AGECAT	**4**	1	-0.5740	0.4178	1.8874	0.1695
region2	**1.00**	1	0.2151	0.3694	0.3390	0.5604
region2	**2.00**	1	-2.2304	0.4827	21.3464	<.0001
region2	**3.00**	1	0.0346	0.3597	0.0093	0.9234
EDUCATE	**2**	1	0.2062	0.3594	0.3292	0.5661
EDUCATE	**3**	1	0.1703	0.2907	0.3433	0.5579
EDUCATE	**4**	1	0.1549	0.3822	0.1642	0.6853

UR		1	-0.5402	0.3206	2.8381	0.0921
BMICAT	**2**	1	0.4002	0.3959	1.0221	0.3120
BMICAT	**3**	1	0.1061	0.4544	0.0546	0.8153
EVERPREG		1	-0.5825	0.2965	3.8583	0.0495
CRPCAT* UR		1	-2.3076	0.9112	6.4129	0.0113

Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
AGECAT 2 vs 1	0.644	0.329	1.262
AGECAT 3 vs 1	0.701	0.291	1.688
AGECAT 4 vs 1	0.563	0.248	1.277
region2 1.00 vs 4.00	1.240	0.601	2.558
region2 2.00 vs 4.00	0.107	0.042	0.277
region2 3.00 vs 4.00	1.035	0.511	2.095
EDUCATE 2 vs 1	1.229	0.608	2.486
EDUCATE 3 vs 1	1.186	0.671	2.096
EDUCATE 4 vs 1	1.168	0.552	2.470
BMICAT 2 vs 1	1.492	0.687	3.242
BMICAT 3 vs 1	1.112	0.456	2.709
EVERPREG	0.559	0.312	0.999

Association of Predicted Probabilities and Observed Responses

Percent Concordant	71.5	**Somers' D**	0.440
Percent Discordant	27.6	**Gamma**	0.444
Percent Tied	0.9	**Tau-a**	0.159
Pairs	90514	**c**	0.720

Contrast Test Results

Contrast	DF	Wald Chi-Square	Pr > ChiSq
POR FOR ID COMPARING INF TO NOINF	1	5.9941	0.0144

Contrast Estimation and Testing Results by Row

Contrast	Type	Row	Estimate	Standard Error	Alpha	Confidence Limits		Wald Chi-Square	Pr > ChiSq
POR FOR ID COMPARING INF TO NOINF	**PARM**	**1**	0.8823	0.3604	0.05	0.1760	1.5886	5.9941	0.0144
POR FOR ID COMPARING INF TO NOINF	**EXP**	**1**	2.4164	0.8708	0.05	1.1924	4.8968	5.9941	0.0144

Association Between AGP and TfR

```
*****************************************;
*Program: H:\Thesis\AGP TfR Modeling     *;
*Date: 04\22\2013                        *;
*Programmer: Kawanda Foster              *;
*                                        *;
*Purpose: This program was used to       *;
*assess the relationship between AGP and *;
*TfR to determine a proper model         *;
*****************************************;

*Performing Chunk Test;
***********************************;

*REDUCED MODEL;
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= AGPCAT AGECAT REGION2 EDUCATE UR BMICAT
EVERPREG/TECHNIQUE=NEWTON;
RUN;

*FULL MODEL;
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= AGPCAT AGECAT REGION2 EDUCATE UR BMICAT
EVERPREG AGPCAT*AGECAT AGPCAT*REGION2 AGPCAT*EDUCATE AGPCAT*UR
AGPCAT*BMICAT AGPCAT*EVERPREG/TECHNIQUE=NEWTON;
RUN;


*PERFORMING BWE;
***********************************;
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= AGPCAT AGECAT REGION2 EDUCATE UR BMICAT
EVERPREG AGPCAT*AGECAT AGPCAT*REGION2 AGPCAT*EDUCATE AGPCAT*UR
```

```
AGPCAT*BMICAT AGPCAT*EVERPREG/TECHNIQUE=NEWTON;
RUN;

*DROPPING EVERPREG INTERACTION;
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= AGPCAT AGECAT REGION2 EDUCATE UR BMICAT
EVERPREG AGPCAT*AGECAT AGPCAT*REGION2 AGPCAT*EDUCATE AGPCAT*UR
AGPCAT*BMICAT/TECHNIQUE=NEWTON;
RUN;

*DROPPING REGION INTERACTION;
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= AGPCAT AGECAT REGION2 EDUCATE UR BMICAT
EVERPREG AGPCAT*AGECAT AGPCAT*EDUCATE AGPCAT*UR
AGPCAT*BMICAT/TECHNIQUE=NEWTON;
RUN;

*DROPPING BMI INTERACTION;
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= AGPCAT AGECAT REGION2 EDUCATE UR BMICAT
EVERPREG AGPCAT*AGECAT AGPCAT*EDUCATE AGPCAT*UR/TECHNIQUE=NEWTON;
RUN;

*DROPPING EDU INTERACTION;
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= AGPCAT AGECAT REGION2 EDUCATE UR BMICAT
EVERPREG AGPCAT*AGECAT AGPCAT*UR/TECHNIQUE=NEWTON;
```

```
RUN;

*DROPPING EDUCATE INTERACTION;
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= AGPCAT AGECAT REGION2 EDUCATE UR BMICAT
EVERPREG AGPCAT*UR/TECHNIQUE=NEWTON;
RUN; *UR INTERACTION NOT SIG SO ITS DROPPED;

*ASSESING CONFOUNDING;
*****************************;

/*Gold Standard*/
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= AGPCAT AGECAT REGION2 EDUCATE UR BMICAT
EVERPREG AGPCAT*UR/TECHNIQUE=NEWTON;
CONTRAST 'POR FOR ID COMPARING INF TO NOINF' AGPCAT 1/ESTIMATE=BOTH;
RUN;

/*MODEL 1*/
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= AGPCAT AGECAT REGION2 UR
AGPCAT*UR/TECHNIQUE=NEWTON;
CONTRAST 'POR FOR ID COMPARING INF TO NOINF' AGPCAT 1/ESTIMATE=BOTH;
RUN;

/*MODEL 2*/
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= AGPCAT EDUCATE REGION2 UR
AGPCAT*UR/TECHNIQUE=NEWTON;
CONTRAST 'POR FOR ID COMPARING INF TO NOINF' AGPCAT 1/ESTIMATE=BOTH;
RUN;
```

```
/*MODEL 3*/
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= AGPCAT BMICAT REGION2 UR
AGPCAT*UR/TECHNIQUE=NEWTON;
CONTRAST 'POR FOR ID COMPARING INF TO NOINF' AGPCAT 1/ESTIMATE=BOTH;
RUN;

/*MODEL 4*/
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= AGPCAT EVERPREG REGION2 UR
AGPCAT*UR/TECHNIQUE=NEWTON;
CONTRAST 'POR FOR ID COMPARING INF TO NOINF' AGPCAT 1/ESTIMATE=BOTH;
RUN;

/*MODEL 5*/
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= AGPCAT AGECAT EDUCATE REGION2 UR
AGPCAT*UR/TECHNIQUE=NEWTON;
CONTRAST 'POR FOR ID COMPARING INF TO NOINF' AGPCAT 1/ESTIMATE=BOTH;
RUN;

/*MODEL 6*/
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= AGPCAT AGECAT BMICAT REGION2 UR
AGPCAT*UR/TECHNIQUE=NEWTON;
CONTRAST 'POR FOR ID COMPARING INF TO NOINF' AGPCAT 1/ESTIMATE=BOTH;
RUN;

/*MODEL 7*/
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
```

```
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= AGPCAT AGECAT EVERPREG REGION2 UR
AGPCAT*UR/TECHNIQUE=NEWTON;
CONTRAST 'POR FOR ID COMPARING INF TO NOINF' AGPCAT 1/ESTIMATE=BOTH;
RUN;

/*MODEL 8*/
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= AGPCAT BMICAT EDUCATE REGION2 UR
AGPCAT*UR/TECHNIQUE=NEWTON;
CONTRAST 'POR FOR ID COMPARING INF TO NOINF' AGPCAT 1/ESTIMATE=BOTH;
RUN;


/*MODEL 9*/
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= AGPCAT EVERPREG EDUCATE REGION2 UR
AGPCAT*UR/TECHNIQUE=NEWTON;
CONTRAST 'POR FOR ID COMPARING INF TO NOINF' AGPCAT 1/ESTIMATE=BOTH;
RUN;

/*MODEL 10*/
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= AGPCAT EVERPREG BMICAT REGION2 UR
AGPCAT*UR/TECHNIQUE=NEWTON;
CONTRAST 'POR FOR ID COMPARING INF TO NOINF' AGPCAT 1/ESTIMATE=BOTH;
RUN;

/*MODEL 11*/
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS BMICAT (REF='1')/PARAM=REF;
```

```
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= AGPCAT AGECAT BMICAT EDUCATE REGION2 UR
AGPCAT*UR/TECHNIQUE=NEWTON;
CONTRAST 'POR FOR ID COMPARING INF TO NOINF' AGPCAT 1/ESTIMATE=BOTH;
RUN;


/*MODEL 12*/
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= AGPCAT AGECAT EVERPREG EDUCATE REGION2 UR
AGPCAT*UR/TECHNIQUE=NEWTON;
CONTRAST 'POR FOR ID COMPARING INF TO NOINF' AGPCAT 1/ESTIMATE=BOTH;
RUN;

/*MODEL 13*/
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= AGPCAT BMICAT EDUCATE EVERPREG REGION2 UR
AGPCAT*UR/TECHNIQUE=NEWTON;
CONTRAST 'POR FOR ID COMPARING INF TO NOINF' AGPCAT 1/ESTIMATE=BOTH;
RUN;

/*MODEL 14*/
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= AGPCAT BMICAT AGECAT EVERPREG REGION2 UR
AGPCAT*UR/TECHNIQUE=NEWTON;
CONTRAST 'POR FOR ID COMPARING INF TO NOINF' AGPCAT 1/ESTIMATE=BOTH;
RUN;

/*MODEL 15*/
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= AGPCAT REGION2 UR AGPCAT*UR/TECHNIQUE=NEWTON;
CONTRAST 'POR FOR ID COMPARING INF TO NOINF' AGPCAT 1/ESTIMATE=BOTH;
RUN;
```

```
/*MODEL 16*/
PROC SURVEYLOGISTIC DATA=PNGMOD;
CLUSTER CLUSTER_;
WEIGHT SMPLWTS;
STRATA REGIONS;
CLASS AGECAT (REF='1')/PARAM=REF;
CLASS EDUCATE (REF='1')/PARAM=REF;
CLASS BMICAT (REF='1')/PARAM=REF;
CLASS REGION2 (REF='4.00')/PARAM=REF;
MODEL TFRCAT (EVENT='1')= AGPCAT AGPCAT*UR/TECHNIQUE=NEWTON;
CONTRAST 'POR FOR ID COMPARING INF TO NOINF' AGPCAT 1/ESTIMATE=BOTH;
RUN;
```

AGP/TfR Full Model Output

The SURVEYLOGISTIC Procedure

Model Information

Data Set	WORK.PNGMOD	
Response Variable	TFRCAT	
Number of Response Levels	2	
Stratum Variable	REGIONS	
Number of Strata	4	
Cluster Variable	cluster_	CLUSTER_ NO
Number of Clusters	94	
Weight Variable	smplwts	smplwts
Model	Binary Logit	
Optimization Technique	Newton-Raphson	
Variance Adjustment	Degrees of Freedom (DF)	

Variance Estimation

Method	Taylor Series
Variance Adjustment	Degrees of Freedom (DF)

Number of Observations Read	746
Number of Observations Used	709
Sum of Weights Read	1133211
Sum of Weights Used	1085711

Response Profile

Ordered Value	TFRCAT	Total Frequency	Total Weight
1	0	542	877558.72
2	1	167	208152.30

Probability modeled is TFRCAT=1.

Class Level Information

Class	Value	Design Variables		
AGECAT	**1**	0	0	0
	2	1	0	0
	3	0	1	0
	4	0	0	1
EDUCATE	**1**	0	0	0
	2	1	0	0
	3	0	1	0
	4	0	0	1
BMICAT	**1**	0	0	
	2	1	0	

	3	0	1	
region2	**1.00**	1	0	0
	2.00	0	1	0
	3.00	0	0	1
	4.00	0	0	0

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	1061191.4	866206.78
SC	1061196.0	866334.57
-2 Log L	1061189.4	866150.78

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	195038.611	27	<.0001
Score	184534.096	27	<.0001
Wald	119.5015	27	<.0001

Type 3 Analysis of Effects

Effect	DF	Wald Chi-Square	Pr > ChiSq
AGPCAT	1	1.3935	0.2378
AGECAT	3	0.1411	0.9865
region2	3	25.7370	<.0001
EDUCATE	3	2.1044	0.5510
UR	1	1.8649	0.1721
BMICAT	2	0.7738	0.6792
EVERPREG	1	2.6931	0.1008
AGPCAT*AGECAT	3	3.7308	0.2920
AGPCAT*region2	3	1.2024	0.7524
AGPCAT*EDUCATE	3	1.6968	0.6376
AGPCAT*UR	1	4.3449	0.0371
AGPCAT*BMICAT	2	0.6777	0.7126
AGPCAT*EVERPREG	1	0.0272	0.8690

Analysis of Maximum Likelihood Estimates

Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-0.8838	0.7320	1.4580	0.2273
AGPCAT		1	1.7417	1.4754	1.3935	0.2378
AGECAT	**2**	1	-0.1406	0.4485	0.0982	0.7540
AGECAT	**3**	1	-0.1589	0.5429	0.0857	0.7697
AGECAT	**4**	1	-0.1968	0.5522	0.1270	0.7216
region2	**1.00**	1	0.1219	0.3402	0.1284	0.7201
region2	**2.00**	1	-2.1906	0.4995	19.2319	<.0001

region2	**3.00**	1	-0.0509	0.3695	0.0190	0.8904
EDUCATE	**2**	1	0.4508	0.4082	1.2192	0.2695
EDUCATE	**3**	1	0.2507	0.3527	0.5053	0.4772
EDUCATE	**4**	1	-0.0810	0.4445	0.0332	0.8554
UR		1	-0.3988	0.2920	1.8649	0.1721
BMICAT	**2**	1	0.3377	0.5014	0.4537	0.5006
BMICAT	**3**	1	0.1644	0.5633	0.0852	0.7704
EVERPREG		1	-0.6233	0.3798	2.6931	0.1008
AGPCAT*AGECAT	**2**	1	-0.9621	0.9205	1.0923	0.2960
AGPCAT*AGECAT	**3**	1	-0.2227	1.1047	0.0406	0.8402
AGPCAT*AGECAT	**4**	1	-1.4121	1.1566	1.4906	0.2221
AGPCAT*region2	**1.00**	1	-0.2796	0.5694	0.2412	0.6233
AGPCAT*region2	**2.00**	1	-0.7902	1.0033	0.6204	0.4309
AGPCAT*region2	**3.00**	1	0.0305	0.6936	0.0019	0.9649
AGPCAT*EDUCATE	**2**	1	-0.7173	0.9487	0.5717	0.4496
AGPCAT*EDUCATE	**3**	1	-0.4429	0.8100	0.2989	0.5845
AGPCAT*EDUCATE	**4**	1	0.3536	0.7816	0.2046	0.6510
AGPCAT*UR		1	-1.1303	0.5423	4.3449	0.0371
AGPCAT*BMICAT	**2**	1	0.3839	0.7598	0.2553	0.6134
AGPCAT*BMICAT	**3**	1	-0.0176	0.9194	0.0004	0.9847

AGPCAT*EVER PREG	1	0.1155	0.7004	0.0272	0.8690

Association of Predicted Probabilities and Observed Responses

Percent Concordant	73.3	**Somers' D**	0.474
Percent Discordant	25.9	**Gamma**	0.478
Percent Tied	0.8	**Tau-a**	0.171
Pairs	90514	**c**	0.737

AGP/TFR Gold Standard Model Output

The SURVEYLOGISTIC Procedure

Model Information

Data Set	WORK.PNGMOD	
Response Variable	TFRCAT	
Number of Response Levels	2	
Stratum Variable	REGIONS	
Number of Strata	4	
Cluster Variable	cluster_	CLUSTER_NO
Number of Clusters	94	
Weight Variable	smplwts	smplwts
Model	Binary Logit	
Optimization Technique	Newton-Raphson	
Variance Adjustment	Degrees of Freedom (DF)	

Variance Estimation

Method	Taylor Series
Variance Adjustment	Degrees of Freedom (DF)

Number of Observations Read	746
Number of Observations Used	709
Sum of Weights Read	1133211
Sum of Weights Used	1085711

Response Profile

Ordered Value	TFRCAT	Total Frequency	Total Weight
1	0	542	877558.72
2	1	167	208152.30

Probability modeled is TFRCAT=1.

Class Level Information

Class	Value	Design Variables		
AGECAT	**1**	0	0	0
	2	1	0	0
	3	0	1	0
	4	0	0	1
EDUCATE	**1**	0	0	0

	2	1	0	0
	3	0	1	0
	4	0	0	1
BMICAT	**1**	0	0	
	2	1	0	
	3	0	1	
region2	**1.00**	1	0	0
	2.00	0	1	0
	3.00	0	0	1
	4.00	0	0	0

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	1061191.4	875387.19
SC	1061196.0	875460.21
-2 Log L	1061189.4	875355.19

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	185834.202	15	<.0001

Score	164357.335	15	<.0001
Wald	82.7844	15	<.0001

Type 3 Analysis of Effects

Effect	DF	Wald Chi-Square	Pr > ChiSq
AGPCAT	1	16.7666	<.0001
AGECAT	3	1.8618	0.6016
region2	3	34.4204	<.0001
EDUCATE	3	0.8899	0.8279
UR	1	1.8800	0.1703
BMICAT	2	2.6033	0.2721
EVERPREG	1	3.3904	0.0656
AGPCAT*UR	1	4.2926	0.0383

Analysis of Maximum Likelihood Estimates

Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-0.7934	0.6062	1.7132	0.1906
AGPCAT		1	1.0140	0.2476	16.7666	<.0001
AGECAT	**2**	1	-0.3680	0.3531	1.0864	0.2973
AGECAT	**3**	1	-0.2617	0.4505	0.3375	0.5613
AGECAT	**4**	1	-0.5302	0.4232	1.5696	0.2103
region2	**1.00**	1	0.0912	0.3642	0.0627	0.8023
region2	**2.00**	1	-2.3755	0.4907	23.4358	<.0001
region2	**3.00**	1	-0.0204	0.3599	0.0032	0.9548

EDUCATE	**2**	1	0.3132	0.3939	0.6323	0.4265
EDUCATE	**3**	1	0.1960	0.3061	0.4098	0.5221
EDUCATE	**4**	1	0.0885	0.3924	0.0509	0.8215
UR		1	-0.4077	0.2974	1.8800	0.1703
BMICAT	**2**	1	0.4469	0.3837	1.3570	0.2441
BMICAT	**3**	1	0.1285	0.4423	0.0843	0.7715
EVERPREG		1	-0.5630	0.3057	3.3904	0.0656
AGPCAT* UR		1	-1.0741	0.5184	4.2926	0.0383

Odds Ratio Estimates

Effect	**Point Estimate**	**95% Wald Confidence Limits**	
AGECAT 2 vs 1	0.692	0.346	1.383
AGECAT 3 vs 1	0.770	0.318	1.861
AGECAT 4 vs 1	0.588	0.257	1.349
region2 1.00 vs 4.00	1.095	0.537	2.237
region2 2.00 vs 4.00	0.093	0.036	0.243
region2 3.00 vs 4.00	0.980	0.484	1.984
EDUCATE 2 vs 1	1.368	0.632	2.960
EDUCATE 3 vs 1	1.217	0.668	2.217
EDUCATE 4 vs 1	1.093	0.506	2.357
BMICAT 2 vs 1	1.563	0.737	3.316
BMICAT 3 vs 1	1.137	0.478	2.706
EVERPREG	0.570	0.313	1.037

Association of Predicted Probabilities and Observed Responses

Percent Concordant	73.0	**Somers' D**	0.469
Percent Discordant	26.1	**Gamma**	0.474
Percent Tied	0.9	**Tau-a**	0.169
Pairs	90514	**c**	0.735

Contrast Test Results

Contrast	DF	Wald Chi-Square	Pr > ChiSq
POR FOR ID COMPARING INF TO NOINF	1	16.7666	<.0001

Contrast Estimation and Testing Results by Row

Contrast	Type	Row	Estimate	Standard Error	Alpha	Confidence Limits		Wald Chi-Square	Pr > ChiSq
POR FOR ID COMPARING INF TO NOINF	**PARM**	**1**	1.0140	0.2476	0.05	0.5286	1.4993	16.7666	<.0001
POR FOR ID COMPARING INF TO NOINF	**EXP**	**1**	2.7565	0.6826	0.05	1.6966	4.4786	16.7666	<.0001

AGP/TfR Final Model Output

The SURVEYLOGISTIC Procedure

Model Information

Data Set	WORK.PNGMOD	
Response Variable	TFRCAT	
Number of Response Levels	2	
Stratum Variable	REGIONS	
Number of Strata	4	
Cluster Variable	cluster_	CLUSTER_NO
Number of Clusters	94	
Weight Variable	smplwts	smplwts
Model	Binary Logit	
Optimization Technique	Newton-Raphson	
Variance Adjustment	Degrees of Freedom (DF)	

Variance Estimation

Method	Taylor Series
Variance Adjustment	Degrees of Freedom (DF)

Number of Observations Read	746
Number of Observations Used	737
Sum of Weights Read	1133211
Sum of Weights Used	1123221

Response Profile

Ordered Value	TFRCAT	Total Frequency	Total Weight
1	0	563	906090.63
2	1	174	217130.45

Probability modeled is TFRCAT=1.

Class Level Information

Class	Value	Design Variables		
BMICAT	**1**	0	0	
	2	1	0	
	3	0	1	
region2	**1.00**	1	0	0
	2.00	0	1	0
	3.00	0	0	1
	4.00	0	0	0

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	1102977.7	918431.46

SC	1102982.3	918477.48
-2 Log L	1102975.7	918411.46

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	184564.226	9	<.0001
Score	163472.352	9	<.0001
Wald	81.1755	9	<.0001

Type 3 Analysis of Effects

Effect	DF	Wald Chi-Square	Pr > ChiSq
AGPCAT	1	19.8948	<.0001
EVERPREG	1	14.1152	0.0002
BMICAT	2	3.2564	0.1963
region2	3	36.6940	<.0001
UR	1	1.4908	0.2221
AGPCAT*UR	1	3.9728	0.0462

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	-0.8396	0.4839	3.0106	0.0827
AGPCAT	1	1.0540	0.2363	19.8948	<.0001
EVERPRE	1	-0.7602	0.2023	14.1152	0.0002

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BMICAT	**2**	1	0.5104	0.3663	1.9421	0.1634
BMICAT	**3**	1	0.1888	0.4167	0.2052	0.6505
region2	**1.00**	1	0.0250	0.3475	0.0052	0.9426
region2	**2.00**	1	-2.4220	0.4609	27.6118	<.0001
region2	**3.00**	1	-0.1511	0.3512	0.1850	0.6671
UR		1	-0.3559	0.2915	1.4908	0.2221
AGPCAT* UR		1	-0.9726	0.4880	3.9728	0.0462

Odds Ratio Estimates

Effect	**Point Estimate**	**95% Wald Confidence Limits**	
EVERPREG	0.468	0.315	0.695
BMICAT 2 vs 1	1.666	0.813	3.415
BMICAT 3 vs 1	1.208	0.534	2.733
region2 1.00 vs 4.00	1.025	0.519	2.026
region2 2.00 vs 4.00	0.089	0.036	0.219
region2 3.00 vs 4.00	0.860	0.432	1.711

Association of Predicted Probabilities and Observed Responses

Percent Concordant	71.3	**Somers' D**	0.461
Percent Discordant	25.2	**Gamma**	0.477
Percent Tied	3.4	**Tau-a**	0.167
Pairs	97962	**c**	0.731

Contrast Test Results

Contrast	DF	Wald Chi-Square	Pr > ChiSq
POR FOR ID COMPARING INF TO NOINF	1	19.8948	<.0001

Contrast Estimation and Testing Results by Row

Contrast	Type	Row	Estimate	Standard Error	Alpha	Confidence Limits		Wald Chi-Square	Pr > ChiSq
POR FOR ID COMPARING INF TO NOINF	**PARM**	**1**	1.0540	0.2363	0.05	0.5908	1.5171	19.8948	<.0001
POR FOR ID COMPARING INF TO NOINF	**EXP**	**1**	2.8691	0.6780	0.05	1.8055	4.5591	19.8948	<.0001