EXXON MOBIL PNG/PNGIMR PARTNERSHIP IN HEALTH (PIH) PROJECT

REPORT ON

NON-COMMUNICABLE DISEASES & ASSOCIATED RISK FACTORS IN THE HIRI, KARKAR & ASARO INTEGRATED HEALTH AND DEMOGRAPHIC SURVEILLANCE SITES

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EXECUTIVE SUMMARY

This reports presents findings from a general population prevalence survey of non-communicable diseases (NCDs) and associated risk factors in three integrated Health and Demographic Surveillance Sites (iHDSS) in Hiri (Central Province), Asaro Valley (Eastern Highlands Province) and Karkar Island (Madang). The broad aims of the survey were to: 1) establish baseline prevalence of selected NCDs, associated lifestyle risk factors, dietary habits and food security; and 2) establish a surveillance system for longitudinal monitoring of NCD prevalence and risk.

A total of 774 adults aged between 15-65 years were recruited across the three sites, using simple random selection from a full population census of the adult general population of each iHDDS. The sample was stratified by age (15-29, 30-44, 45-65 years) and sex. A range of questionnaire, anthropometric and biological data was collected from each participant.

Key findings included:

- 67.4% of participants met criteria for 'substantially increased risk of metabolic complications' based on waist-to-hip ratio
- 63.5% of participants had microalbuminuria
- 49.9% of participants recorded an 'abnormal' lung function
- 43.5% of participants were anaemic
- 43.0% of participants reported 'daily' tobacco use
- 38.9% of participants reported perceived food shortages within the past 12 months.
- 18.7% of participants recorded high blood glucose levels
- 17.7% of participants recorded elevated cholesterol levels
- 15.9% of participants met criteria for hypertension

Site-specific data for these and other variables are detailed in the following pages.

The reported findings indicate an immediate need for NCD prevention, screening and intervention programs within Hiri iHDSS and NCD prevention and health promotion programs across all iHDSS sites. The data from Asaro and Karkar iHDSS are most likely to be representative of NCD burden (and NCD risk) in rural communities across PNG, underlying their value as longitudinal surveillance sites.

1. INTRODUCTION

Papua New Guinea (PNG) is a culturally, environmentally and biologically diverse country of approximately seven million people located in the Western Pacific Region. Whilst a low income country according to world bank criteria, PNG is currently experiencing rapid economic development. This development 'boom' is largely driven by a range of mineral and gas resource projects, the most substantial of which is the Exxon Mobil led PNG Liquefied Natural Gas (PNG LNG) project. The PNG LNG project is expected to more than double the PNG gross domestic product and provide a stable revenue stream for 25-30 years once fully operational [1]. As has been observed elsewhere, rapid economic development of this scale is likely to result in an epidemiological transition that sees a reduction in infectious disease and a simultaneous increase in non-communicable diseases (NCDs) as a result of associated lifestyle change [2, 3].

Non-communicable diseases (NCD) are a leading cause of morbidity and mortality throughout the world. In 2005, an estimated 35 million deaths were caused by NCDs (principally, cardiovascular diseases (CVDs), diabetes, cancers, and chronic respiratory diseases), a number predicted to rise by 17% by 2015 [4]. Chronic diseases are further responsible for about 47% of the 1.49 billion years of healthy life "lost" to illness globally [5]. The burden is highest in low income countries where 80% of NCD related deaths occur [4]. Furthermore, about 29% of all NCD related deaths occur in those aged less than 60 years (i.e. an economically active age group) in low-middle income countries compared to 13% in high income countries [6]. The NCD burden is already substantial and growing in the Western Pacific Region (WPR). The WHO estimates that more than 30 million people across WPR countries currently have diabetes mellitus alone and this figure is expected to double by the year 2025 [7].

NCDs and associated risk factors such as smoking, excessive alcohol consumption, obesity, hypertension, abnormal cholesterol and lipid profiles, and physical inactivity have not been well investigated in PNG. A number of relatively small studies conducted among specific populations have identified an increasing or relatively high prevalence of diabetes, cardiovascular disease and cancers [8-14]. Available evidence further suggests variation in NCD risk within PNG based on ethnic origin [15-17] and lifestyle and living environment

[18. 19]. For example, the Wanigela people of Port Moresby have some of the highest rates of diabetes recorded in the Pacific [9] and urban dwellers of any ethnic origin in PNG are more at risk of NCDs relative to their rural peers [11, 18], although even rural populations appear to be increasingly prone to NCDs [12]. NCDs currently account for a minor proportion of outpatient and inpatient admissions within the country [20], yet this is not necessarily reflective of treatment need. According to a survey completed in 2000, less than half of the estimated 180,000 diabetes cases in PNG were on treatment [8], suggesting a majority of diabetic cases go undiagnosed or untreated. Given the acknowledged shortcomings of the PNG health system, including deteriorating infrastructure, poor governance, aging and inadequate healthcare workforce and a paucity of specialist services [21-24], then it is likely that many (if not most) other forms of NCD are equally undetected or untreated.

Despite the aforementioned studies, the PNG evidence-base is currently insufficient to reliably identify the prevalence of NCDs across the country. Neither is there the capacity within the current health system to monitor the anticipated epidemiological transition and the expected rise in NCD prevalence and associated risk factors. As such, it is prudent to establish prevalence for NCDs and their risk factors in the early stages of the development 'boom' as well as implement a reliable monitoring system. By doing so, subsequent changes in NCD burden and their associated risk factors may be readily identified and appropriate public health interventions and policies developed and deployed in a timely manner. Accordingly, the aims of this study were to:

1. Establish a baseline data set to determine among people living in three diverse study sites:
    a. the prevalence of selected NCDs (namely diabetes mellitus type 2, hypertension, acute coronary syndrome, stroke, chronic lung diseases and cancers) and associated lifestyle risk factors;
    b. dietary habits and food security; and
2. Establish a surveillance system for longitudinal monitoring to detect any changes in the prevalence of NCDs and associated lifestyle risk factors, and also any changes in dietary habits and food security, among the three study sites.

2. METHODOLOGY

Study Design

The study is a cross sectional survey conducted in three integrated Health and Demographic Surveillance Sites (iHDSS) established as part of a larger research program [25]. Detailed demographic records are maintained and regularly updated for each site and a wide range of socio-demographic and health data are continuously collected at an individual and household level. The study included completion of a standardised questionnaire loosely based on the WHO STEPS NCD Risk Factor survey, a 24 hour dietary recall (not reported herein), selected physical measurements and biological sample collection with randomly selected adults (15-65 years) from the general population of each iHDSS. Pending continued funding, repeat cross sectional surveys will be completed in each iHDSS to allow longitudinal surveillance of NCD risk factors and prevalence.

Sample Size and Selection

A total of 300 adult participants stratified according to sex and age (15-29, 30-44, 45-65 years) were sought from each iHDSS (i.e. 100 participants from each of the three age groups, 50 male and 50 female, were sought from each site). Study participants were selected from each iHDSS using a simple random sampling procedure. The sampling frame was a full population census of the adult general population of each iHDDS stratified by age and sex. The overall sample size (n=900) was calculated to confer 80% power and a 0.05 significance level (2-sided).

Study Sites

The three iHDSS include the West Hiri iHDSS (Central Province) located in a PNG LNG project impact site and the Asaro Valley iHDSS (Eastern Highlands Province) and Karkar Island iHDSS (Madang Province) located in non-project comparison sites. The West Hiri iHDSS comprises the villages Porebada, Boera, Papa, and Lealea in Hiri District with the baseline (2011) population recorded at 11,531 people [24]. The West Hiri villages are distributed along a 20-30 kilometre stretch of coastline starting about 20 kilometres North West of Port Moresby, the National Capital and largest city in PNG. The villages have been

affected by their proximity to Port Moresby and traditional skills in fishing, gardening and other areas have been eroded [26]. Subsistence farming is relatively rare within the Hiri iHDSS, with the majority of the adult population (15-64 years) engaged in some form of employment, including on the LNG-PNG project [25]. The West Hiri iHDSS surrounds the PNG LNG processing site.

The Asaro Valley iHDSS comprises a baseline (2011) population of 10,034 people [25] situated within 40 kilometres of Goroka Town. Rural people in the Asaro Valley live in hamlets, grouped together into villages and most houses are made out of bush material. People are primarily subsistence farmers, but earn cash through smallholder production of coffee, employment on plantations and marketing of garden produce [27]. The Karkar Island iHDSS comprises an approximate population of 20,000 people [25] and is located about 30 kilometres off the Northern coastline of Madang Province. The island's soil is known for its fertility and large plantations produce the island's main exports of cocoa and coconut and provide a large amount of the local employment opportunities. Subsistence farming and unskilled labour are the primary occupations of the adult (15-64 years) population and most houses are made out of bush material or are semi-permanent [25].

Procedures

Interviews were conducted at participants' homes, or community-based health facilities. The study purpose and procedures were explained to participants and written consent obtained prior to participating in the study. To be eligible to take part in this survey, an individual had to meet the following criteria: living in one of the three iHDSS; aged between 15-64 years; and consented to be part of the study. Individuals were excluded from the study if they were pregnant or were known or reported to have a mental illness. All survey forms and procedures were completed at a single time point; however, participants were provided a specimen container the evening prior to survey for an early morning urine collection or the urine specimen was collected the day after survey. Non-clinical components of the adult NCD questionnaire, 24 hour dietary recall and all physical measurements were completed by a trained research officer. Clinical components of the NCD questionnaire and all biological samples were collected by a qualified health professional.

Each adult participant's blood sample was analysed and investigated for anaemia, Haemoglobin A1c (as a marker for diabetes mellitus) and associated NCD risk factors such as

elevated cholesterol or triglycerides. NCDs were determined based on clinical findings during the NCD survey in the field and/or from laboratory results. Participants identified to have NCDs during the field survey were referred to the local General Hospital for further investigation and management without delay. Participants with laboratory confirmed NCDs were scheduled to be seen by a visiting medical registrar in the health facility closest to the respective iHDSS. All data were collected between April 2013 and October 2014. This study was approved and granted ethical clearance by the PNGIMR Institutional Review Board (IRB) and the PNG Medical Research Advisory Committee (MRAC) (IRB No. 1208, 23 March, 2012; MRAC No.12.34, 19 November, 2012).

Measures

NCD Risk Factor Questionnaire: An interviewer administered questionnaire based on the WHO STEPS NCD Risk Factor survey. Question domains included: participant demographics, self-reported health status, self-reported stress or anxiety, diet, food security, tobacco, buai and alcohol use, physical activity and participant history of NCD and/or associated treatments. The self-reported stress/anxiety, diet and physical activity questions were all developed specifically for this study and for use with PNG-based populations. The questionnaire was available in English and *Tok Pisin* versions. The *Tok Pisin* version was translated from the English original and back-translated for accuracy. All questionnaires were piloted extensively prior to survey commencement.

24 Hour Dietary Recall (not reported herein): A structured interview designed to collect quantitative information on all foods and drinks consumed by the participant the day prior to survey (from midnight to midnight), including foods and drinks consumed both at and away from home. The 24-hour dietary recall was administered in the following four stages using a standardised protocol [28]: 1) A 'quick list' of all foods, beverages and dietary supplements consumed during the preceding day was obtained; 2) Detailed descriptions were then sought of all items consumed, using specific questions and prompts, including cooking method, recipe for mixed dishes (where known), any additions made before consumption, where the food was sourced, brand and product name and time consumed. 3) Estimates were then made of amounts of items consumed, wherever possible (eg, cups, tablespoons), using food photographs, shape dimensions, food portion assessment aids (eg, dried beans) and packaging information; and 4) All items were reviewed in chronological order. Any additions and

changes were made at this point. On completion of the 24-hour diet recall, the interviewer asked the participant to show them any container in which salt used by the household was purchased. Once it had been sighted the interviewer recorded size of container and frequency of purchase. The questions were adapted from the salt module of the 2005 PNG National Nutrition Survey [29].

Physical Measurement: Weight records were obtained using a Seca uniscale with 100g precision. Stature was measured to 0.1 cm precision using a Seca leiscester height measure or stadiometer with plastic tape measure securely taped against a flat timber with participants standing at a plane position against it. A figure finder constant tension tape was used to measure waist and hip circumferences with precision to 0.1 cm. An OMRON T9P digital automatic blood pressure monitor was used to measure blood pressure three times at one minute intervals. All participants were measured in the sitting position after resting for more than 10 minutes. Systolic and diastolic readings from the digital monitor were recorded. Heart rate was measured from the automatic blood pressure monitor. Lung function was measured using a portable spirometer. Measurement included forced vital capacity (FVC) and the forced expiratory volume (FEV_1). Each participant was asked to blow three times into the mouth piece of the spirometer before a reading was taken and recorded.

Capillary Blood: Finger prick blood spot analysed for haemoglobin levels using a portable Hemocue device.

Venous Blood: 30mls of non-fasting blood was collected by venepuncture using size 20-21G butterfly needles into 2 types of sample containers. From each participant, the initial 10mls of blood was collected into EDTA vacutainers and another 20mls into serum vacutainers. All samples were separated into several aliquots and stored initially at -20°C until analysed in batches within 1-2 months of collection. EDTA samples were analysed for Haemoglobin A1c. The serum samples were analysed for lipid profile which includes total cholesterol, triglycerides, low and high density lipoprotein. After analysis, remaining aliquots were placed in -80°C freezers for long-term storage.

Urine: An early morning urine sample was collected from each adult participant and analysed for microalbuminuria and cortisol levels; the latter as a general indicator of stress [30, 31].

Complementary data: Information pertaining to education and occupation was available for all survey participants from complementary datasets collected as part of the larger iHDSS research program.

Determining Non-Communicable Disease

In accordance with the American Diabetes Association standards of medical care in diabetes [32], diabetes mellitus type 2 was diagnosed if an adult participant's Haemoglobin A1c ≥ 48 mmol/l (≥6.5%). The above criteria were confirmed by repeat testing on a different day. Hypertension was diagnosed if blood pressure is >140/90 mmHg (seated and after 5 minutes rest). Three separate readings were conducted to confirm hypertension. An elevated lipid profile was defined according to the updated guidelines for cholesterol management and the 2011 report of the National Cholesterol Education Program expert panel team in the evaluation, monitoring and treatment of cholesterol in adults [33, 34]: Normal Cholesterol levels if <200 mg/dL or (5.17 mmol/L), borderline high if 200-239 mg/dL or 5.2 to 6.2 mmol/L and elevated if > 240 mg/dL or >6.21 mmol/L; Poor HDL-cholesterol levels if <40mg/dL or (<1.03 mmol/L) and elevated or best if >60 mg/dL or >1.55 mmol/L, normal triglyceride if <150mg/dL or <1.7mmol/L, borderline high if 150 to 199 mg/dL or 1.7 -2.2 mmol/L, high if >200-499 mg/dL or >2.3 mmol/L, normal LDL-c if <2.6 mmol/L or <100 mg/dL, above optimal if 2.6-3.3 mmol/L or 100-129 mg/dL, high if >3.3 mmol/L or >130 mg/dL. Microalbuminuria was defined as an albumin/creatinine ratio (ACR) ≥2.5mg/mmol and ≥3.5mg/mmol for males and females, respectively [35]. Obstructive pulmonary disease was diagnosed if lung function FEV_1/FVC <0.7. Anaemia was diagnosed if haemoglobin level was below the WHO Hemoglobin thresholds [36]: Women, non-pregnant (>15 years) Hb threshold 12.0 g/dL or 7.4 mmol/L; men (>15 years) Hb threshold 13.0 g/dL or 8.1 mmol/L.

Data Analysis

Stata/SE version 12 was used for all data analysis. Analysis was limited to descriptive summaries of all major measures obtained during the NCD survey and inferential analyses assessing inter-site differences on major outcome variables, using chi-square, one-way ANOVA, t-test, or Kruskal-Wallis as appropriate. More detailed analyses exploring relationships between specified risk factors and NCDs will be presented in subsequent peer-

reviewed publications. The totals (No.) presented in all Tables are denominators unless otherwise stated. There is some variance in the totals presented across Tables due to missing data on certain variables. It should also be noted that the tobacco, buai and alcohol questions were not originally included in the NCD questionnaire and, as a result, these questions were not asked of all participants.

3. RESULTS

Sample Characteristics

Participant age and sex characteristics are presented in Table 1. As shown, a majority of participants were in the 45-65 year age category (38.2%) and a minority in the 15-29 year age category (27.9%). The mean participant age was 39.2 years (SD 13.8). No statistically significant differences between iHDSS were identified in the distribution of participants across the three age categories (p=0.986) or in mean age (p=0.708). Some variation in participant sex ratio was evident across sites, although not at a level of statistical significance (p=0.192).

Table 1. Participant age and sex characteristics

Site	**No.**	**Age (yrs)**			**Sex**	
		15-29	30-44	45-65	Male	Female
Hiri	268	27.2%	35.1%	37.7%	43.3%	56.7%
Asaro	254	27.2%	34.7%	38.2%	51.2%	48.8%
Karkar	252	29.4%	31.8%	38.9%	46.4%	53.6%
Overall	**774**	**27.9%**	**33.9%**	**38.2%**	**46.9%**	**53.1%**

Participant education levels and occupations are presented in Tables 2 and 3, respectively. Overall, 67.1% of participants had received less than a secondary level education (≤ primary) and only 3.4% a tertiary or vocational education. Participant education levels were higher in Hiri relative to other iHDSS and at a statistically significant level (p<0.001). The majority of participants were subsistence farmers or cash croppers (45.1%) or responsible for home duties (20.3%). Statistically significant variation in the percentage of participants in each occupation grouping was evident across iHDSS (p<0.001) with a greater proportion of participants in paid employment in Hiri iHDSS and a conversely lower proportion of subsistence farmers/cash croppers relative to other sites.

Table 2. Participant education level

Site	No.	Highest education level attained			
		≤ Primary	≤ Secondary	Tertiary/vocat.	Not answered
Hiri	268	44.4%	34.7%	7.5%	13.4%
Asaro	254	78.0%	11.0%	1.2%	9.8%
Karkar	252	80.2%	15.5%	1.2%	3.2%
Overall	**774**	**67.1%**	**20.7%**	**3.4%**	**8.8%**

Table 3. Participant occupation

Site	No.	Occupation				
		Paid employment	Subsistence/ cash cropper	Home duties	Student/ unemployed	Not answered
Hiri	268	33.6%	8.6%	34.3%	20.9%	2.6%
Asaro	254	5.9%	70.5%	5.9%	9.5%	8.3%
Karkar	252	6.8%	58.3%	19.8%	13.9%	1.2%
Overall	**774**	**15.8%**	**45.1%**	**20.3%**	**14.9%**	**3.9%**

Self-Reported Health Status

As shown in Table 4, a majority of participants' rated their general health 'excellent' (26.3%) or 'good' (32.6%). A statistically significant difference in self-rated general health status was identified across sites ($p<0.001$) with ratings of health status lowest in Asaro where a majority of participants rated their health as 'moderate' (42.5%) or 'bad' (42.9%) and highest in Karkar where a majority of participants rated their health as 'excellent' (69.8%).

Overall, 32% of participants considered their own general health status to be 'better than' others, 53.8% the 'same as' others and 14.3% 'worse than' others (Table 5). Again, statistically significant differences were evident across sites ($p=0.001$) with a majority of participants from Asaro rating their own health the 'same as' (39.4%) or 'worse than' (31.5%) others as compared to participants from Hiri and Karkar who were more likely to

rate their own health the 'same as' (63.0% and 60.2%, respectively) or 'better than' (30.5% and 36.7%) others.

Table 4. Self-rated general health status

Site	No.	Self-rated health status				
		Excellent	Good	Moderate	Bad	Very Bad
Hiri	259	7.3%	62.6%	23.2%	6.2%	0.8%
Asaro	252	2.4%	10.7%	42.5%	42.9%	1.6%
Karkar	252	69.8%	23.8%	6.0%	0.4%	0%
Overall	**763**	**26.3%**	**32.6%**	**23.9%**	**16.4%**	**0.8%**

Table 5. Self-rated general health status as compared to others

Site	No.	Self-rated health status as compared to others		
		Better than	Same as	Worse than
Hiri	243	30.5%	63.0%	6.5%
Asaro	254	29.1%	39.4%	31.5%
Karkar	226	36.7%	60.2%	3.1%
Overall	**723**	**32.0%**	**53.8%**	**14.3%**

Mental Health Status

The NCD questionnaire included up to three questions (the number dependent upon participant response) examining aspects of participant mental health. This included a general question asked of all participants as to whether they were currently experiencing any 'wari or hevi' (stress or concern) and, if the response was 'yes', two further questions exploring potential sleeping difficulties or appetite changes experienced as a result of these concerns. Findings are presented in Table 6. Overall, 32% of participants reported experiencing a current 'wari or hevi'. Participants from Hiri and Asaro iHDSS were significantly more likely to report a current wari/hevi as compared to participants from Karkar (46.2%, 44.1% & 4.8%, respectively; $p<0.001$). Of those participants who reported a current wari/hevi, 59.5%

reported experiencing some sleep loss in the past week as a result and 33.2% reported a change in appetite. Inter-site variation on the latter two measures did not reach levels of statistical significance ($p<0.073$ & $p<0.560$, respectively).

Table 6. Percentage of participants' reporting a current *wari* or *hevi* and related loss of sleep or appetite change

Site	**Experienced wari/hevi**		**Experienced sleep loss***		**Experienced appetite change***	
	No.	% (95% CI)	No.	% (95% CI)	No.	% (95% CI)
Hiri	266	46.2 (40.1, 52.4)	121	63.6 (54.4, 72.2)	122	34.4 (26.1, 43.6)
Asaro	254	44.1 (37.9, 50.4)	110	52.7 (43.0, 62.3)	111	30.6 (22.2, 40.1)
Karkar	252	4.8 (2.5, 8.2)	11	81.8 (48.2, 97.7)	11	45.5 (16.7, 76.6)
Overall	**772**	**32.0 (28.7, 35.4)**	**242**	**59.5 (53.0, 65.7)**	**244**	**33.2 (27.3, 39.5)**

* Only asked if participant responded 'yes' to having a current wari/hevi

Food Consumption

The median number of days on which one or more of the specified food groupings/items were reportedly consumed during a typical week (7 days) over the month prior to survey are presented in Tables 7 and 8. The interquartile range (IQR) is presented in brackets.

Table 7. Self-reported frequency with which vegetables, fruits and meat were consumed during a typical week in past month

Site	**No.**	**Median No. (IQR) of days in which listed food items consumed**				
		Root veges. /banana	Greens/ other veges.	Fruit	Fresh meat	Tinned meat
Hiri	267	2 (2)	1 (3)	1 (4)	4 (5)	5 (5)
Asaro	254	7 (1)	7 (3)	2 (2)	1 (1)	2 (2)
Karkar	252	7 (0)	7 (0)	0 (0)	2 (7)	0 (0)
Overall	**773**	**7 (4)**	**7 (5)**	**1 (2)**	**2 (6)**	**2 (4)**

Variation in the reported frequency of consumption was evident across sites, reaching a level of statistical significance on all items: root vegetables/banana ($p<0.001$); greens/other vegetables ($p<0.001$); fruit ($p<0.001$); fresh meat ($p<0.001$); tinned meat ($p<0.001$).

Table 8. Self-reported frequency with which fired foods, sugary drinks and salted food were consumed during a typical week in past month

Site	**No.**	**Median No. (IQR) of days in which listed food items consumed**				
		Fried food from shop	Fried food from home	Soft drinks	Stock added to food	Salt added to food
Hiri	267	0 (1)	2 (2)	1 (2)	0 (0)	7 (5)
Asaro	254	1 (1)	3 (5)	1 (1)	0 (1)	7 (5)
Karkar	252	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Overall	**773**	**0 (1)**	**2 (3)**	**0 (1)**	**0 (0)**	**5 (7)**

Variation in the reported frequency of consumption was evident across sites, reaching a level of statistical significance on all items: fried food from shop ($p<0.001$); fried food from home ($p<0.001$); soft drinks ($p<0.001$); maggie stock ($p<0.001$); and salt ($p<0.001$).

Food Security

Overall, 38.9% of participants reported that there were times in the past 12-months where some people in their respective communities ate less than they should have because they did not have sufficient food to eat (Table 9). This varied between a high of 64.3% of participants in Asaro and a low of 6.9% in Karkar. The variation between sites reached a level of statistical significance ($p<0.001$).

Table 9. Percentage of participants' reporting perceived food shortages in their respective communities within the past 12 months

Site	No.	Reported food shortage
		% (95% CI)
Hiri	259	44.8 (38.6, 51.1)
Asaro	252	64.3 (58.0, 70.2)
Karkar	248	6.9 (4.0, 10.7)
Overall	**759**	**38.9 (35.4, 42.4)**

Participants who responded 'yes' to the question exploring perceived food shortages in their respective communities were asked 'how often' such shortages were thought to occur (Table 10). As shown in Table 10, Hiri participants were more likely to report food shortages 'every month' as compared to participants from the other iHDSS. The inter-site variation in the reported frequency of food shortages reached a level of statistical significance ($p<0.001$).

Table 10. Reported frequency with which perceived food shortages were thought to occur within past 12 months*

Site	No.	Reported frequency of perceived food shortages		
		Every month	Some, but not all months	Only one or two months
Hiri	114	20.2%	63.2%	16.7%
Asaro	160	1.3%	55.0%	43.7%
Karkar	16	0%	0%	100%
Total	**290**	**8.6%**	**55.2%**	**36.2%**

* Analysis restricted to 260 participants who reported a perceived food shortage in their respective communities

Tobacco Use

Table 11 presents the percentage of participants' who identified themselves as 'current' or 'daily' smokers. The inter-site variation approached statistical significance for 'current smokers' ($p=0.080$) and reached significance for 'daily smokers' ($p=0.019$). For those who identified as current 'daily' smokers, the mean age of starting daily smoking was 18.9 years (SD 6.9) and the mean number of tobacco products smoked per day was 5.5 (SD 4.9). No

statistically significant differences in the mean smoking age or the mean number of tobacco products smoker per day were identified by site (p=0.4562 & p=0.9599, respectively).

Table 11. Percentage of participants' reporting to be a current or daily smoker

Site	No.	Current smoker % (95% CI)	Daily smoker % (95% CI)
Hiri	173	39.9 (32.5, 47.6)	36.5 (29.2, 44.2)
Asaro	189	46.6 (39.3, 53.9)	41.0 (33.9, 48.3)
Karkar	202	51.5 (44.4, 58.6)	50.5 (43.4, 57.6)
Overall	**564**	**46.3 (42.1, 50.5)**	**43.0 (38.9, 47.3)**

Table 12 presents the percentage with which three specified types of tobacco product were reportedly used by daily smokers. The use of manufactured cigarettes was highest in Hiri iHDSS (58.2%) and nil in Karkar. Conversely, the use of 'brus' (homegrown tobacco) was exclusive to Asaro and Karkar iHDSS where it was the most frequently reported form of tobacco consumption.

Table 12. Reported use of three types of tobacco product (daily smokers only)*

Site	No.	Cigarettes % (95% CI)	Spear/mutrus % (95% CI)	Brus % (95% CI)
Hiri	60	58.3 (44.9, 70.9)	65.0 (51.6, 76.9)	0 (0, 6.0)
Asaro	75	22.7 (13.8, 33.8)	9.3 (3.8, 18.3)	89.3 (80.1, 95.3)
Karkar	92	0 (0, 3.9)	1.1 (0, 5.9)	95.6 (89.1, 98.8)
Overall	**227**	**22.9 (17.6, 28.9)**	**20.7 (15.6, 26.6)**	**68.1 (61.6, 74.2)**

*Analysis restricted to 227 participants who reported daily tobacco use.

Buai Use

Table 13 presents the percentage of participants who reported buai consumption in the past 30 days. Use was highest in Hiri and lowest in Asaro (93.5% & 55.1%, respectively) with inter-site variation reaching a level of statistical significance (p<0.001). Mean number of days in which buai was chewed in the past 30 days and mean number of nuts chewed per day, as reported by participants who had chewed at least one nut in the past 30 days, was 25.7 (SD 8.8) and 6.2 (SD 5.7), respectively. A statistically significant difference in mean number of days in which buai was chewed was identified between sites (29.7±2.1 in Karkar vs.

21.1±11.1 and 24.6±9.5 in Asaro and Hiri, respectively; p<0.001). No statistically significant variation in reported number of nuts chewed was identified. 92.4% of participants reporting buai use in the past thirty days further reported that they 'always' use mustard and lime when chewing.

Table 13. Percentage of participants' reporting buai use in the past 30 days

Site	No.	Use in past 30 days
		% (95% CI)
Hiri	155	93.5 (88.5, 96.9)
Asaro	167	55.1 (47.2, 62.8)
Karkar	170	86.5 (80.4, 91.2)
Overall	**492**	**78.0 (74.1, 81.6)**

Alcohol Use

Self-reported consumption of alcohol at any point in time (ever), in the past 12-months and past 30 days is presented in Table 14. Reported alcohol consumption on all three measures was lowest in Karkar iHDSS. The percentage of participants reporting having 'ever' consumed alcohol was similar in Hiri and Asaro (65.8% and 66.3%, respectively), although a higher percentage of participants from Hiri reported alcohol use in the past 12-months or 30-days. The inter-site variation in reported alcohol consumption reached statistical significance on all three measures ('ever' p<0.001; '12-months' p<0.001; '30-days' p<0.001, respectively).

Table 14. Percentage of participants' reporting alcohol consumption

Site	No.	Alcohol use measure		
		Ever	Past 12 months	Past 30 days
		% (95% CI)	% (95% CI)	% (95% CI)
Hiri	152	65.8 (57.7, 73.3)	58.3 (50.0, 66.2)	45.1 (36.8, 53.6)
Asaro	169	66.3 (58.6, 73.4)	40.4 (32.9, 48.1)	22.9 (16.7, 30.0)
Karkar	200	42.0 (35.1, 49.2)	19.6 (14.3, 25.8)	7.1 (4.0, 11.7)
Overall	**521**	**56.8 (52.4, 61.1)**	**37.6 (33.4, 41.9)**	**23.1 (19.5, 27.0)**

Physical Activity

Table 15 presents the median hours or minutes per day (and inter quartile range in brackets) spent on sedentary, moderate or vigorous physical activity by sex and iHDSS. As shown, both male and female participants from Karker reported the highest median number of sedentary minutes per day (397.1 and 425.0, respectively). Male and female participants from Asaro reported the highest median number of moderate activity minutes per day (62.3 and 61.5, respectively) and median minutes spent on vigorous activity were uniformly low across sites (ranging from 0 for females from Karkar to 2.8 for males from Karkar). Inter-site variation reached a level of statistical significance on all measures for both sexes (Male: Total, $p=0.006$; Sedentary, $p=0.027$; Moderate, $p<0.001$; Vigorous, $p<0.001$; Female: Total, $p<0.001$; Moderate, $p<0.001$; Vigorous, $p<0.001$) with the exception of total hours spent per day on sedentary activity among females ($p=0.052$).

Table 15. Median (IQR) hours (hrs) or minutes (mins) spent per day (d) on sedentary, moderate or vigorous physical activity by sex and iHDSS*

Site	Male					Female				
	No.	Total Hr/d	Sedentary Min/d	Moderate Min/d	Vigorous Min/d	No.	Total Hr/d	Sedentary Min/d	Moderate Min/d	Vigorous Min/d
Hiri	68	13.1 (5.7)	311.5 (307.1)	29.8 (97.1)	0.2 (14.0)	84	11.6 (3.8)	366.0 (155.1)	14.9 (35.3)	0.7 (1.3)
Asaro	91	13.3 (6.2)	336.6 (185.1)	62.3 (83.0)	0.3 (2.7)	84	15.3 (7.6)	370.1 (239.2)	61.5 (58.5)	0.4 (0.9)
Karkar	59	10.8 (5.0)	397.1 (193.1)	20.5 (33.8)	2.8 (1.2)	79	10.1 (3.6)	425.0 (172.1)	22.4 (43.7)	0 (0)
Overall	**218**	**12.5 (5.7)**	**341.3 (239.8)**	**40.3 (78.1)**	**0.2 (3.3)**	**247**	**11.9 (6.0)**	**383.5 (201.0)**	**33.7 (62.6)**	**0.2 (1.0)**

* Participants whose total spent time on the reported physical activities was less than 8 hours or over 24 hours were excluded from the analysis. We calculated the time based on the physical activity intensity distribution we observed for each reported activity using the accelerometer in Hiri and Asaro. The accelerometer underestimates the intensity of physical activities that involve upper body movement and those with minimal vertical displacement and does not capture the extra energy cost of load-bearing activities.

Table 16. Percentage of participants meeting WHO's recommendation on physical activity for the prevention of NCDs*

Site	Male			Female		
	No.	Vigorous physical activity≧75 min/w or Moderate physical activity≧150 min/wk	Vigorous physical activity≧150 min/w or Moderate physical activity≧300 min/wk	No.	Vigorous physical activity≧75 min/w or Moderate physical activity≧150 min/wk	Vigorous physical activity≧150 min/w or Moderate physical activity≧300 min/wk
Hiri	66	63.6%	47.0%	77	37.7%	22.1%
Asaro	87	86.2%	70.1%	83	84.3%	72.3%
Karkar	56	46.4%	21.4%	74	52.7%	39.2%
Overall	**209**	**68.4%**	**49.8%**	**234**	**59.0%**	**45.3%**

*Analysis restricted to participants aged 18 years or older.

The World Health Organisation (WHO) recommends adults aged 18 years and above to perform at least 150 minutes of moderate-intensity aerobic physical activity throughout the week, or do at least 75 minutes of vigorous-intensity aerobic physical activity throughout the week, or an equivalent combination of moderate- and vigorous-intensity activity to reduce the risk of NCDs. WHO further recommends adults of this age group to perform more than 300 minutes of moderate-intensity aerobic physical activity per week, or 150 minutes of vigorous-intensity aerobic physical activity per week, or an equivalent combination of moderate- and vigorous-intensity activity for additional health benefits (World Health Organization, 2010: http://whqlibdoc.who.int/publications/2010/9789241599979_eng.pdf?ua=1). Table 16 (previous page) presents the percentage of participants meeting these WHO recommendations for the prevention of NCDs. As shown, the highest percentage of both males and females meeting the specified WHO criteria are from Asaro (86.2%, 70.1% & 84.3%, 72.3%, respectively). Conversely, the iHDSS with the lowest percentage of participants meeting these criteria were Karkar for males (46.4% & 21.4%) and Hiri for females (37.7% & 22.1%). The inter-site variation reached a level of statistical significance on both measures for both males and females (Male: $p<0.001$ & $p<0.00$, respectively; Female: $p<0.001$ & $p<0.001$, respectively).

History of Non-Communicable Disease (NCD)

Table 17 presents the percentage of participants' reporting a history of selected NCDs. All questions pertained to lifetime history of disease. Overall, few participants reported having received any form of NCD diagnosis from a health worker especially in the Asaro and Karkar iHDSS. Among those that had, diagnoses of high blood pressure/hypertension and chronic lung disease, COPD or asthma were most commonly reported. Inter-site variation in participant responses failed to reach a level of statistical significance on all items.

Table 18 presents the percentage of participants' reporting an experience of specified NCD-related symptoms. Pain or discomfort in the chest when walking, hurrying or walking uphill is considered indicative of heart disease. Shortness of breath during rest, coughing or wheezing for greater than 10 minutes or coughing up sputum/phlegm most days during a three month period are considered indicative of lung disease. Statistically significant inter-site variation was identified for two symptoms: pain in chest when walking ($p<0.001$); and pain in chest when hurrying or walking up hill ($p<0.001$).

Table 17. Self-reported history of selected non-communicable diseases (NCDs)

Site	No.	% (95% CI) of participants' who report having been told by a health worker that they have/have had…						
		Stroke	Heart disease	High blood sugar /diabetes	Chronic lung dis. /COPD/asthma	High blood press/ hypertension	High cholesterol	Cancer
Hiri	263	1.1 (0.2, 3.3)	1.5 (0.4, 3.8)	1.9 (0.6, 4.3)	4.2 (2.1, 7.3)	7.6 (4.7, 11.5)	0.4 (<0.1, 2.1)	0.4 (<0.1, 2.1)
Asaro	249	0 (0, 0)	0 (0, 0)	0 (0, 0)	2.4 (0.9, 5.1)	2.9 (1.1, 6.2)	0 (0, 0)	0 (0, 0)
Karkar	248	0 (0, 0)	0 (0, 0)	0 (0, 0)	2.4 (0.9, 5.2)	0.4 (0.01, 2.2)	0 (0, 0)	0.4 (<0.1, 2.2)
Overall	**760**	**0.4 (0.08, 1.1)**	**0.5 (01, 1.3)**	**0.7 (0.2, 1.5)**	**3.0 (1.9, 4.5)**	**3.7 (2.5, 5.4)**	**0.1 (<0.1, 0.7)**	**0.3 (0.03, 0.9)**

Table 18. Self-reported experience of NCD-related symptoms by iHDSS and overall

Site	No.	% (95% CI) of participants' reporting the following symptoms					
		Sudden weakness or paralysis on one side of body for 24+ hours	Experience pain in chest when walking	Experience pain in chest when hurrying or walking uphill	Experience shortness of breath when resting	Experience coughing or wheezing for 10+ minutes	Coughed up sputum or phlegm most days in past 3 months
Hiri	266	9.4 (6.2, 13.6)	27.0 (21.7, 32.9)	21.4 (16.5, 26.9)	7.5 (4.7, 11.4)	11.7 (8.1, 16.2)	5.3 (2.9, 8.8)
Asaro	253	0.8 (<0.01, 2.9)	6.1 (3.4, 9.8)	13.6 (9.6, 18.5)	3.1 (1.4, 6.1)	3.9 (1.9, 7.1)	0.8 (<0.01, 2.8)
Karkar	202	0 (0, 0)	0.8 (0.1, 3.0)	0.4 (<0.01, 2.3)	0.4 (<0.01, 2.2)	0.8 (<0.01, 2.8)	0.8 (<0.01, 2.8)
Overall	**770**	**3.5 (2.3, 5.1)**	**11.6 (9.4, 14.2)**	**12.0 (9.7, 14.5)**	**3.8 (2.5, 5.4)**	**5.6 (4.1, 7.4)**	**2.3 (1.4, 3.7)**

Physical Measurements

Mean participant heights (centimetres), weights (kilogram) and body mass index (BMI) are presented by sex and across sites in Tables 19 and 20, respectively. Inter-site variation reached levels of statistical significance on all measures: Weight male ($p<0.001$); weight female ($p<0.001$); height male ($p<0.001$); height female ($p<0.001$); BMI male ($p<0.001$); BMI female ($p<0.001$); BMI combined ($p<0.001$).

Table 19. Mean participant height and weight by sex

Site	**Male**			**Female**		
	No.	Height (cm) Mean (SD)	Weight (kg) Mean (SD)	No.	Height (cm) Mean (SD)	Weight (kg) Mean (SD)
Hiri	113	168.3 (7.5)	70.4 (14.0)	152	158.2 (5.9)	66.7 (18.1)
Asaro	128	162.0 (5.9)	62.2 (8.8)	124	153.3 (5.1)	57.2 (12.7)
Karkar	116	160.8 (6.8)	54.8 (9.2)	135	152.1 (5.4)	50.7 (12.4)
Overall	**357**	**163.6 (7.5)**	**62.4 (12.5)**	**411**	**154.7 (6.1)**	**58.6 (16.3)**

Table 20. Mean Body Mass Index (BMI) by sex

Site	**Male**		**Female**		**Combined**	
	No.	Mean (SD)	No.	Mean (SD)	No.	Mean (SD)
Hiri	112	24.5 (5.3)	152	26.6 (6.9)	264	25.7 (6.0)
Asaro	128	23.7 (2.6)	124	24.4 (5.7)	252	24.0 (4.4)
Karkar	115	21.1 (2.9)	134	21.9 (4.7)	249	21.6 (4.0)
Overall	**355**	**23.1 (3.6)**	**410**	**24.4 (6.2)**	**765**	**23.8 (5.2)**

Table 21 presents a breakdown of participants' body mass index (BMI) by category. Underweight was defined as a BMI <18.5, normal weight defined as a BMI between >18.5 and <25, overweight as a BMI between 25 and <30 and obese as a BMI 30+. The highest levels of overweight or obese were among adults from Hiri iHDSS and lowest in Karkar (46.8% and 10.8% of participants, respectively). Inter-site variation reached a level of statistical significance ($p<0.001$).

Table 21. Percentage of participants in each BMI category

Site	No.	BMI classification			
		Underweight % (95% CI)	Normal % (95% CI)	Overweight % (95% CI)	Obese % (95% CI)
Hiri	265	6.8 (4.1, 10.5)	46.4 (40.3, 52.6)	24.5 (19.5, 30.2)	22.3 (17.4, 27.8)
Asaro	252	4.0 (1.9, 7.2)	66.3 (60.1, 72.1)	23.4 (18.3, 29.1)	6.3 (3.7, 10.1)
Karkar	250	12.4 (8.6, 17.1)	76.8 (71.1, 81.9)	8.0 (5.0, 12.1)	2.8 (1.1, 5.7)
Overall	**767**	**7.7 (5.9, 9.8)**	**62.8 (59.3, 66.3)**	**18.8 (16.1, 21.7)**	**10.7 (8.6, 13.1)**

Table 22 presents the mean Waist-to-Hip Ratio (WHR) by sex and Table 23 presents the percentage of participants meeting World Health Organisation criteria for a 'substantially increased' risk of metabolic complications based on WHR measurement (0.85 in females and 0.9 in males). Mean WHRs were highest for both males and females from Asaro (0.97 and 0.91, respectively) and lowest for both males and females from Hiri (0.89 and 0.88, respectively). Inter-site variation in mean WHR reached statistical significance for males, but not females ($p<0.001$ & $p=0.0532$, respectively).

Similarly, a greater percentage of both males and females from Asaro iHDSS met the WHO criteria for substantially increased risk of metabolic complications based on WHR as compared to males and females from other sites (97.7% and 82.0%, respectively). Inter-site variation on this measure reached levels of statistical significance for both sexes (male $p<0.001$; female $p<0.001$; combined $p<0.001$).

Table 22. Mean waist-to-hip ratio by sex

Site	Male		Female		Combined	
	No.	Mean (SD)	No.	Mean (SD)	No.	Mean (SD)
Hiri	112	0.89 (0.08)	152	0.88 (0.14)	264	0.88 (0.12)
Asaro	128	0.97 (0.05)	122	0.91 (0.10)	250	0.94 (0.08)
Karkar	111	0.90 (0.07)	133	0.90 (0.05)	244	0.90 (0.06)
Overall	**351**	**0.92 (0.08)**	**407**	**0.89 (0.10)**	**758**	**0.91 (0.09)**

Table 23. Percentage of participants meeting WHO criteria for 'substantially increased' risk of metabolic complications based on waist-to-hip ratio (Females ≥0.85; Males ≥0.9)

Site	Male		Female		Combined	
	No.	% (95% CI)	No.	% (95% CI)	No.	% (95% CI)
Hiri	112	44.6 (35.2, 54.3)	152	57.9 (49.6, 65.8)	265	52.1 (45.9, 58.2)
Asaro	128	97.7 (93.3, 99.5)	122	82.0 (74.0, 88.3)	254	88.6 (84.0, 92.2)
Karkar	111	38.7 (29.6, 48.5)	133	81.2 (73.5, 87.5)	244	61.9 (55.5, 68.0)
Overall	**351**	**62.1 (56.8, 67.2)**	**407**	**72.7 (68.1, 77.0)**	**763**	**67.4 (63.9, 70.7)**

Blood Pressure

Tables 24 and 25 present participants' mean resting systolic and diastolic blood pressure readings based on the average of three consecutive reads taken at least one minute apart. Mean blood pressure was highest on both measures for males from Hiri IHDSS (130.3 and 79.2) and females from Asaro iHDSS (124.6 and 78.0). Inter-site variation reached levels of statistical significance on both measures for both males and females: Systolic male ($p<0.001$); systolic female ($p<0.001$); systolic combined ($p<0.001$); diastolic male ($p<0.001$); diastolic female ($p<0.001$); diastolic combined ($p<0.001$).

Table 24. Mean resting systolic blood pressure by sex

Site	Male		Female		Combined	
	No.	Mean (SD)	No.	Mean (SD)	No.	Mean (SD)
Hiri	112	130.3 (16.9)	152	122.3 (21.2)	264	125.7 (19.8)
Asaro	115	128.7 (17.0)	107	124.6 (16.5)	222	126.7 (16.8)
Karkar	117	120.2 (12.3)	135	113.8 (13.6)	252	116.8 (13.3)
Overall	**344**	**126.3 (16.1)**	**394**	**120.1 (18.2)**	**738**	**123.0 (17.5)**

Table 25. Mean resting diastolic blood pressure by sex

Site	Male		Female		Combined	
	No.	Mean (SD)	No.	Mean (SD)	No.	Mean (SD)
Hiri	112	79.2 (12.5)	152	75.4 (12.2)	264	77.0 (12.4)
Asaro	115	78.7 (9.9)	107	78.0 (9.4)	222	78.4 (9.7)
Karkar	117	71.1 (8.1)	135	70.4 (8.8)	252	70.7 (8.5)
Overall	**344**	**76.3 (10.9)**	**394**	**74.4 (10.8)**	**738**	**75.3 (10.9)**

Table 26 presents the percentage of participants meeting criteria for hypertension, defined as systolic blood pressure ≥140 and/or diastolic blood pressure ≥ 90. Among males, 28.6% of participants from Hiri met the criteria for hypertension as compared to 4.3% from Karkar. Among females, the highest percentage was recorded in Asaro (17.8%) and the lowest in Karkar (5.3%). The inter-site variation reached levels of statistical significance for males, but not females: male (p=0.003); female (p=0.139); combined (p<0.001).

Table 26. Percentage with hypertension (SBP ≥140 and/or DBP ≥90) by sex

Site	Male		Female		Combined	
	No.	% (95% CI)	No.	% (95% CI)	No.	% (95% CI)
Hiri	112	28.6 (20.4, 37.9)	152	17.1 (11.5, 24.0)	264	22.0 (17.1, 27.5)
Asaro	115	24.3 (16.8, 33.2)	107	17.8 (11.0, 26.3)	222	21.2 (16.0, 27.1)
Karkar	117	4.3 (1.4, 9.7)	135	5.2 (2.1, 10.4)	252	4.8 (2.5, 8.1)
Overall	**344**	**18.9 (14.9, 23.4)**	**394**	**13.2 (10.0, 16.9)**	**738**	**15.9 (13.3, 18.7)**

Heart Rate

Mean heart rate by sex is presented in Table 27 (based on mean of three reads of resting pulse rate at least one minute apart). The highest mean pulse rates were recorded in Hiri iHDSS for both male and female participants (73.6 and 78.4, respectively) and the lowest in Asaro (66.5

and 73.3%, respectively). Inter-site variation in mean pulse rate was statistically significant: male ($p<0.001$); female ($p<0.001$); combined ($p<0.001$).

Table 27. Mean heart rate – beats per minute – by sex

Site	**Male**		**Female**		**Combined**	
	No.	Mean (SD)	No.	Mean (SD)	No.	Mean (SD)
Hiri	112	73.6 (10.8)	152	78.4 (9.9)	264	76.4 (10.5)
Asaro	115	66.5 (10.6)	107	73.3 (11.3)	222	69.8 (11.4)
Karkar	117	69.2 (9.4)	135	75.3 (10.7)	252	72.4 (10.6)
Overall	**344**	**69.7 (10.7)**	**394**	**76.0 (10.7)**	**738**	**73.1 (11.1)**

Lung Function

A total of 509 valid lung function results were obtained from study participants of which 49.9% met criteria for abnormal lung function ($FEV_1/FVC<0.7$; Table 28). A higher percentage of male and female participants from the Hiri and Asaro iHDSS produced abnormal lung function results as compared to Karkar; however, inter-site variation did not reach levels of statistical significance for either sex or the combined sample: male ($p=0.150$); female ($p=0.155$); combined ($p=0.0258$).

Table 28. Percentage of participants meeting criteria for 'abnormal' lung function ($FEV_1/FVC <0.7$).

Site	**Male**		**Female**		**Combined**	
	No.	% (95% CI)	No.	% (95% CI)	No.	% (95% CI)
Hiri	62	48.4 (35.5, 61.4)	96	63.5 (53.1, 73.1)	158	57.6 (49.5, 65.4)
Asaro	100	49.0 (38.9, 59.2)	101	53.5 (43.3, 63.5)	201	51.2 (44.1, 58.3)
Karkar	73	32.9 (22.3, 44.9)	77	46.8 (35.3, 58.5)	150	40.0 (32.1, 48.3)
Overall	**235**	**43.8 (37.4, 50.4)**	**274**	**55.1 (49.0, 61.1)**	**509**	**49.9 (45.5, 54.3)**

Anaemia

Table 29 presents the percentage of participants meeting the World Health Organisation (WHO) criteria for anaemia (female Hb ≤12.0 g/dL and male ≤13.0 g/dL). Anaemia was most prevalent among both male and female participants from Karkar iHDSS (67.0% and 75.4%, respectively) and lowest overall in Asaro (24.4%). Inter-site variation reached levels of statistical significance for males (p<0.001), females (p<0.001) and the combined sample (p<0.001).

Table 29. Percentage meeting WHO criteria for anaemia (female Hb ≤12.0 g/dL and male ≤13.0 g/dL).

Site	**Male**		**Female**		**Combined**	
	No.	% (95% CI)	No.	% (95% CI)	No.	% (95% CI)
Hiri	112	17.0 (10.5, 25.2)	150	47.3 (39.1, 55.6)	261	34.1 (28.4, 40.2)
Asaro	118	21.2 (14.2, 29.7)	117	27.4 (19.5, 36.4)	234	24.4 (19.0, 30.4)
Karkar	115	67.0 (57.6, 75.4)	134	75.4 (67.2, 82.4)	247	71.7 (65.6, 77.2)
Overall	**345**	**35.1 (30.0, 40.4)**	**401**	**50.9 (45.9, 55.9)**	**742**	**43.5 (39.9, 47.2)**

Haemoglobin A1c

Haemoglobin A1c (HbA1c) is a measure of the percent of glucose in the blood stream. A HbA1c result of less than 5.7% is considered 'normal', 5.7% to 6.4% is considered pre-diabetic (i.e. 'at risk' of developing diabetes mellitus type 2) and 6.5% or more is considered diagnostic of diabetes. Table 30 presents HbA1c results by iHDSS. Overall, 18.7% of participants had blood glucose levels in the pre-diabetic (15.1%) or diabetic (3.6%) range. Prevalence was highest in the Hiri iHDSS where 34.5% of adult participants tested in the pre-diabetic (25.3%) or diabetic (9.2%) range. Inter-site variation in the proportion of participants in each HbA1c category reached a level of statistical significance (p=0.001).

Table 30. Percentage of participants' with HbA1c results in the pre-diabetic (5.7% to 6.4%) or diabetic (6.5%+) range.

Site	No.	HbA1c result	
		Pre-diabetic % (95% CI)	Diabetic % (95% CI)
Hiri	261	25.3 (20.1, 31.0)	9.2 (6.0, 13.4)
Asaro	220	11.8 (7.9, 16.8)	0 (0, 1.6)
Karkar	240	7.1 (4.2, 11.1)	0.8 (0.01, 3.0)
Overall	**721**	**15.1 (12.6, 17.9)**	**3.6 (2.4, 5.2)**

Lipid Profile

Elevated cholesterol and triglycerides are known risk factors for cardiovascular disease. The percentage of participants with elevated levels of these respective lipids are presented in Table 31. As shown, 17.7% of all participants had elevated cholesterol levels and 32.6% elevated triglyceride levels. Inter-site variation reached a level of statistical significance for both elevated cholesterol ($p=0.005$) and elevated triglycerides ($p<0.001$).

Table 31. Percentage of participants' meeting criteria for elevated cholesterol (>6.2mmol/L) and elevated triglycerides (>2. 3mmol/L)

Site	No.	Elevated cholesterol	Elevated triglycerides
		% (95% CI)	% (95% CI)
Hiri	265	23.4 (18.4, 29.0)	43.6 (37.5, 49.8)
Asaro	218	16.1 (11.4, 21.6)	35.3 (29.0, 42.1)
Karkar	219	12.3 (8.3, 17.4)	16.8 (12.1, 22.4)
Overall	**702**	**17.7 (14.9, 20.7)**	**32.6 (29.2, 36.2)**

Microalbuminuria

Tables 32 and 33 presents the percentage of participants with microalbuminuria and with abnormally high microalbuminuria levels, respectively. As shown, 63.5% of participants had microalbuminuria and 2.8% had abnormally high microalbuminuria levels. Statistically significant inter-site variation was identified on both measures with respect to males ($p<0.001$ & $p=0.017$, respectively), females ($p<0.001$ & $p=0.023$, respectively) and the combined sample (both $p<0.001$).

Table 32. Percentage of participants with microalbuminuria present (males = albumin/creatinine ratio (ACR) ≥2.5mg/mmol; females = ACR ≥3.5mg/mmol)

Site	**Male**		**Female**		**Combined**	
	No.	% (95% CI)	No.	% (95% CI)	No.	% (95% CI)
Hiri	89	86.5 (77.6, 92.8)	132	91.7 (85.6, 95.8)	121	89.6 (85.0, 93.3)
Asaro	109	92.7 (86.0, 96.8)	109	86.2 (78.3, 92.1)	218	89.4 (84.6, 94.2)
Karkar	92	6.5 (2.4, 13.7)	110	7.3 (3.2, 13.8)	202	6.9 (3.8, 11.4)
Overall	**290**	**63.4 (57.6, 69.0)**	**351**	**63.5 (58.3, 68.6)**	**641**	**63.5 (59.6, 67.2)**

Table 33. Percentage of participants with abnormally high microalbuminuria levels (males ACR >25 mg/mmol; females ACR >35 mg/mmol)

Site	**Male**		**Female**		**Combined**	
	No.	% (95% CI)	No.	% (95% CI)	No.	% (95% CI)
Hiri	89	5.6 (1.8, 12.6)	132	6.8 (3.2, 12.5)	221	6.3 (3.5, 10.4)
Asaro	109	0.9 (0.02, 5.0)	109	1.8 (0.2, 6.5)	218	1.4 (0.3, 4.0)
Karkar	92	0 (0, 3.9)	110	0.9 (0.02, 5.0)	202	0.5 (0.01, 2.7)
Overall	**290**	**2.1 (0.8, 4.4)**	**351**	**3.4 (1.8, 5.9)**	**641**	**2.8 (1.7, 4.4)**

4. DISCUSSION

This report presents key findings from a survey of NCDs and associated risk factors in the general adult populations of the Hiri, Asaro Valley and Karkar Island iHDSS. The data were collected during the construction phase of the Exxon Mobil led PNG LNG project. As such, the reported findings serve as a baseline of NCD prevalence and associated risk factors in the initial years of a PNG LNG project impact site (Hiri) and in two non-project impact communities (Asaro and Karkar) in the period immediately prior to anticipated accelerated growth in PNG's gross domestic product (as a result of the PNG LNG project). The three study populations were comparable in terms of participant age and gender; however, the Hiri participant population was better educated and more likely to be in paid employment as compared to participants' from Asaro and Karkar. These differences in education and employment were expected and reflect the different socioeconomic contexts of the three iHDSS. A multitude of differences in the prevalence of NCD risk factors were also observed across sites (discussed in more detail below) and no one site had a consistently higher or lower prevalence of each risk factor assessed. The study findings will be discussed in the context of each iHDSS below and then an overall summary presented.

Hiri iHDSS

Food consumption data for Hiri indicate a diet low in root vegetables, green vegetables and fruits (consumed on a median of 2, 1 and 1 days per week, respectively) and a comparatively high consumption of fresh- and tinned-meats (consumed on a median of 4 and 5 days per week, respectively). Food insecurity was widely perceived to be a problem in the Hiri iHDSS (44.8% of participants) and those participants who reported perceived food insecurity considered it to be a more frequent occurrence in Hiri as compared to other iHDSS. Hiri participants were the least likely to be daily smokers (36.5%), although not at a statistically significant level; however, buai consumption was highest in Hiri (93.5%) as was alcohol consumption over the past 12-months or 30-days (58.3% & 45.1%, respectively). Hiri smokers most commonly smoked manufactured cigarettes and the use of brus (home grown tobacco) was not reported. Hiri participants were, on average, taller and heavier than their counterparts from Asaro and Karkar and were more likely to be overweight (24.5%) or obese (22.3%) based on BMI criteria. Nevertheless, across all three iHDSS the mean waist-to-hip

ratio (WHR) was lowest among Hiri participants who were also the least likely to meet WHR-based criteria for a substantially increased risk of metabolic complications. This raises the possibility that the higher mean BMI among Hiri participants may reflect differences in body mass composition rather than greater body fat per se.

Few Hiri participants reported a history of NCD disease or any experience of NCD-related symptoms, a majority (62.6%) rated their general health as 'good' and most thought their health was 'the same as' (63%) or 'better than" (30.5%) others. However, of the seven clinical indicators of NCD risk presented in this report, six were highest among Hiri participants, including: hypertension (22%), abnormal lung function (57.6%), HbA1c (25.3% pre-diabetic, 9.2% diabetic), microalbuminuria (89.6%), elevated cholesterol (23.4%) and elevated triglycerides (43.6%). Collectively, these findings indicate that out of the three iHDSS included in this survey Hiri has the greatest NCD burden and/or is the population most at risk of developing a high NCD burden.

Asaro iHDSS

Food consumption data indicate ready access to the root- and green-vegetables associated with a subsistence farming lifestyle. However, consumption of either fresh or tinned meat was lowest in Asaro (median of 1 and 2 days per week, respectively) and the median consumption of fats, sugars and salts was higher than the peri-urban Hiri population. Perceived food insecurity was also highest in Asaro iHDSS (64.3%). Prevalence of daily smoking (41%) was in-between that of Hiri and Karkar (31.5% & 50.5%, respectively), buai consumption (55.1%) was the lowest of the three iHDSS and alcohol consumption over the past 12-months (40.4%) or 30-days (22.9%) was substantially higher than Karkar (19.6% & 7.1%, respectively) and closer to that of Hiri. Mean height and weights were middling of the three iHDSS as was BMI, although 88.6% of participants from Asaro had a WHR indicative of a substantial risk of metabolic complications. This was the highest percentage among the three iHDSS and suggests the Asaro (Highlands) population may be particularly susceptible to a build-up of abdominal adipose tissue. Asaro participants most commonly rated their own general health as 'moderate' (42.5%) or 'bad' (42.9%), even though very few reported any history of NCD disease or NCD-related symptoms. Consistent with this common perception of poor health, many of the clinical indictors were comparable to the high risk Hiri population: the prevalence of hypertension (21.2%) was only marginally lower than in Hiri

(22%) and substantially higher than Karkar (4.8%) and close to a quarter of participants had elevated cholesterol or triglyceride levels (16.1%, and 35.3%, respectively). Abnormal lung function and microalbuminuria were also particularly high among Asaro Valley participants (51.2% & 89.4%, respectively), although HbA1c results indicative of diabetes were absent (0%). These findings are indicative of a high risk of cardiovascular and respiratory disease, and at a level similar to Hiri iHDSS, but lower risk of type II diabetes mellitus at present.

Karkar iHDSS

Food consumption data indicated a healthier diet among Karkar iHDSS participants as compared to their Hiri and Asaro peers. Root- and green-vegetables were consumed on a median of seven days of the week, fresh meat was consumed a median of two days per week and consumption of fats, sugars and salts were rarely reported. Furthermore, only 6.9% of participants perceived any food shortages in the community, a level significantly lower than Hiri or Asaro. Karkar did report the highest percentage of daily smokers (50.5%), almost all of whom exclusively smoked brus (95.6%), and a high percentage (86.5%) chewed buai within the past 30 days; however, alcohol consumption was the lowest among all three iHDSS with only 19.6% reporting alcohol use in the past 12-months and 7.1% alcohol use in the past 30 days. Mean heights and weights were lowest among Karkar participants as was the mean BMI with only 10.8% of participants overweight (8%) or obese (2.8%), although 61.9% had a WHR indicative of a substantially increased risk of metabolic complications. Karkar participants generally considered themselves to be healthy with 69.8% rating their own health as 'excellent' and only 4.8% reporting a current *wari* or *hevi*. This self-perception of good health was (to a certain extent) reflected in the clinical indicators with the Karkar sample having the lowest prevalence of: hypertension (4.8%), elevated triglycerides (16.8%), microalbuminuria (6.9%) and abnormal lung function (40%). Prevalence of elevated cholesterol (12.3%) was comparable to Asaro (16.1%) and lower than Hiri (23.4%), as were the percentage of participants with HbA1c results in the pre-diabetic (7.1%) or diabetic (0.8%) range. The only clinical indicator in which Karkar participants had a higher prevalence than their counterparts in other iHDSS was anaemia. Overall, 71.7% of Karkar participants were anaemic as compared to 34.1% and 24.4% in Hiri and Asaro, respectively. Collectively, these data indicate NCD risk was lowest in the Karkar iHDSS, although findings pertaining to smoking prevalence, WHR, cholesterol, lung function and anaemia remain of substantial concern.

Summary

The reported findings indicate a substantial existing NCD burden in the general adult population of Hiri or, in the very least, a population at serious risk of developing a high NCD burden. As few Hiri participants had previously been diagnosed with an NCD and/or reported NCD-related symptoms then, despite the high NCD burden, general population awareness of NCDs and NCD risk factors would appear to be low and current NCD prevention, screening and treatment services inadequate. As study participants from Hiri had the highest level of educational attainment, were more likely to be in paid and professional employment and have ready access to health facilities and programs in the nation's capital (as compared to participants from Asaro and Karker), then the apparent lack of NCD awareness in the Hiri general population and inadequate professional support is of particular concern. Higher NCD prevalence in this population is likely to be the result of a number of factors including genetic susceptibility and proximity to Port Moresby. Nevertheless, NCD risk is likely to be further heightened by the economic and lifestyle changes resulting from the PNG LNG project (given its predicted contribution to future Gross Domestic Product) that – due to the presence of both the PNG LNG processing site and proximity to Port Moresby – the Hiri iHDSS population are likely to experience to a greater extent relative to other iHDSS. The reported findings, therefore, indicate an immediate need for NCD prevention, screening and intervention programs in this project impact site.

The reported findings further indicate the NCD burden/risk is lower in Asaro iHDSS as compared to Hiri, although not substantially so. The NCD burden/risk was lowest of all in Karkar iHDSS, although risk factors of considerable concern were still evident in a large proportion of this population. Indeed, risk factors for cardiovascular and respiratory disease were evident in a large proportion of study participants across all sites. The major difference in terms of NCD risk between the peri-urban Hiri population and the rural Asaro and Karkar populations pertained to diabetes. BMI and HbA1c results indicated a substantially higher prevalence and/or risk of diabetes mellitus type II in Hiri as compared to the other sites. The findings from Asaro and Karkar iHDSS' are most likely to be reflective of NCD prevalence and risk in the broader (largely rural) population of PNG. Thus, it is of considerable concern that up to 21.3% and 35.3% of adult participants in these iHDSS had elevated cholesterol or triglycerides (respectively), 7-11% had high blood glucose levels, 40-51.2% had abnormal lung function and up to 21.2% were hypertensive. Few participants (and even fewer than

Hiri) reported having received an NCD diagnosis further suggesting current screening and intervention programs may be inadequate or potentially non-existent in these rural populations. In addition, the reported prevalence of NCDs and associated risk factors were substantially higher than those reported in earlier studies from the same or comparable communities [37-42]. For example, Scrimgeour et al [37] found no cases of elevated cholesterol or triglycerides in a randomised cross sectional survey conducted in the Asaro valley in the late 1980s, and Boyce at al reported no cases of hypertension in a cross sectional survey conducted on Karkar island in the late 1970s [38]. The findings from Asaro and Karkar iHDSS', when viewed in the light of these earlier studies, are strongly suggestive of a generalised increase in NCD burden and risk across the country.

The need for prevention, screening and intervention campaigns may be less urgent in Asaro and Karkar relative to Hiri; however, complacency will only exacerbate the future cost of the NCD burden to these communities. Thus, NCD prevention and health promotion campaigns should be prioritised in the short-term across all iHDSS with more intensive screening and intervention programs targeted towards Hiri iHDSS. The particularly high rates of elevated cholesterol and triglycerides as well as hypertension further suggest that cardiovascular disease prevention and treatment may warrant a priority focus across all iHDSS. Prevention and treatment programs pertaining to diabetes mellitus should be prioritised in Hiri. The Asaro and Karkar iHDSS continue to present as especially valuable longitudinal surveillance sites in which the NCD burden and associated risk factors may be closely monitored over time. As suggested, NCD prevalence in these sites is likely to be reasonably representative of rural communities across PNG. The same is less true of the Hiri iHDSS. Such long-term NCD surveillance in the Asaro and Karkar iHDSS would afford some assessment of the impact of NCD prevention campaigns and provide advance warning for the need to scale up screening and intervention programs elsewhere.

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