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The extent to which the domestic conditions of cocoa farmers in Bougainville impede livelihoods

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ABSTRACT

Background: Bougainville, an autonomous region of Papua New Guinea (PNG) is slowly improving services and infrastructure destroyed 20 years ago during the ten year civil war. However, the region still faces significant constraints to economic growth and human development and remains under-developed compared to PNG and close Pacific neighbours. PNG's 2017 Human Development Category (HDC) was one of the lowest at 0.544. The Bougainville Strategic Development Plan 2018–2022 noted significant gaps in health services and infrastructure, had inadequate water and waste disposal and experienced weak markets and cocoa quality. This research examines domestic conditions and the extent to which they impact on livelihoods.

Method: A cross-sectional livelihood survey was administered to cocoa growing households in 33 Village Assemblies (VAs) with 11 VAs in each of the three regions.

Results: Data was collected from 5172 individuals. A significant majority of households reported multiple health issues, rudimentary housing, unimproved sanitation and unimproved water. Over two-thirds of cocoa growers did not sell any cocoa bags in 2014–2016 resulting in low incomes and greater food insecurity compared to families selling cocoa. Families that produced no saleable cocoa were more likely to have rudimentary housing, unimproved toilet facilities and unsafe water, factors that increase the likelihood of chronic disease and exacerbate malnutrition and poor labour productivity.

Conclusion: This study provides key information about the health and livelihood status of cocoa growers in Bougainville. If productivity is to increase, farmer health needs to improve including improving water and sanitation practices and diets. Building a responsive health system for the community is a challenge when a majority of the population live in small villages with difficult access to health centres. Establishing and integrating outreach village health clinics will enable health care to be more accessible to these remote communities.

1. Introduction

The Autonomous Region of Bougainville (ARoB), with a population of 270,000 [1] voted overwhelmingly in 2019 to become a separate country from Papua New Guinea (PNG). More than one-third of the population in PNG including Bougainville lives below the World Bank estimate of \$1.90 per day required for basic needs [2]. Improving cocoa farmer's livelihoods is key to growing Bougainville's economy and supporting country status. The term livelihood is used to describe how

people make a living, and encompasses people's capabilities (including health and education), assets, income and activities required to secure the necessities of life [3]. Life expectancy for Bougainvillians for males and females is 58.8 and 60.4 years respectively compared to the PNG national average of 64 and 68 years for men and women respectively. Today the majority of the population in Bougainville are under 30 [5]. The Bougainville Strategic Development Plan 2018–2022 noted significant gaps in health services, basic infrastructure, unimproved water sources, unimproved waste disposal, poor markets and cocoa quality

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[6]. Lowering the incidence of diarrhoeal disease, increasing immunisation, improving nutrition and access to health care are key priorities for the ARoB. The Bougainville Government's 2018 agricultural strategy included increasing cocoa farmer skills and diversifying quality and quantity of cash crop exports and building resilience in food security among communities [6].

Because the challenges faced by Bougainville are multifactorial and cross many government areas and responsibilities, the traditional research methods were not deemed appropriate or informative for understanding cocoa farmer livelihoods. Instead a One Health method was selected to better understand the circumstances and challenges facing cocoa farming families. One of the preliminary activities undertaken was the administration of a livelihood survey covering household characteristics, cocoa farming, men's and women's health and child health (under 5 years), plus environmental and cultural questions about religion, food security, water sources, sanitation practices, domestic violence, family planning. Our research produces new knowledge about the lived experience of cocoa growers in Bougainville and the extent to which their domestic conditions impact on livelihoods and productivity. Domestic conditions of cocoa farmers includes information about education, housing, transport, food security, health of men and women, access to safe water, sanitation practices, bank account, mobile phone ownership. The survey collected additional information about religion, attitudes to domestic violence, labour supply, agricultural practices, land ownership, nutrition, maternal and child health which are analysed in separate papers. A detailed description of the One Health method used in this research is also covered in a separate paper.

This research, part of an Australian Government funded One Health 6-year project 'Developing the cocoa value chain in Bougainville', describes the main domestic conditions including health experienced by cocoa growing households in Bougainville and investigates their relationship to livelihoods and productivity.

2. Impact of the 'crisis'

Bougainville is slowly rebuilding infrastructure after the destruction of bridges, roads, and health and social services during the civil war of 1988–1998 where over 15,000 people died [2]. Significant constraints to economic growth and human development remain with Bougainville still under-developed compared to PNG and close Pacific neighbours. Papua New Guinea's Human Development Category (HDC) in 2017 was one of the lowest at 0.544, ranking it 153 out of 189 countries and territories behind Tonga (98/189), Samoa (104/189) and Timor Leste (132/189). [2]

3. Cocoa growing in Bougainville

Constraints facing cocoa farmers, who comprise two-thirds of the population, include managing plant pests and diseases, farmer training and markets [6] but knowledge about non-agricultural challenges may also impact on farmers' yields and livelihoods. Research elsewhere shows under-nutrition of cocoa growers results in ill health, poor cognitive development and increased health care costs associated with low productivity [8]. A study of nutrition in PNG estimated that under-nutrition cost the government USD 508 million noting poor health, impaired cognitive ability, a less productive labour force and healthcare expenditure associated with childhood undernutrition in the 2016–2017 financial year [9]. Children in cocoa households in the Cote d'Ivoire suffer acute malnutrition as a consequence of inadequate food, often associated with infectious diseases [10]. A 2019 report on food systems in 251 households in South Bougainville found that irrespective of wealth, households were not consuming the minimum daily amount of protein [11].

4. One health approach

Implementing agricultural practices to improve productivity without considering the multiple factors that might impact on productivity is short-sighted. A One Health Framework [12] anticipates that multiple factors, such as education, poverty, food insecurity, poor health, unsafe water, vector-borne diseases, sanitation practices, may also play a part. Lack of market incentives, poor infrastructure, transport systems and climate uncertainty are also likely factors. [9]

Cocoa production does not occur in a vacuum but is part of an ecosystem comprising humans, animals, plants, soils and the environment. Public health advances have long acknowledged the close relationships between human, animal and environmental health [13–15] but research about their interdependency is recent. Using a One Health Framework [12] the multiple factors underpinning cocoa production in Bougainville were identified by the research team, the research partners (ARoB) and invited participants (Government department staff, farmers, women's groups, farmer cooperatives, community leaders) in a workshop conducted in Bougainville in 2016. The One Health integrated approach highlighted the many factors and uncertainties associated with cocoa production (Table 1).

5. Method

5.1. Consultation with the community

Extensive consultations were held with the ARoB local and district governments and village representatives about the research, the One Health method, and the planned survey and village selection. The agreed sampling unit was the Village Assembly (VA) comprising clusters of two or more settlements. An Advisory Committee was established to provide advice. (Table 2).

5.2. The Livelihood questionnaire

A livelihood questionnaire incorporated relevant components from validated tools including the UNICEF Multiple Indicator Cluster Survey, the USAID Demographic and Health Survey and the WHO World Health Survey plus questions about plant management, cocoa production, pests and livestock from two previous surveys administered by ACIAR projects ASEM/2006/127 and PC/2012/051. Questions were contextualised and modified after piloting and translated into Tok Pisin. The survey was undertaken over a 12-month period in 2017. The questionnaire covered the following seven areas: (i) household demographics and characteristics [education, housing, food security, asset ownership, income, water sources, water storage and availability, hygiene and sanitation practices, diet], (ii) cocoa farming (agricultural practices), (iii) men's health ([15 years and older], religion, health care utilisation, chronic health conditions, access to health care, history of morbidity/illness, attitudes to domestic violence), (iv) [4] women's health ([15–49 years] religion, health care utilisation, chronic health conditions, access to health care, history of morbidity/illness, attitudes to domestic violence), (v) children (under 5 years), (vi) [7] women's anthropometric measurements (15–49 years) and (vii) [7] children's anthropometric measurements (under 5 years). Anthropometric measurements were captured using stadiometers and scales by trained team members.

5.3. Selection of Interviewers and Households

Three teams of 10 interviewers (n=30) were recruited with an equal number of men and women who attended a 4-day training program. Interviewers remained in the field until all households had been interviewed. A cross-sectional livelihood survey was administered to all households in the 33 (out of 442) VAs (village assemblies) from the districts of Siwai, Buin, Bana, Torokina, Kieta, Panguna, Wakunai,

Table 1

Using a One Health Research Framework for investigating low productivity of cocoa farmers (this conceptualisation used the framework developed by Lebov et al. [12]).

Farming factors	Potential environmental factors	Potential animal factors	Potential human health factors	Potential human behaviour/susceptibility factors
Cash crop (cocoa, copra) production	Farm management	Domestic animals	Malaria	Poor adoption of improved production methodologies
Food crop production	Water sources	Pigs	Disease vectors (mosquitoes)	Few incentives to increase production
Farm management skills	Soil degradation	Chickens	Tuberculosis	High price volatility
Income diversification	Deforestation	Wild animals	Respiratory diseases	Fortress crop (crops for cash when needed)
Number and size of blocks	Forest conservation	Loss of animal habitat	Communicable diseases	Labour shortages
Market knowledge	Food security	Extinction	Non-Communicable diseases	Poor education
Pests	Climate uncertainty	Food sources	Other chronic conditions (Diabetes)	Poor access to government services (health, education, agriculture and veterinary)
			Lack of medications	Poor roads
			Lack of health professionals	Poor transport systems and market access
			Lack of health services	Low borrowing capacity (Banks)
			Prevalence of Domestic violence	Poor housing conditions
				Unimproved water sources
				Unimproved sanitation
				Proximity to animals
				Food insecurity
				Nutrition insecurity
				Women's roles
				Cultural norms (births, deaths)
				Beliefs (health, food, witchcraft)
				Religion

Many uncertainties relate to low production of cocoa – A One Health methodology explores the possible factors associated with poor cocoa production. Factors in bold are new One Health factors.

This is not a comprehensive list, but the key areas that arose during discussions with the research team and workshop participants.

Table 1

Factors considered for selecting sample population for survey.

Village Assemblies: majority of villages:-
<ul style="list-style-type: none"> ● had to grow cocoa or identify as a cocoa farmer ● had the potential to show leadership and sustain motivation ● had the potential to expand outside of the Village Assembly ● complement existing projects on the ground ● were a balance between villages with good transport access and those in more remote places ● were a good balance between communities that have and have not received support ● did not duplicate other projects ● had the potential for diversification ● were secure in farm ownership ● had good geographic spread

Tinputz, Selau Suir, Buka and Kunua, representing 11 VAs from each region. Villages were purposively selected by the advisory committee based on the factors listed in Table 2. Households qualified for interview if they grew cocoa or identified as a cocoa grower. One selected village declined to participate due to one of the interviewers being on an opposing side during the civil war. Another village from the same area was added.

5.4. Statistical analysis

Data were captured and stored on the CommCare server and downloaded into Excel. Data processing involved a number of steps 1) removing households and individuals who did not consent 2) removing duplicated entries 3) editing and coding open ended variables and 4) merging sections into a single dataframe. The CommCare generated unique identifier form.case.@case_id was used for merging sections and for repeat groups we used 'number'. All data analysis and manipulation was done using R.

Health outcomes included food security measures (based on the Household Food Insecurity Access Scale (HFIAS) [16] and whether respondents had ever been treated for backpain, arthritis, angina, asthma, diabetes, dental issues, malaria, tuberculosis, depression, mental health, alcohol consumed and number of betel nuts (buai) chewed per day. Water and sanitation were classified as improved or unimproved using WHO definitions. A severely food insecure household is one that has cut back on portion size or the number of meals eaten per day and/or has experienced either going to bed hungry, running out of food or going a full 24 h without eating. Anthropometric indices height-for-age and weight-for-height were calculated using the 2006 WHO Child Growth Standards [17].

Table 2
Sample population.

Category	Number eligible for interview	Number of respondents	Lost to follow-up ^a
Household	2475	2348	127
Men	3058	1993	1065
Women	2531	1911	620
Child	1384	1268	116
Child Anthropometrics	1388	1281	107
Women Anthropometrics	2201	1796	405

Total number registered household members 11,685 (data was captured on all household members but only one person from a household interviewed)

^a Lost to follow-up includes non-responders. These are cases which were registered in a household listing, but the head of the household was not available for interview (away, at work, at school, sick or refusal).

An index that represents accumulated chronic health conditions was calculated by combining the conditions of backpain, arthritis, angina, asthma, and diabetes. A score of 5, for example, represents a respondent who has reported all 5 chronic health problems. A Welch's *t*-test was used for the bivariate comparison of cocoa production (\log_e number of cocoa bags produced) and health outcomes.

6. Results

6.1. Demographics and education

Data were collected from 5172 individuals (1993 men; 1911 women; 1268 children under 5 years). Table 3 shows the breakdown of those surveyed including the number of anthropometric measures taken. A total 57.3% were in the productive years 15–64 years with 40.8% of the 0–14 years in the non-productive years. Only 1.9% were over 65 years. The population breakdown shows a high birth rate and high death rate for those over 65 years. Increasing population, but declining fertility, child mortality or migration may account for the base not being maintained in terms of growth numbers of male and female babies (Table 4).

6.2. Education

Similar numbers of males (24.8%) and females (24%) had no schooling with slightly more females attending primary school. Although only 16% attended a high school or a tertiary institution males outnumbered females with twice as many males attending a university (Table 4).

Table 4
Household education and age groups.

	Female	Male	Female vs male (p-value)	Total
Characteristic	(n = 5692)	(n = 5993)		(n = 11,685)
Education level				
No school	1365 (24.0%)	1486 (24.8%)	0.37	2851 (24.4%)
Primary	3484 (61.2%)	3513 (58.6%)	0.07	6997 (59.9%)
Highschool	738 (13.0%)	782 (13.0%)	0.91	1520 (13.0%)
Tertiary	105 (1.8%)	212 (3.5%)	< 0.0001	317 (2.7%)
Age groups				
< 5	784 (13.8%)	838 (14.0%)	0.76	1622 (13.9%)
5–14	1500 (26.4%)	1643 (27.4%)	0.27	3143 (26.9%)
15–49	2830 (49.7%)	2872 (47.9%)	0.16	5702 (48.8%)
50–64	492 (8.6%)	499 (8.3%)	0.56	991 (8.5%)
65+	83 (1.5%)	137 (2.3%)	0.001	220 (1.9%)
Missing	3 (0.1%)	4 (0.1%)		7 (0.1%)

6.3. Household characteristics

Data were collected for floor and wall materials as well as source of drinking water and sanitation practices.

6.3.1. Housing

Just over half, 53.2% of households, had natural or rudimentary floor material (earth, sand, palm, wood planks, mud, bamboo or mats) and 82.6% of houses had either natural or rudimentary walls (no walls, cane, palm, trunks, plywood, cardboard, mud bricks) (Table 5).

6.3.2. Transport

Less than half (42.2%) owned any transport. Only 19.8% of those living in Central region owned transport compared to nearly half of those in the North owning some transport (50.8%) (Table 5).

6.3.3. Food security

Nearly half the households interviewed were food insecure (47.1%). Across all households approximately 40% reported being worried about not having enough food to eat in the four weeks preceding the survey. The most food insecure region was the North (54.9%) with the least food insecure the South (37.6%) (Table 5). Almost a third of men ($n = 502$) and women ($n = 408$) experiencing food insecurity were from households categorised as severely food insecure. Similarly, around 40% reported having a limited variety of foods due to a lack of resources.

6.3.4. Bank accounts and phone ownership

Only one third of the surveyed population had a bank account (33.4%) but nearly two thirds owned a mobile phone (60.4%) with the South having the highest percentage of mobile phone ownership (67.7%) and Central region having less than half owning a mobile (48.3%) (Table 5).

6.4. Water

Nearly one third (30.6%) had unimproved drinking water (unprotected wells/springs, surface water, tanks/drums, bottled water) with significant variation among the three regions with the South (45.1%) having the highest percentage of unimproved drinking water. Overall only 13.5% had improved pipe water, with 42.2% of those in the Central region having improved pipe water compared to the South (7.4%) and the North (6.9%) (Table 7).

6.5. Sanitation

A high percentage of households (61.3%) had unimproved sanitation (shared toilets, pit toilet, latrine, bucket, river, bush, field) and was a feature for all three regions; South (65.7%), North (63.8%) and the Central (46.9%) (Table 7). Open defecation was practised by 44% of the population. Composting toilets (34.7%) and flush septic tank facility (2.3%) were more common in Central Bougainville compared to the south where only 5.5% of toilets are composting and 0.4% using flush septic tank.

6.6. Health of household members

More women than men (aged 15–49 years) reported symptoms associated with arthritis, angina, diabetes, eyesight, depression and dental issues although a formal diagnosis was rare (Table 8). The most common health condition was back pain with both men (48.4%) and women (57.9%) reporting back pain during the 30 days preceding the survey. Over one-third of both sexes had a diagnosis of arthritis with 17% of women and 12% of men receiving treatment. In the 12 months prior to the survey, 265 (17.3%) men and 377 (19.7%) of women reported pain, aching, stiffness or swelling in or around a joint unrelated

Table 5
Household characteristics.

Characteristic	Central n (%) (n = 429)	North n (%) (n = 1166)	South n (%) (n = 763)	P-value	Total n (%) (n = 2348)
Floor material					
Finished	174 (40.6%)	675 (57.9%)	135 (17.9%)	< 0.0001	984 (41.9%)
Natural	8 (1.9%)	192 (16.5%)	43 (5.7%)	< 0.0001	243 (10.3%)
Rudimentary	237 (55.2%)	265 (22.7%)	505 (67.1%)	< 0.0001	1007 (42.9%)
Missing	10 (2.3%)	34 (2.9%)	70 (9.3%)		114 (4.9%)
Wall material					
Finished	61 (14.2%)	307 (26.3%)	34 (4.5%)	< 0.0001	402 (17.1%)
Natural	43 (10.0%)	50 (4.3%)	16 (2.1%)	< 0.0001	109 (4.6%)
Rudimentary	321 (74.8%)	808 (69.3%)	702 (93.2%)	< 0.0001	1831 (78.0%)
Missing	4 (0.9%)	1 (0.1%)	1 (0.1%)		6 (0.3%)
Family Size					
Mean (SD)	4.01 (2.32)	5.11 (2.17)	4.80 (2.23)		4.81 (2.25)
Number of sleeping rooms					
> 2	349 (81.4%)	938 (80.4%)	623 (82.7%)	0.96	1910 (81.3%)
2 or less	80 (18.6%)	228 (19.6%)	130 (17.3%)	0.46	438 (18.7%)
Bank account ownership	143 (33.3%)	405 (34.7%)	238 (31.6%)	0.42	786 (33.5%)
Mobile phone ownership-yes	207 (48.3%)	701 (60.1%)	510 (67.7%)	0.83	1418 (60.4%)
Transport ownership(bicycle, motorbike, boat)	85 (19.8%)	592 (50.8%)	314 (41.7%)	< 0.0001	991 (42.2%)
Food Secure	245 (57.1%)	526 (45.1%)	470 (62.4%)	< 0.0001	1241 (52.9%)

to injury. One fifth of women (19.5%; $n = 373$) reported blurry vision yet only 10.7% had ever had an eye examination. Slightly fewer men reported blurry vision with 14.4% ($n = 221$) ever having had an eye examination. Significantly fewer women (16.1%) reported drinking alcohol compared to men (68.1%) but a significant percentage of both sexes chewed buai (betel nut) with over half of women ($n = 1035$; 53%) starting between the ages of 11 and 20. Fewer (less than 10%) men and women reported symptoms of asthma, diabetes, depression and mental health (Table 8).

6.7. Reasons for seeking health care

The five main reasons for men seeking health care in the previous six months were fever, cough, injury, malaria and arthritis (Table 9). A similar percentage of women and men sought health care for fever. Only 28% per cent ($n = 430$) of men sought health care in the previous 12 months with 65.7% (1008 out of 1532) indicating they had sought health care at some stage. Significantly fewer men than women sought health care in the previous 12 months, however the percentage changes over longer timeframes (greater than one year). Over one quarter of both men and women had never sought health care (Table 9). Table 9 shows that more men (22.3%, $n = 342$) than women (14.4%, $n = 275$)

Table 7
Household water and sanitation.

Characteristic	Central n (%) (n = 429)	North n (%) (n = 1166)	South n (%) (n = 763)	p-value	Total n (%) (n = 2348)
Drinking water source					
Improved non-piped water	131 (30.5%)	824 (70.7%)	357 (47.4%)	< 0.0001	1312 (55.9%)
Improved piped water	181 (42.2%)	81 (6.9%)	56 (7.4%)	< 0.0001	318 (13.5%)
Unimproved	54 (12.6%)	235 (20.2%)	309 (41.0%)	< 0.0001	598 (25.5%)
Surface water	63 (14.7%)	26 (2.2%)	31 (4.1%)	< 0.0001	120 (5.1%)
Toilet facility					
Improved	228 (53.1%)	421 (36.1%)	258 (34.3%)	< 0.0001	907 (38.6%)
Unimproved	84 (19.6%)	116 (9.9%)	207 (27.5%)	< 0.0001	407 (17.3%)
Open Defecation	117 (27.3%)	629 (53.9%)	288 (38.2%)	< 0.0001	1034 (44.0%)
Toilet shared between households	226 (52.7%)	351 (30.1%)	239 (31.7%)	< 0.0001	816 (34.8%)
Yes					
Handwashing facility					
Observed	175 (40.8%)	673 (57.7%)	159 (21.1%)	< 0.0001	1007 (42.9%)
Not in dwelling/not	254 (59.2%)	493 (42.3%)	594 (78.9%)	< 0.0001	1341 (57.1%)

were treated for malaria in the preceding 6 months. A similar number of women (11%; $n = 211$) and men (12.7%, $n = 195$) reported a cough lasting more than 3 weeks in the previous 12 months. Very few men or women were tested for tuberculosis (men 1.8%, $n = 27$ and women 1.6%, $n = 31$).

6.8. Women and children < 5 years anthropometric measurements

A total 1796 women aged between 15 and 49 were weighed and measured to determine their body mass index. Anthropometric measurement data were available from 1738 (97%) individuals and of these 108 (6.2%) were underweight, 1122 (64.6%) were normal weight and 375 (21.6%) overweight and 132 (7.6%) obese. Anthropometric data were available for 1104 children < 5 yrs., of whom 1009 had complete and valid data for height and age and 1033 for weight and height. Among < 5 yrs., 36.5% of children were stunted, 4.7% wasted (women and children's anthropometric measurements are reported separately in another publication being prepared by the research team).

6.9. Cocoa production and health in men and women

The data showed that 73.85% (1734 of 2348) of the households did

Table 8

Proportion of men and women (15–49 years of age) who have been diagnosed or experienced chronic health conditions and whether they received treatment or medication.

Health condition	Women (n = 1911)			Men (n = 1532)		
	Ever Diagnosed/ Experience (%)	Ever treated n (%)	Received medication n (%)	Ever Diagnosed/ Experienced n (%)	Ever treated n (%)	Received medication n (%)
Backpain	1098 (57.5%)			742 (48.4%)		
Arthritis	703 (36.8%)	326 (17.1%)	253 (13.2%)	445 (29.0%)	182 (11.9%)	130 (8.5%)
Angina	407 (21.3%)	194 (10.2%)	120 (6.3%)	284 (18.5%)	156 (10.2%)	91 (5.9%)
Asthma	149 (7.8%)	90 (4.7%)	45 (2.4%)	123 (6.2%)	75 (4.9%)	53 (3.4%)
Diabetes	104 (5.4%)	16 (0.8%) ^a 16 (0.8%) ^b		49 (3.2%)	23 (1.5%) ^a 16 (1.0%) ^b	
Eyesight (Blurry Vision)	373 (19.5%)			221 (14.4%)		
Dental issues	427 (22.3%)	228 (11.9%)		358 (18.0%)	58 (3.8%)	
Depression	147 (7.7%)	52 (2.7%)	25 (1.3%)	66 (4.3%)	23 (1.5%)	15 (1.0%)
Mental Health	70 (3.7%)	39 (2.0%)	29 (1.5%)	19 (1.2%)	10 (0.7%)	6 (0.4%)
Alcohol (ever tried)	307 (16.1%)			1357 (68.1%)		
Buai (currently chew)	1536 (80.4%)			1299 (84.8%)		

^a Exercise program

^b Insulin.

Table 9

Health characteristics for men and women aged 15–49 yrs.

Reason for seeking healthcare	Men n = 1532	Reason for seeking healthcare	Women n = 1911
Fever	335 (21.9%)	Fever	385 (31.8%)
Cough	218 (14.2%)	Cough	295 (24.4%)
Injury	111 (7.2%)	Reproductive health and childbirth	91 (7.5%)
Malaria	71 (4.6%)	Headache	62 (5.1%)
Arthritis	34 (2.2%)	Injury	62 (5.1%)
Diarrhoea	28 (1.8%)	Diarrhoea	54 (4.5%)
Headache	27 (1.8%)	Arthritis	47 (3.9%)
Oral Health	21 (1.4%)	Family Planning	47 (3.9%)
Heart Disease/Chest Pain	20 (1.3%)	Oral Health	46 (3.8) %
Minor surgery	18 (1.2%)	Minor Surgery	42 (3.5%)
Symptoms and treatment for Tuberculosis and Malaria			
Cough for 3 or more weeks	195 (12.7%)	Cough for 3 or more weeks	211 (11.0%)
Coughed blood	22 (1.4%)	Coughed blood	32 (1.7%)
Tested for Tb	27 (1.8%)	Tested for Tb	31 (1.6%)
Treated for Malaria	342 (22.3%)	Treated for Malaria	275 (14.4%)
Last needed healthcare			
Last 30 days	126 (8.2%)	Last 30 days	410 (21.5%)
Last 1–12 months	304 (19.8%)	Last 1–12 months	596 (31.2%)
Last 1–5 years	314 (20.5%)	Last 1–5 years	235 (12.3%)
> 5 years	264 (17.2%)	> 5 years	114 (6.0%)
Never	524 (34.2%)	Never	556 (29.1%)

not sell any cocoa bags between 2014 and 2016. We examined whether there were any distinguishing features of the group selling cocoa. A bivariate analysis showed that the average cocoa production for women was significantly higher in the food secure group ($n = 307$) than the food insecure group ($n = 210$) (Table 10). Other health factors were not significantly correlated. Food secure households (60%) were found to have a significant association with producing more cocoa.

Men aged 15–49 suffering from angina ($n = 68$) produced significantly fewer bags of cocoa compared to those never diagnosed with angina ($n = 420$) (Table 10). Men who chewed buai ($n = 389$), also produced significantly fewer cocoa bags compared to those who did not chew ($n = 99$). Other health factors were not significantly associated with production.

6.10. Chronic conditions and productivity

The cumulative chronic health data shows that production of cocoa in producing households for 2014–2016 indicates that many

Table 10

comparison of cocoa production (log number of bags produced 2014–2016) and health conditions for women and men aged 15–49 yrs.

Health condition	Mean log bags: No	Mean log bags: Yes	t	DF	P-value
Women					
Food secure	2.68	2.9	-2.125	458.186	0.034
Back Pain	2.72	2.89	-1.556	475.033	0.12
Arthritis	2.79	2.86	-0.686	382.099	0.493
Angina	2.85	2.68	1.319	174.959	0.189
Asthma	2.82	2.77	0.25	34.768	0.804
Diabetes	2.84	2.41	1.843	26.794	0.076
Eyesight	2.84	2.77	0.538	177.835	0.591
Dental issues	2.84	2.75	0.683	190.018	0.495
Treated malaria	2.81	2.82	-0.07	115.278	0.944
Tuberculosis	2.79	3.02	-1.553	75.697	0.125
Depression	2.85	2.35	1.781	27.12	0.086
Mental health	2.82	3.07	-1.007	13.276	0.332
Alcohol	2.85	2.56	1.675	76.271	0.098
Buai	2.87	2.79	0.746	255.846	0.457
Men					
Food secure	2.788	2.933	-1.378	304.616	0.169
Back Pain	2.881	2.876	0.05	462.535	0.96
Arthritis	2.89	2.856	0.298	252.071	0.766
Angina	2.994	2.478	2.823	83.53	0.006
Asthma	2.904	2.62	1.463	23.307	0.157
Diabetes	2.892	3.035	-0.484	5.335	0.648
Eyesight	2.886	2.881	0.034	132.161	0.973
Dental issues	2.878	3.883	-0.034	92.851	0.973
Treated malaria	2.889	2.761	0.976	133.97	0.331
Tuberculosis	2.9	2.699	1.147	61.04	0.256
Depression	2.893	2.299	1.275	19.365	0.218
Mental health	3.004	2.817	0.675	2.014	0.569
Alcohol	3.152	2.8	1.754	343.554	0.08
Buai	3.183	2.859	2.708	152.618	0.008

households produced no bags of cocoa for sale over this period and that poor family health is associated with lower cocoa production (Fig. 1). It is important to note that age was not correlated with productivity or the number of bags of cocoa produced for this age group (data not shown). Furthermore, while the trend is not significant ($t = -1.126$, $p = .26$), there are no high producers (> 150 bags) in the three or more chronic conditions group.

7. Discussion

This One Health study describes the domestic circumstances of cocoa farmers and covers education, housing, transport, food security,

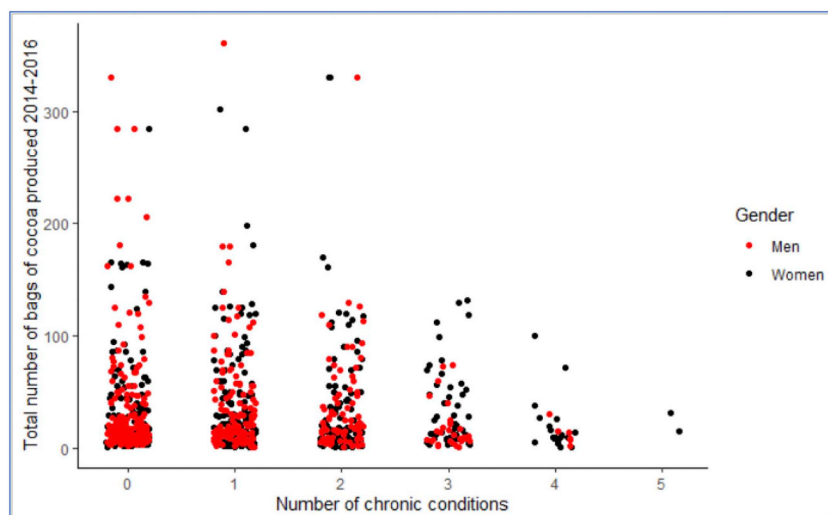


Fig. 1. Annual cocoa production per household aged 15–49 from 2014 to 2016 by number of chronic health conditions.

health of men and women, access to safe water, sanitation practices, bank account, mobile phone ownership. A significant majority of households reported multiple health issues, rudimentary housing, unimproved sanitation and unimproved water. Over two-thirds of growers whose main source of income was cocoa did not sell any bags of cocoa in 2014–2016 resulting in low incomes and greater food insecurity compared to families selling cocoa. Families that produced no saleable cocoa bags were more likely to have rudimentary housing, unimproved toilet facilities and unsafe water, factors that increase the likelihood of chronic disease and exacerbates malnutrition and poor labour productivity [16]. However, the question asked how many bags of cocoa were sold, possibly excluding smaller amounts of wet beans sold or traded opportunistically, often by women.

7.1. The health of cocoa farmers in Bougainville

The primary non-communicable diseases experienced by cocoa households are back pain, arthritis, angina, asthma and diabetes and if left untreated can lead to debilitating complications [18]. While diabetes mellitus is a major health problem across Oceania [19] there is little published evidence of this in Bougainville leading to speculation that diabetes remains unrecognised and undiagnosed. The Secretary of Health said that after tuberculosis, meningitis was the second leading cause of death followed by diabetes and respiratory illnesses. He also reported an increase in the number of maternal deaths between 2012 and 2015. [20] Our data did identify respondents with symptoms of cough, but only a handful had ever been tested for TB. Given the fragile health infrastructure and the transport challenges with few people owning any means of transport, it is not surprising that chronic health conditions remain under recognised, undiagnosed and untreated.

Most people reporting symptoms of a chronic illness did not receive a diagnosis and, if they did, rarely received treatment either because it was not available or because it was unaffordable. Health services are not easily accessed as the majority of the population live long distances from aid posts and health clinics. Health staff also lack capacity to treat many health problems due to poor diagnostic capacity as well as treatment options.

The crisis in Bougainville resulted in between 15,000 and 20,000 civilian deaths. (9)The autonomous region is still coming to terms with the conflict where unresolved trauma, gender-based violence, sexual assaults and substance abuse are significant problems [21]. A 2013 study of depression among Bougainvilleans that found 33% of men and 26% of women reported depression. [22] Based on WHO data for the Western Pacific Region [23], we would expect that the prevalence of

depression to be 3%, and the prevalence of anxiety disorder 3.2%, totalling 6.2%. Bougainville recorded higher rates of depression but in the context of the civil war this is not unexpected. The weak health infrastructure is especially acute with regard to mental health; there are no psychiatrists and no specialised mental health professionals. A 2017 study in Bougainville found that 38% of women suffered mental ill health and 32% of men had high levels of depressive symptomatology. Twenty-three percent of women said they had been raped in the previous 12 months, with 33% experiencing physical or sexual partner violence [21]. Most research in Bougainville concerning mental illness has been done in relation to the conflict.

Cultural belief systems such as witchcraft may also impact on health care and attitudes to accessing western health care services. [24] “Sanguma” is the Tok Pisin word for sorcery and witchcraft which is widely practised in PNG including Bougainville, and is often seen as the primary cause of psychological and physical illness. Sanguma is also used in treating these conditions. [25]

Designing village-based interventions that address the burden of mental health disease arising from known drivers such as conflict, domestic violence, substance abuse [26] and disability associated stigma, [27] would be an innovative and culturally relevant approach for research. In 2019 the Government of the AROB passed its first mental health policy taking into account these factors.

A significant proportion of men and women chew buai. Buai (betel nut) has been classified as a Group 1 carcinogen by the International Agency of Cancer Research because chewing induces oral precancerous lesions that may progress [28]. In high doses betel nut chewing can induce effects similar to cocaine such as elevated heart rate, high blood pressure, dilated pupils, anxiety, insomnia and cardiac arrhythmia [29]. Given the wide practice of buai chewing and its associated health problems there is good evidence for educational campaigns about the risks associated with buai.

A key finding of the WHO 2016 report on sanitation, drinking water and health in the Pacific Island countries found that population growth cancelled gains by the Pacific Islands, to improve drinking water and sanitation leaving populations vulnerable to water-borne diseases, diarrhoeal diseases and malaria [30]. Our study found most households live in rudimentary dwellings, often shared with animals and with poor access to improved water and sanitation. Unsafe drinking water and unsafe sanitation are closely linked with deaths from diarrhoeal diseases with 90 % of them being children under five years.[31]

7.2. Water

A 2018 study examining different housing conditions and association with stunting found that good quality housing and (indoor plumbing) piped water into the home were the main factors found to ameliorate malnutrition and stunting [32]. While our study asked respondents where they obtained their water it did not examine water quality that may be polluted due to population growth, catchment degradation, contamination by heavy metals, animal and human faecal contamination, and microbial pollution [19]. This is an area requiring further research.

7.3. Sanitation

A significant 44% of households practice open defecation which is much higher than the 13% for the Pacific region [30]. The frequency of unimproved sanitation practices was highlighted by the AROB Health Department which has prioritised improved sanitation and lowering the incidence of diarrhoeal disease. The Panguna Mine, located in Central Bougainville, before its closure in 1989 had advanced infrastructure which may account for the legacy of better water and toilet facilities in that region.

7.4. Food security

Nearly half the households experienced severe food insecurity [16]. Typically, villages rely upon starchy root vegetables such as taro as their staple food which are not supplemented with micro and macro nutrients. [11] A rural household survey on food systems conducted in 2019 revealed that within the AROB poor and non-poor households were not meeting minimum daily protein intake [11]. Many communities supplement taro with processed canned food and drinks- high in sugar and salt. Improving dietary diversity has been linked to improved food security, improved birth outcomes and child anthropometric outcomes. [33,34] Both the lack of quantity and quality of foods within these communities' diets suggests the need for more interdisciplinary One Health approaches to improve crop management and crop diversity as well as community-based education about healthy diets.

7.5. Health and cocoa production

Previous research shows that chronic health conditions have a negative impact on household income and farm-labour productivity. A review by Asenso-Okyere et al. [35] found that when productive family members are incapacitated for an extended time savings are spent, assets sold, children removed from school, and the quantity and quality of food consumed reduced to care for the family member. A study in Ghana about the cost burden of managing chronic conditions found the largest percentage of the costs were attributable to medication and treatment [36]. With little capacity in Bougainville to provide medication and health services, people with a diagnosis of a serious condition have to be treated off the island which most cannot afford. This study found that an accumulation of chronic conditions may be associated with the family's capacity to sell cocoa. Research in Ghana did not find that chronic illness had a major impact on cocoa production but it did acknowledge that household farm labour productivity will be reduced as a result of chronic morbidity or death affecting a productive member of the household. [37] In our study individuals with three or more chronic conditions did not produce many bags of cocoa.

A significant decrease in productivity was associated with males suffering symptoms of angina confirming earlier research showing a clear link between angina and workplace productivity [38]. Betel nut chewing also had a negative association with productivity. Our study did not find extensive use of marijuana contrary to a 2012 study which found it a leading cause of dropout, family fragmentation, and also most likely work productivity in post conflict Bougainville. [39] The

small numbers may relate to the households we interviewed in rural Bougainville and missing younger household members who may have moved into the towns. Betel nut chewing impact on work productivity is less researched.

Our study also found a positive association between food secure households and cocoa production. When we looked at food security and wealth we found more wealthier households in the food secure category, indicating these households may access more resources including nutritious foods as well as more time to grow cocoa instead of worrying about the next meal.

8. Study limitations

One of the limitations about publishing One Health research is managing the volume of data that captures the essence of the One Health project. This results in fragmenting the results in order to publish. Not everything can be fitted into a single article. This One Health research has resulted in 4 publications (domestic/livelihood challenges, cocoa management and agricultural challenges, maternal and child health nutrition and a One Health methods paper about the project) describing the different components but in doing so misses a comprehensive picture of the entire project.

9. Conclusion

This study reported on the results of the first large scale survey of cocoa farming households in Bougainville and provides key information about their health and livelihoods. The significant poor health experienced by cocoa farmers combined with weak health infrastructure and associated environmental/ecological conditions contribute to their persistent poverty. Our results are similar to other studies of cocoa farmers in hard-to-reach rural communities in low and middle income countries where poverty and inequality including poor nutrition and health, lack of education, and access to clean water are the norm. [40] The data provide a strong case for education campaigns directed at improving water and sanitation in the villages.

Our survey confirms that poor education, health and nutrition are major constraints to improving livelihoods. If productivity is to increase farmer health needs addressing concurrent with improvements in water and sanitation practices. Building a health system that is responsive to the needs of the people is a challenge where most of the population live in small villages with difficult access to health centres. Many health problems can be addressed with village education programs that 'show' as well as 'tell' people how to improve water and sanitation. Helping farmers who suffer debilitating chronic conditions that remain undiagnosed and untreated is more difficult. Integrating outreach health clinics at the village level with hospitals and clinics will improve access to health services. The challenge for the AROB government is to facilitate health, agricultural and other local government services to work in concert with villages to deliver integrated programs that recognise the interconnectedness of the different components of village life.

Authors' contributions

All authors made substantial contributions to the conception and design of the research. MW & JH are joint author leaders of the manuscript. All authors were involved in critically revising the intellectual content of the manuscript. All authors read and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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