Review of the potential for harmonisation of sustainable food system indicators, and the assessment of key aspects of nutrition and health in two atoll Islands of Kiribati, a West Pacific Island State.

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Abstract

Sustainable diets, which links nutrition and food systems, cuts across all seventeen Sustainable Development Goals (SDG), with particular relevance to SDG 2. Despite much recent attention being given to sustainable diets and food systems, methodologies for assessing sustainable diets are complex and may not be generally applicable. This thesis describes a series of studies, which aimed to review the methodologies for assessing sustainable diets and potential for development of a harmonized indicators; assess the knowledge, attitude and practice (KAP) on nutrition of the households in South Tarawa and Butaritari Islands; conduct dietary assessments amongst the household members using a 24-h diet recall and weighed food records methodology in the Islands; and carry out anthropometric and body adiposity measurements of the householders and secondary school students. A total 468 households were randomly selected in South Tarawa (n=161) and Butaritari (n=307) for the 24-h dietary recall and a sub-sample of 28 households participated in the weighed food record. Another 320 subjects were recruited for the KAP study on nutrition; and 483 adults and 194 adolescents were selected for the anthropometric and body adiposity study respectively.

Food consumption patterns of the households in the islands reflected high consumption of non-traditional diets and refined foods, which manifested in inadequate micronutrient intake estimates and low dietary diversity

The KAP study showed the majority of respondents had good knowledge and attitudes towards good nutrition, however, these were not adequately reflected in their nutritional practices.

Based on measures of bioelectric impedance, two-thirds of the subjects (68.4%) had a very high body fat (BF) %, 22.2% had high BF%, 8.8% had normal BF% and 0.6% had low BF%. Based on body mass index (BMI), about three-quarters of the subjects (73.2%)

were obese and 22.5% were overweight. Obesity prevalence among the adolescents was low based on BMI and BF% criteria.

In conclusion, despite the investments on nutrition programmes in Kiribati, no change was noticed from the results of 1985 Kiribati National Nutrition Survey and the findings of this study. Policies and interventions to sustainably improve diets in Kiribati, and thus reduce diet-related morbidity and mortality, need to address elements of sustainable diets.

Author's Declaration

This thesis was produced according to Massey University's "thesis-by-paper" requirements i.e. it is based on research that is published or in the format of a publication paper. Each individual chapter is set out in the style of the journal in which it has been published or to be published. Consequently, some of the chapters are relatively succinct, there is some repetition (particularly in the methods sections) and there are small stylistic differences between the chapters.

The published manuscripts include other authors who provided technical expertise and contributed to the writing of the papers, including my PhD Supervisors and, in some cases, collaborators in different institutes in Canada and Italy. However, for most chapters, my input was greatest, as reflected by being first author on the paper. I was the lead investigator for the studies described, involved in oversight of study design, recruitment, work co-ordination and data collection, data analysis and preparation of manuscripts. I was also involved in preparation of the ethics application prior to the conduct of these studies.

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Table of content

List of figures

Chapter 7

List of tables

Chapter 1

Chapter 2

Chapter 3

Chapter 4

Chapter 5

Chapter 6

Chapter 7

1.1 **Background**

Meeting the expanding need for nutritious food in the face of a growing world population, increasing consumption levels, dietary shifts and resultant environmental degradation constitutes a considerable threat for humankind in this century (Chaudhary, Gustafson and Mathys, 2018). Food systems presently don't convey the expected food and nutrition security outcomes, have numerous social disparities ingrained in them and are viewed as a leading driver of worldwide environmental harm (Garnett, 2011; Mckeon, 2015). The need to change our food systems to be more sustainable (including in agriculture, health, environmental, social and economic terms) is broadly recognized in research and policy circles (High Level Panel Experts [HLPE], 2017; Brunori et al., 2013). While some of the proposed changes come with improved nutritional outcomes, many do not.

The economic burden of malnutrition has both direct and indirect effects, because over-nutrition and under-nutrition not only present a heavy burden on public health systems, but also exert impact through reduction in human capital and loss of productivity (Hassen-Wassef, 2012). The magnitude and the intensity of the health problems associated with diet, which influence development, social activity and persons' innovative and productive competency, have advanced the food security problems into the rank of United Nation population concerns (Hassan-Wassef, 2012). Sufficient and low-cost nutrition is not delivered evenly or to all of the world's population of over 7 billion people, despite food systems generating appreciable food energy. Studies have shown that when the co-existence of hunger, obesity and micronutrient deficiencies are considered, about half of the global population are disproportionately and insufficiently nourished (High Level Panel Experts [HLPE], 2017; Gerber *et al.*, 2013; Swinburn *et al.*, 2011).

According to FAO (2014), ‘most developing nations, non-governmental organizations (NGOs) and international agencies are currently promoting food-based approaches incorporating locally available foods as a sustainable solution for combating nutrition insecurity. The assumption behind the food-based approach is that local foods can be easily accepted by the community and so the approach aligns with normal feeding patterns and cultural food preferences. Another assumption of the food-based approach is that nutrient-dense foods are locally available and accessible by the target population’.

Dietary adequacy is one of the measures of success of food-based approaches. Its key challenge in many populations of developing countries is the shift away from diets with high food diversity towards diets dominated by less diverse and more refined foods. This shift can often be accompanied by a move away from indigenous diets and traditional food systems (Konishi et al., 2011).

1.2 Indicators, sustainability and what makes a sustainable diet

1.2.1 Overview

Indicators are used to demonstrate the condition of a circumstance or situation. With regards to monitoring and evaluation, an indicator is a quantitative metric that gives data to screen execution, measure accomplishment or decide responsibility (Hales, Pearlsman and Kiwango, 2010). In the context of sustainable consumption and production, indicators are important to oversee time-patterns including whether a society’s consumption and production patterns lead to more socially equitable and environmentally sustainable development (Watson et al., 2012). They are likewise important to assess the effect of dietary patterns on long-term health status and, specifically, on the evolving and occurrence of non-communicable chronic diseases. A number of international organizations, as well as different governments, have created sets of markers for sustainable consumption and production, mostly as efforts to monitor sustainable development, but also as part, or in support, of dedicated sustainable consumption and production strategies (Watson et al., 2012). The main usefulness of indicators is to guide policy and decision-making and provide a framework through which the effectiveness of interventions can be assessed.

A food system's sustainability is affected by natural and human elements. These elements interact with one another within a food system. For instance, the availability of water and land for food production is impacted by human activities, while human decisions are influenced by environmental conditions. A report jointly written by FAO, UNTCTAD, UNIDO and World Bank stated 'Creating the enabling conditions for the shift to more sustainable food systems will require monitoring using indicator-based approaches that can consider the range and complexity of interactions prevalent in the production, distribution and consumption of food. These links between food production, distribution, consumption, and nutritional health and the underlying social-economic, biophysical and institutional elements, ultimately affect the quantity, quality and affordability of food, as well as health and wellbeing' (United Nations, 2015).

The issue of diets has been reviewed by many intersectoral bodies and interdisciplinary perspectives and also known as a driver of sustainable food systems. Its study involves large amount of information, analytical research and agreed methodologies; some of which are not presently used in standard measures such as the Mediterranean diet (Dernini *et al.*, 2013). This drives a need to examine the other aspects such as environmental, social, economic and cultural views for better understanding of sustainable diets. The range of existing methodological approaches to capturing or characterising sustainable diets in indicator measures needs to be refined, harmonized and tested in many regions especially in the Pacific Small Island Developing States (PSIDS) for determinations of its specificity, appropriateness and applicability to these regions.

1.2.2 Problems with current approaches

The first problem in developing a globally acceptable set of indicators of sustainable diets would be to define and agree what is meant by the term 'sustainability', in this context. In policymaking the concept of 'sustainability' is widely used but is often poorly defined. In the area of food systems and nutrition, various aspects of sustainability have been taken to include varying attributes of diets affecting land use, water, energy, planetary body and many ecosystem services that were based on all the processes along food chain (Eme, 2019). The second issue is simply that a wide range of approaches and indicator frameworks have been proposed and applied. The diversity of approaches makes it especially hard to compare one area with another. Thus, one of the aims of this thesis was to undertake a review of current approaches in this area to arrive at recommendations about a way forward, including assessing the potential for a harmonised system of indicators for dietary sustainability.

Early endeavours to comprehend diet-disease associations concentrated on the role of specific nutrients, but later on it became evident that in many examples, whole diets composition and dietary pattern may be key. Attempting to record what individuals eat isn't a simple undertaking and, notwithstanding when the most ideal technique or mix of strategies are chosen, some estimation mistakes are introduced and need to be accounted for in the analysis and understanding of results. Adequate dietary intake assessment is significant not just in the investigation of relationship among diet and health-related outcomes but also for nutritional surveillance and the evaluation of nutritional status of patients in clinical settings. In this work, this reasoning prompted the use of dietary intake assessment methods in providing baseline nutrition survey data in two islands of Kiribati.

1.3 Pacific Small Island Developing States

A report from the United Nations Office of the High Representative for the Least Developed Countries Landlocked Developing Countries and Small Island Developing States defined Small Island Developing States (SIDS) as ‘a distinct group of developing countries facing specific social, economic and environmental vulnerabilities’ [Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island developing States [(UN-OHRLLS), 2013]. SIDS were recognized as a special case both for their environment and development at the United Nations Conference on Environment and Development (UNCED), also known as the Earth Summit, held in Rio de Janeiro, Brazil (3-14 June, 1992) (UN-OHRLLS, 2013). There are 52 countries and territories that are presently classified as SIDS (Robinson, 2018).

Bell and Taylor (2015) stated that the Pacific Island nations were confronting numerous difficulties concerning food security – in particular accessibility, availability and utilization of nutritious foods. The authors outlined the causes of the challenges: fast population growth and urbanization; limited opportunities to acquire income; easy availability of food imports, and the inability of communities to engage in large-scale agricultural production due to the deficit of cultivable land (Bell and Taylor, 2015). The common staple food crops in the Pacific are many varieties of banana (*Musa* species), cocoyam (*Xanthosoma sagittifolium*), coconuts (*Cocos nucifera*), sweet potatoes (*Ipomoea batatas*) and taro (*Cyrtosperma merkusii*). Other staple crops such as rice and wheat flour are entirely imported (Bell and Taylor, 2015). The projected effect of climate change on the production of the indigenous staple crops is devastating and of great concern. Mcgregor et al. (2006) reported high rainfall frequency and intensity can destroy crops that are sensitive to waterlogging such as sweet potatoes. In the works of Lebot (2009), domesticated yams were highly prone to elevated rainfall inconstancy and intense rainfall events.

1.4 Kiribati

1.4.1 Background

The second main component to this thesis involved field work in one SIDS, Kiribati (Figure 1). The main purpose of the field work (Section 1.5) was to assess current dietary status in two representative areas (one urban, the other rural); and provide baseline data that could be used to inform future sustainable diet indicator assessments.

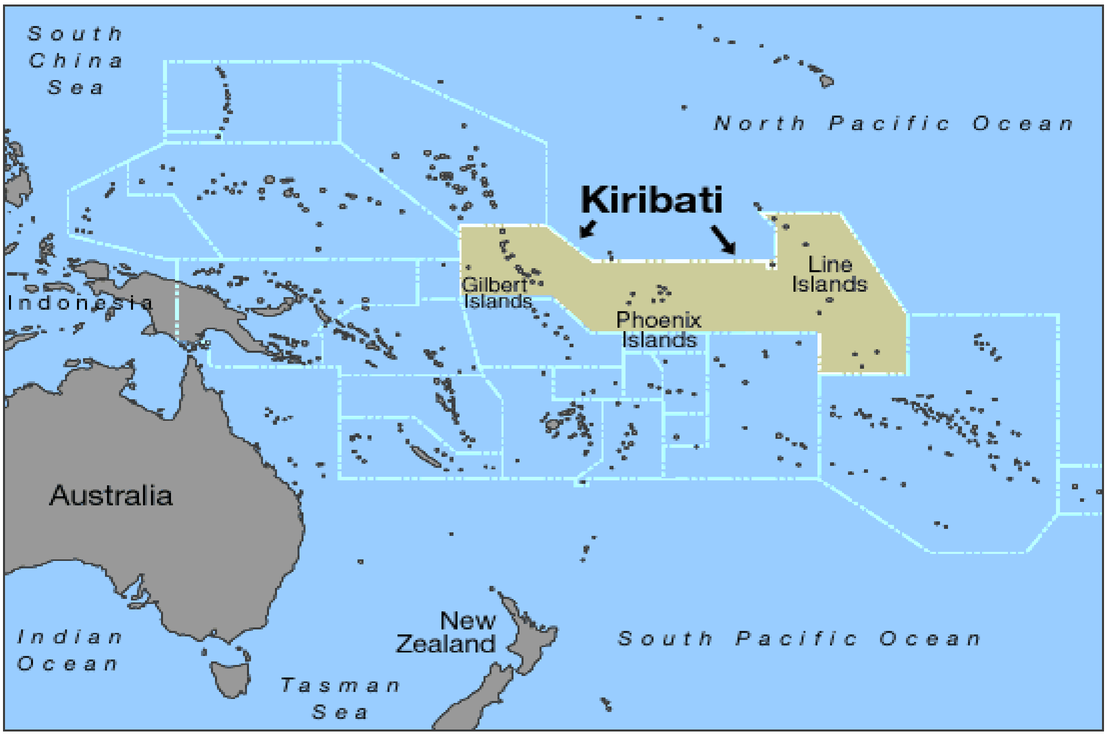

Figure 1. Map of Kiribati (source: Office of Te Beretitenti, Government of Kiribati)

Kiribati, a west Pacific island state, comprises of chain of sixteen atolls and one coral island with a populace of 110,136 (2015 Census) and a GDP per capita of US$1,651 (Morate, 2015). A transition of dietary patterns in Kiribati and other Pacific regions is shown by expanded interest for packaged imported foods such as canned meats, instant noodles, rice and sugar-sweetened beverages, and subsequently, reduced consumption of traditional indigenous plants and animals, thereby leading to food and nutrition insecurity and a high incidence of diet-related non-communicable diseases (FAOSTAT, 2008). Survey in the mid-70s revealed a high prevalence of malnutrition in children in Kiribati. An epidemiologic survey completed in four regions from 1976 to 1978 revealed a high prevalence of underweight in children under five years (Ministry of Health and Family Planning, 1985). The 1985 National Nutrition Survey covering 22% of households showed that 10-15% of children under 5 were underweight. This prevalence continued to increase after 24 years; the 2009 Demographic health survey reporting that 23% of children were underweight or severely underweight (Ministry of Health, 2015). This figure positioned Kiribati over the WHO limit (10%), making the prevalence of underweight children a significant public health issue. Among the adult population, the Global Nutrition Report 2018 for Kiribati showed a worsening scenario for adult obesity, diabetes and anaemia (UNICEF/WHO/World Bank Group, 2018). The report shows that the underlying determinants of malnutrition such as availability of fruits and vegetables, total calories obtained from non-staples, sanitation and drinking water coverage, and female secondary education enrolment had not significantly improved (UNICEF/WHO/World Bank Group, 2018).

Studies with nutrition-related components that have previously been carried out in Kiribati are summarised in Table 1 and discussed further below.

Table 1: What was already known in Kiribati

Year period	What was measured	Results
Mid-70s (Ministry of Health and Family Planning, 1985)	Vitamin A status using clinical measures	High prevalence of vitamin A deficiency
1976 to 1978 (Ministry of Health and Family Planning, 1985)	Underweight in children (under five years)	High prevalence of underweight
1985 (Ministry of Health and Family Planning, 1985)	Underweight in children Anaemia in pregnant women	10-15% of children were underweight High prevalence of anaemia
2004/2005 STEPS survey (adults 18-64 years) (WHO, 2006)	Mean number of days/week fruit consumed	1.6
	Mean number of days/week vegetables consumed	0.4
	Mean number of servings of fruit consumed on average per day/week	2.0
	Mean number of servings of vegetables consumed on average per day/week	0.4
	Mean BMI	29.5 kg/m^2
	Percentage who are overweight (BMI ≥25 kg/m^2)	75.8%
	Percentage who are obese (BMI ≥30 kg/m^2)	42.9%

2009 DHS (Ministry of Health, 2015)	Underweight in children	23% of the children were underweight
2015/2016 STEPS Survey (adults 25-64 years) (WHO, 2016)	Mean number of days/week fruit consumed	1.6
	Mean number of servings of fruit consumed on average per day/week	0.5
	Mean number of days/week vegetables consumed	1.5
	Mean number of servings of vegetables consumed on average per day/week	0.4
	Mean BMI	30.5 kg/m^2
	Percentage who are overweight (BMI ≥25 kg/m^2)	81.4%
	Percentage who are obese (BMI ≥30 kg/m^2)	46.4%

The first documented work, which was carried out in the mid-1970s, had a focus on Vitamin A deficiency, which can cause blindness (Ministry of Health and Family Planning, 1985). This formed part of a wider effort to characterise and address this serious issue in various Pacific Island countries (Ganpat, 2014). Following this work, in 1976-8 and again in 1985, the focus shifted towards prevalence of malnutrition in children with a key variable being the proportion of children who were underweight, and anaemia in pregnant women (Table 1). There was a return to this theme in 2009. From 1985 to 2009 there appeared to be no improvement in the proportion of underweight children, in fact the trend appeared to be worsening (with 10-15% of children being recorded as underweight in 1985, and 23% in 2009). Between these dates (2004/05) the first work had been put into characterising Kiribati diets in adults using the STEPS methodology (Table 1). This survey approach was repeated in 2009, again showing an either flat or worsening trend. For example, in 2004/05, 42.9% of adults were characterised as obese; by 2015/16 this had increased to 46.4% (Table 1). In a systematic review carried out by Cauchi et al. (2019), the authors noted that there are a few articles on how diets and importation of poor quality foods contribute to the problem of micronutrient deficiencies (Thomas, 2002; Englberger et al., 2006), and the influence of international trade and socio-cultural issues as structural drivers of dietary risk factors have also been documented (Estime et al., 2014; Weir et al., 2017).

The overall picture for Kiribati shows three main aspects. First, compared with many other countries, few nutritional surveys have been carried out in these islands. This lack is likely to reflect the geographic spread of Kiribati, the comparative inaccessibility of many parts of it, and the difficulty of its physical terrain and climate, as well as limited resourcing. Secondly, based on the work that has been carried out, there is no evidence that nutritional health statistics are improving. In contrast, the limited data available suggests that both the prevalence of underweight children and adult obesity may have been gradually rising. Thirdly, no recent or reliable data exists based on 24 h recall and weighed food records and such data provides evidence of a whole diet composition of the I-Kiribati people.

1.4.2 A snapshot of food systems in South Tarawa and Butaritari

The top partners that exported foods to Kiribati in 2016 included Australia, China, Thailand, Fiji and Denmark (World Bank, 2016). Data from World Bank shows that food imports in Kiribati varied largely in recent years, rising through the 1993-2016 period to reach 40.7% in 2016 (World Data Atlas, 2016). Another study reported that only 10% of the Kiribati population are economically active in agriculture in a cultivable land area of 310 km^2 (Otiuea et al., 2019) and since the country massively relies on importation of foods, food items covered 42% of Kiribati import bills and about 35% of the available dietary energy supply in 2009 (World Bank, 2011). I-Kiribati still rely heavily on fish as their main protein source (FAO, 2014).

There is considerable variation in reliance on imports versus local foods across Kiribati, and some variation in the availability and consumption of locally grown foods. The largest divide is between urban and rural areas. In Urban South Tarawa, fish are significant as a food source and a source of income for many men without jobs and school dropouts, fishing for proprietors of fishing boats around South Tarawa. Betio, Bairiki, Teaoraereke and Bikenibeu are the main fishing centres selling principally tuna, flying fish, and tidal pond fish. With constrained space for planting crops, home nurseries are recognizable sights around South Tarawa. With the help of the Taiwan Technical Mission, many people are planting vegetables and raising pigs (Kiribati Island Report Series, 2015).

Modernization and the increasing populace have both placed a great deal of pressure on the environment as far as disintegration and contamination to numerous locales in view of the over extraction of sand, rock and shakes (totals), expulsion of trees from shoreline for kindling or building, and poor systems for waste disposal.

In rural areas (like the outer Island of Butaritari) there is a double economy where practically 50% of family wages come directly from the land and sea. Regular subsistence activities include and incorporate fishing, toddy cutting, planting and gathering of food crops (in particular coconut, pandanus, breadfruit, and bwabwai (mammoth taro)), weaving mats, making cover, moving string, bringing water, gathering kindling, and making fish traps and snares. Butaritari has rich soil and frequent rainfall, along with an enormous and resource-rich reef and tidal pond (lagoon). Accordingly, food resources are plenteous and diverse, and the individuals of Butaritari invest wholeheartedly in their capacity to give an excess of nourishment to their visitors, and to send food produce to family members in South Tarawa. While copra cutting is the primary source of income for individuals on the vast majority of the external (outer) islands, it is not so for the individuals of Butaritari. Reasons for this include the high rainfall of the island (which prevents or reduces sun drying of the copra), the harm to coconuts by rodents, and the land residency arrangements which depend on family-claimed grounds as against independently possessed lands (Kiribati Island Report Series, 2015).

1.4.3 The Kiribati Health Champion programme:

The Kiribati Health Champions (KHC) programme is a four year (2017-2020) New Zealand Partnerships Funded initiative that is implemented by the Caritas Aotearoa New Zealand with developing partner organizations – Diocese of Tarawa and Nauru. The KHC program has the overall goal for I-Kiribati people to live healthy lives. The four-year activity is based on inter-connected components – sustainable diet research; nutrition leadership training; auctioning health promotion; and capability strengthening (Caritas, 2017).

In light of the size, reach and influence of the Catholic Church in Kiribati with 57% of the population identifying as Catholic, this Activity is being delivered in partnership with the Catholic Diocese of Tarawa through three CBOs: the Catholic Women's Association (CWA), the Kiribati Catholic Youth (KCY) and Caritas Kiribati Youth Group (CKYG). The nutrition leadership training has a focus on being culturally appropriate and relevant for the Kiribati-context. It was decided that this should use a student-centred approach that creates an environment where participants are comfortable and receptive to learning. A Pacific nutrition course (developed by Professor Elaine Rush) was adapted to ensure that it recognises the realities of everyday life where affordability and convenience are central to decision-making around food. Professor Rush is overseeing adaptation of the course material for the Kiribati-context with support from an advisory panel of local technical and community experts. Research into traditional foods and sustainable diets is informing the training component and activity as a whole. Baseline data was collected through using the 24-hour dietary recall, weighed food records methodology and anthropometry/body composition as well as collecting current knowledge and attitudes towards nutrition. This essential baseline work formed the basis for the PhD outlined in this thesis. The data from these assessments has also been provided to the Kiribati Ministry of Health and the New Zealand Ministry of Health for their information (Caritas, 2017).

The nutrition leadership training is being targeted to key members of CWA, KCY and CKYG who will then deliver community-level trainings. Training places are also being offered to other community actors in nutrition promotion from government and church agencies and can include the Centre for Nutrition's volunteers, the KHRA, RAK, KFHA, etc. All participants will be encouraged to act on their learning and promote healthy lifestyles in their communities and areas of influence. CBOs (CWA, KYC and CKYG) will develop community action plans to roll out training and support to their members. The nutrition training will be linked to community action with participant from CWA, KCY and CKYG contributing to implementing their organisational action plans. To enable the development and delivery of the action plans, CBOs will be engaged in an organisational capability self-assessment process and a workplan developed to build knowledge and skills. Results will be measured regularly, a course review would take place following the delivery of the first course. The research into knowledge, attitudes and nutrient intake would frame the nutrition training and health promotion, while the organisational self-assessment would shape the capacity building. Caritas would provide staffing support costs to the Diocese and CWA to support the delivery of the Activity (Caritas, 2017).

The work in this thesis was designed to contribute to the KHC programme by providing baseline information using the 24-hour dietary recall, weighed food records methodology and anthropometry/body composition as well as collecting current knowledge and attitudes towards nutrition. This baseline will help to establish priority areas for the project and the results of the baseline study will inform the decision makers the impact the project has had on the people.

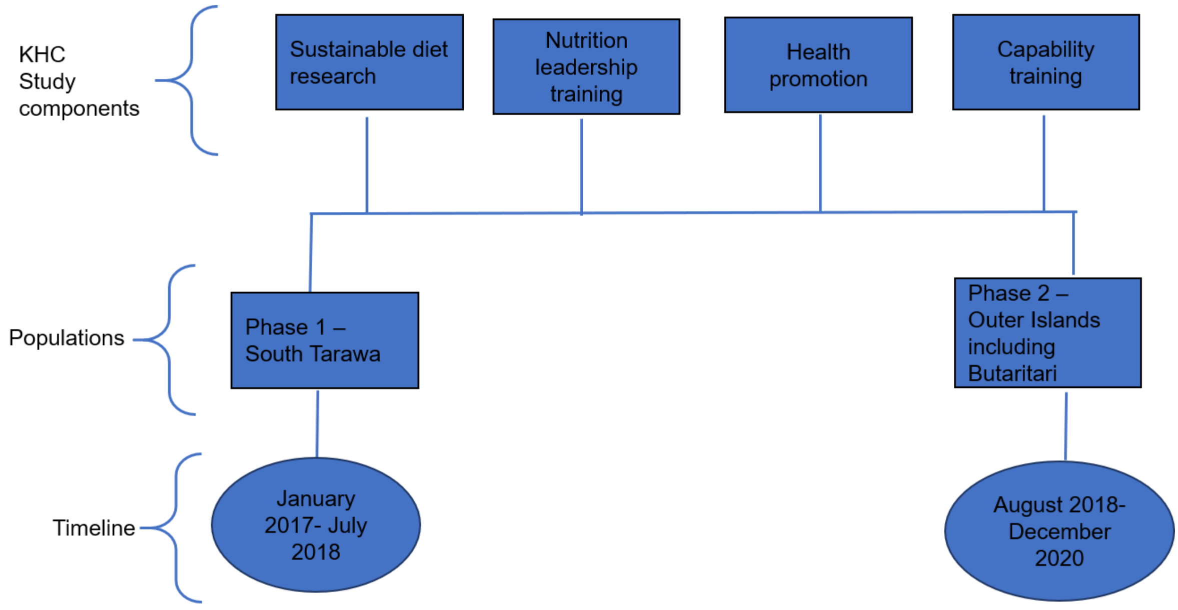

Fig. 2: An Overview of the KHC study components, specific populations and timeline

1.5 Research rationale, framework and strategy

Gaps and rationale

To date, there have been no documented 24 h recall studies and no weighed food record studies among population groups in Kiribati. There have also been no studies investigating food consumption patterns, leading to a lack of reliable data on which to assess the dietary diversity of Kiribati food systems and their health implications. Research investigating consumption (specifically dietary diversity) would provide much needed insight into the current nutrition situation of the Islands of South Tarawa and Butaritari in Kiribati. Furthermore, no previous studies examining knowledge, attitude, and practice (KAP) towards nutrition in Kiribati have been carried out. The aim of this work was to fill these gaps by investigations in two representative areas of Kiribati – urban South Tarawa (ST) and rural Butaritari (BT), with the goal of guiding the development of effective and sustainable interventions to improve the nutritional status among Kiribati households.

There has been some national data carried out on the prevalence of overweight and obesity (WHO, 2018) but this was not distributed on the different atoll Islands. One of the objectives of my thesis was to provide the current overweight and obesity prevalence with body adiposity measures (waist circumference, waist-hip ratio and body fat percent) among adults and adolescents in the two study areas. This work will serve as a baseline survey providing the research aspects of the Kiribati Health Champion programme and the results acquired could later be used to populate the following indicators proposed (Chapter 2) as having potential in a harmonized system: nutrition and health, environment, and socio-economic indicators.

Framework and strategy

Research in this thesis was designed to both provide a useful contribution to the KHC programme, and obtain data that could be used to populate three of five indicators under the nutrition and health indicators of a proposed harmonised model (Eme et al., 2019) to assess the sustainability of food systems in Kiribati Islands of South Tarawa and Butaritari

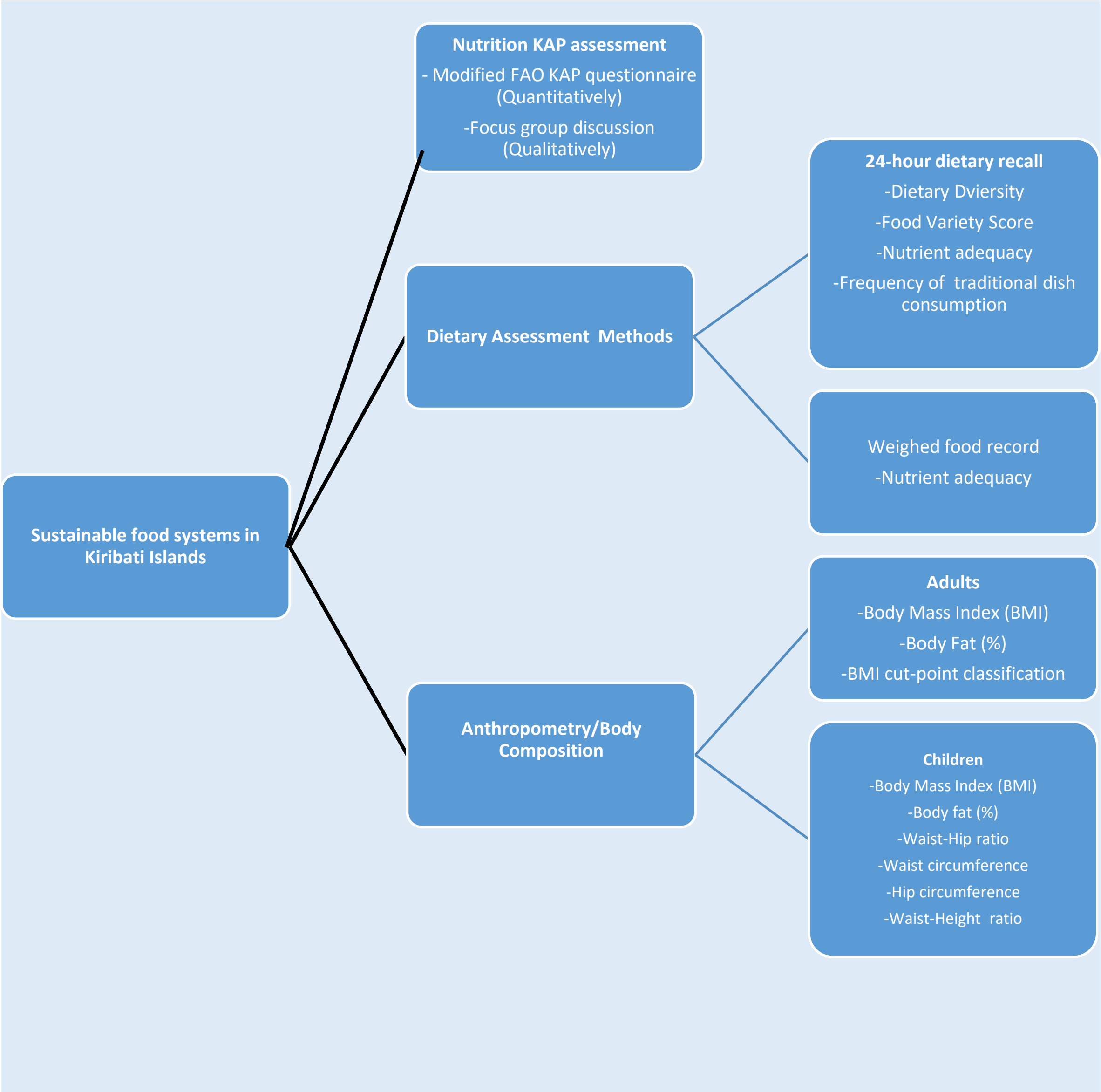

Fig. 3: Study framework

The work was designed to provide new or updated information about three key facets of sustainable diets: dietary assessment, knowledge, attitudes and practice (KAP), and anthropometry/body composition (Figure 2).

Key considerations in selecting the population in this research were budget and logistics. The high costs of a census survey often limits its use as a strategy to select participants for a study and the challenges in terms of staff, equipment, etc to carry out a study were the factors considered in choosing the study population.

Key elements of the study design and measurement methods were as follows:

Dietary assessment was undertaken using two approaches:24 h recall and weighed food records.

Of these, the weighed food record (WFR) is recognized as the ‘gold standard’ dietary assessment method for quantitative approximates of an individual’s dietary intake, because foods are measured and listed as they are eaten (Gibson and Fergurson, 2007). Weighed food records were undertaken using household dietary/food scales to weigh all raw food ingredients, all cooked food, and individual food portions per person at each meal. Leftovers and inedible portions of each meal were also weighed. This dietary method was as a reference method for validating the 24-h dietary recall and all the household members participated.

The 24-h recall approach is more efficient because it is comparably quick to conduct, has a reduced respondent difficulty and is less troublesome for people with low literacy. In 24 h recall surveys, the participants were asked to describe all foods and drinks consumed the preceding day as well as the time these foods or drinks were consumed. Names of dishes and all ingredients used were recorded. The amount of food consumed was expressed using common household measures. The local measures were standardized and converted into metric measures. Portion sizes were estimated using visual aids (photographs of food portion sizes). Preparation techniques of the foods and occasions they were consumed were recorded. The food and drink consumption data were not restricted to any quantity or form for any of the items consumed, and all items were included in the analysis. In this method, the household head or a householder who was involved in cooking/purchasing of the food were used to represent the households.

A Knowledge, Attitude and Practices (KAP) survey is a technique that gives access to both quantitative and subjective data. KAP reviews can uncover confusion or false impressions that may work as impediments to change. KAP surveying was undertaken used a modified FAO KAP model questionnaire (Macias and Glasauer, 2014) , which was modified into 35-item questions (selected from module 5, 6, 9 and 11) with topics on under-nutrition, iron-deficiency (anaemia), food safety, and water and sanitation (Macias and Glasauer, 2014). Eighteen items were knowledge questions, 10 items were questions on attitude and 7 questions were on nutrition practice. This was adapted by translating the questionnaire into the local Gilbertese language and further changes were made to improve comprehension, conceptual coverage and meet cultural values of the participants.

Anthropometry/body composition was measured using two approaches in adults and six measures in adolescents (Figure 2). The Body Mass Index (BMI) and Bioelectric Impedance Analysis (BIA) were used for measuring obesity. Research has shown that BMI is significantly correlated with the gold standard method for measuring body fat (Gallagher et al., 1997) and BIA has also shown high agreement with the gold standard measures (Guida et al., 2007). BMI was calculated by dividing weight (kg) by the square of height (m), and BIA was measured using a single bio-impedance analyser system (BC-549, Tanita Corp, Illinois, USA).

Several other considerations contributed to the research strategy. Key among these was difficulty of access and limited time. Work across two geographically separate area required two separate trips to Kiribati, one (from August 4th to September 5th, 2017), during [name season]) for South Tarawa and the other (from August 11th to September 14th, 2018), during [name season]) for Butaritari. Each trip these was planned in some detail to ensure maximum use of limited time allowing for difficulty of access and training of enumerators. Three villages Betio, Bikenibeu and Teaoraereke out of 16 villages were selected for the survey in South Tarawa and in Butaritari, 10 out of 12 villages were selected. The two villages that were not selected were Temanokunuea and Onomaru.

1.6. Aims, hypothesis and objectives

This research thesis was divided into two main aims:

- To review the indicators for assessing sustainable food systems and sustainable diets with a view to assessing their potential for harmonisation.
- To assess current dietary status in two representative areas (one urban, the other rural) of Kiribati; provide baseline data that could be used to inform policies and programs, and contribute to achieving SDGs generally and sustainable diets specifically.

These aims were broken down into the following set of five objectives:

a. To review the methodologies for assessing sustainable diets and potential for development of a harmonised indicators; and review the contribution of indigenous food systems to sustainable food systems/diets.

b. To assess the knowledge, attitude and practice on nutrition of the households in South Tarawa and Butaritari Islands;

c. To conduct dietary assessments amongst the household members using a 24-hour dietary recall and weighed food records methodology in South Tarawa and Butaritari Islands;

d. To carry out and collect some anthropometric measurements (height, weight and body fat percentage, waist circumference, waist-hip ratio and physical activity) of the householders; and

e. To carry out and collect some anthropometric measurements (height, weight and body fat percentage, waist circumference, waist-hip ratio) of secondary school students in Butaritari.

f. To provide some analysis to inform policies

Research Hypothesis

a. There is no difference in the level of knowledge, attitudes and practice towards nutrition between households of South Tarawa and Butaritari.

b. Households in South Tarawa have higher nutrient adequacies measured using 24-hour dietary recall and weighed food record than those in Butaritari

c. Obesity prevalence measured using body mass index and bioelectric impedence analysis among adults in South Tarawa are higher than those in Butaritari.

d. There is no relationship between adulthood and childhood obesity in Butaritari Islands of Kiribati.

1.7 Structure and layout of this thesis

The rest of this thesis is divided into the following parts:

Chapter 2 is divided into two main sections. The first part (Chapter 2.1) comprises a comprehensive review of methods and indicators for assessing sustainable food systems. This chapter meets the first aim and also the first objective of the thesis, and was published in *International Journal of Environmental Research and Public Health.* The second part (Chapter 2.2) is a book chapter on Indigenous Food Systems: Contributions to Sustainable Food Systems and Sustainable Diets. Sustainable diets: Linking Nutrition and Food Systems, published by CABI. This work was 50% co-authored by me and also relates to the same area.

Chapters 3 to 7 detail the outcomes of my field work in Kiribati. This work was undertaken over two visits and majorly supported by Caritas International with funding received from New Zealand's of Ministry of Foreign Affairs and Trade.

- **Chapter 3** provides a dietary assessment based on the work in South Tarawa, and was published in *Asia Pacific Journal of Clinical Nutrition*. The field work described in this chapter was carried out from 8th August to 5th September, 2017.
- **Chapter 4** provides results of a follow-up assessment in Butaritari compared to South Tarawa. The fieldwork for Butaritari was carried out in a second visit to Kiribati from 15th August to 17th September, 2018. At time of thesis submission, this chapter was published in *Food and Nutrition Bulletin*.
- **Chapter 5** is an analysis of food-related knowledge, attitudes and dietary practices of households in two islands of Kiribati: urban South Tarawa (ST) and rural Butaritari (BT). At the time of thesis submission, this chapter is under review with the journal *PLOS One*.
- **Chapter 6** provides information on the magnitude of obesity, the relationship between BMI and BF%, influence of factors such as age and gender, and an assessment of its linearity or curvilinearity among the adult population in South Tarawa and Butaritari, Kiribati. At the time of thesis submission, this chapter is under review with *Asia Pacific Journal of Public Health*.
- **Chapter 7** shows the assessment of obesity prevalence using different anthropometric measures among adolescents in Butaritari Island, Kiribati. At the time of thesis submission, this chapter will be under review with *Pacific Health Dialog*.

Chapter 8 provides a discussion of the main findings and analysis of their significance.

1.8 Ethical considerations

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving study participants were assessed and approved as Low Risk under Massey Ethics Committee System with Application No 4000018013. A research permit was also obtained from Kiribati Immigration with RP No 14/2017. Written and verbal informed consent was obtained from all subjects. Verbal consent was witnessed and formally recorded.

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2.1 Review of methodologies for assessing sustainable diets and potential for development of harmonised indicator

Abstract

The underlying values and priorities that drive policy responses depend largely on the constructs that researchers and decision makers select to measure, and the metrics used. Despite much recent attention being given to sustainable diets and food systems and to the importance of clearly measuring sustainability to meet targets, to achieve goals, and to appraise dietary and environmental policies, it is not commonly agreed how the different indicators of sustainable diets are assessed. The evidence base for assessment of these indicators are frequently weak, fragmented, and arbitrary. The aim of this paper was to compare a range of published methods and indicators for assessing sustainable diets and food systems in order to harmonise them. Keyword and reference searches were performed in PubMed, Scopus, CAB Abstracts, and Web of Knowledge. Fifty-two studies (21 proposed methods and 31 used methods) that combined environment, nutrition and health, and socioeconomic aspects of sustainable diets were reviewed. The majority (over 90%) of the studies focused on high-income countries. Twenty-eight studies assessed the environmental effects of different dietary practices, eight of the studies examined the nutrition and health indicators used for assessing sustainable food systems, and seven studies assessed the social and economic costs of diets. A classification of the elements was developed, and common elements are proposed for standardizing. These elements were categorized into nutrition and health indicators, environment indicators, and socioeconomic indicators. Standardized or harmonized indicators can be used for consistency and applicability purposes and to support, implement, and monitor relevant policies.

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2.1.1 Introduction

The Food Agriculture Organization (FAO), World Health Organization (WHO), and United Nation University (UNU) [1] define diet as the set of food, beverages, and nutrients that are consumed by an individual or by a community of individuals during a certain period. A number of environmental, health-related, and socioeconomic factors can influence diets. The consideration of the interrelationships between these factors, particularly in the context of environmental resource limits, led to the concept of sustainable diets. According to FAO [2], sustainable diets are defined as those diets with low environmental impacts, which contribute to food and nutrition security and to a healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable, nutritionally adequate, safe, and healthy while optimizing natural and human resources.

"All food systems are sustainable." is the central policy objective of the UN's Zero Hunger Challenge and an explicit feature of Sustainable Development Goal 2 (SDG 2) which seeks to "end hunger, achieve food security and improved nutrition, and promote sustainable agriculture." Although they may appear straightforward, food systems and dietary patterns are in fact determined by a complex interplay of human, economic, social, environmental, and political factors. They can be difficult to define and characterise from any one perspective in terms of sustainability and may require multiple indicators for effective measurements.

In keeping with this, food systems have been defined and assessed in the literature from a range of perspectives [3,4]. At the same time, it is appreciated that a complete and encompassing definition should reflect the sum total of processes that link agricultural production to consumption, including food losses and waste, as well as the positive and negative impacts of these activities and processes on human and environmental health and wellbeing. The High Level Panel of Experts for the Committee on World Food Security states: A food system gathers all the elements (environment, people, inputs, processes, infrastructures, institutions, etc.); activities that relate to the production, processing, distribution, preparations, and consumption of food; and the outputs of these activities, including socioeconomic and environmental outcomes [5].

Globally, food security is threatened by the degradation of terrestrial, freshwater, and marine ecosystems and species used for medicine and food which are increasingly being neglected, underutilised, and ultimately lost. For example, according to FAO [6], approximately 200 million people are employed by the worlds' fisheries, which contribute about 16 percent of the total protein eaten by the world. Nonetheless, approximately 80 percent of the world marine fish stocks, for which appraisal information is available, are overburdened, weakened, or recuperating from depletion. Bell and Taylor [7] reported that the Pacific Island Countries were facing many challenges to food security—accessibility, availability, and the utilization of nutritious foods. The authors outlined the causes of the challenges: fast population growth and urbanization; limited opportunities to acquire income; high levels of imported and processed foods high in salt, sugars, and fats; and the inability of communities to engage in small-scale agriculture production (SDG 2) due to a deficit of cultivable land.

Diets as drivers of sustainable food systems have been discussed across many inter-sectoral bodies and interdisciplinary perspectives, resulting in mounting information and analytical research and a range of methodologies [8]. Despite being agreed upon, methodologies for quantifying sustainable diets show considerable variation with each other and may or may not be generally applicable, and resolving this variation is the rationale of the study. The harmonization of these indicators will contribute to the global monitoring of SDGs in addition to reporting on targets related to food systems and diets. This will ensure that the interconnected issues represented by different assessment targets are bridged as well as that the total amount of indicators needed for creating an extensive monitoring indicators framework for assessing sustainable food system is reduced. For example, the harmonization of gender indicators in Kyrgzstan strengthened the gender monitoring of the Millennium Development Goals (MDGs) in their different regions [9]. Some of the indicators have been field-tested more than others. In our view, there are two interrelated needs. Firstly, and to the extent possible, it would be desirable for the various methodologies to be harmonised. Secondly, methodological approaches for characterising sustainable diets should be field-tested in different regions to determine their specificity, appropriateness, and applicability. The need to characterise pressures that drive the divergence between current dietary patterns and sustainable diets is particularly urgent for populations with extreme and immediate vulnerabilities such as Small Island Developing States (SIDS). The main challenge in this area is that there are several diverse ways to aggregate different methods and indices for the purpose of harmonisation. In this paper, the aim of the study was to compare the different methodological frameworks proposed for assessing sustainable diets and food systems and to harmonize the proposed indicators.

2.1.2 Materials and Methods

A literature search was performed in PubMed, Scopus, CAB Abstracts, and Web of Knowledge bibliographies between March 2017 and November 2018 using the search terms “sustainable food system” or “sustainable diet” and “assessment”, “health”, “environment”, “nutrition”, “social”, or “economics”. The search window was 1995–2018 with restriction to items published in English. Figure 1 shows the detailed process of the manuscripts included. Both peer-reviewed works and appropriate publications from the grey literature (such as conference proceedings and technical reports) were included, as long as they met all the following inclusion criteria: the quantification of environmental indicators linked to dietary intakes as greenhouse gas emissions, land use, or water use at a population level; the collection of dietary information to elucidate baseline diets at the national, household, or individual level; the estimation of the healthy aspects of sustainable diets; and the measurement of socioeconomic variables. Articles with no clearly identifiable indicators for assessing sustainable food systems, as well as review articles, were excluded. Potential papers meeting the inclusion criteria were accessed, and the details were extracted on the following variables: country of the study, main objective(s) of the paper, main findings, and main indicators identified. Only the full texts were included in the final analyses.

The harmonisation of the indicators was undertaken using the "interoperability cube" approach introduced by Mulder [10], specifically designed to explore and enable the harmonisation of methods and tools used in "living labs" research, including among the European Network of Living Labs (ENoLL). The cube builds on the idea that the main focus is on synergies and the parts that living labs wish to exchange with one another and with other forms for the harmonization of methods and tools. The cube identifies these exchange prospects and expressly defines these parts from structural, technical and discourse views. The more elements that match, the better the harmonisation. Up to five clusters can be used in the harmonization process. In this research, three of the clusters were used: user involvement, innovation outcomes, and methods and framework because they were deemed to be of the most relevance or applicability to the topic under investigation.

The "user involvement" indicators were designed according to an iterative approach [11]. The questions asked about the indicators included: "How to organize user involvement?", "Who are the right users?" and "What is the efficacy level?" Users are important to define context-aware services, e.g., cultural differences. User context includes experience in the use of the indicator for data collection, the ability to apply and interpret the data using acceptable standard measures, and developing a strong interest in translating the set data into beneficial policies. Under the "innovation outcomes" cluster, the factors considered were the degree of flexibility of the indicators, user knowledge ability and the frequency of usage among the international agencies in measuring sustainable food systems. For "availability of the framework and methods", the existence of reference standard methods and cultural preferences were considered. The indicators were classified under three categories: environment, nutrition and health, and socioeconomic.

2.1.3 Results and Discussion

This review covered 51 empirical studies of which only eight were published more than 10 years ago. The reviewed articles were classified under the categories of environment, nutrition and health, and socio-economic. An inventory of the environmental indicators used for assessing sustainable diets across the different studies is provided in Table 1. A tabulation of nutrition and health indicators is provided in Table 2, and compiled socioeconomic indicators are shown in Table 3. A short-list of harmonised indicators across these three categories is given in Table 4.

Potential for geographic bias

The majority (over 90%) of studies focused on high-income countries in Western Europe and the USA (Figure 2). In spite of the fact that these high-income countries have substantially contributed to greenhouse gas emissions (GHGEs) related to food systems and agriculture, the detrimental effects of climate change and resource degradation shown in several of the measured segments of sustainability are likely to be felt most heavily in the low- and middle-income countries (LMICs) [12]. As evidence obtained from these high-income countries are being used by the governments of the LMICs to establish dietary guidelines, the problems and needs of these countries may not be effectively addressed

Environmental indicators

Thirty-two studies assessed the environmental effects of different dietary practices. These studies analysed the varying attributes of diets affecting land use, water, energy, planetary boundaries and many ecosystem services that were based on all the processes along food chain. Some of the environmental data in the studies showed decreased environmental footprints from the replacement of animal-based foods with plant-based foods, while others showed that plants had a higher footprint [13,14,15,16]. Whereas most studies showed lower environmental impacts from plant-based diets, a few studies showed a higher water footprint, and GHG emissions were observed from the replacement of calories from meat-reduction scenarios with increased plant-based foods [17,18]. Studies have shown that the formulation of substitute dietary patterns was also a factor in instances of higher environmental effects. For example, in Vieux et al. [19], meat reduction supplemented isocalorically by fruits and vegetables reflected a rise in emissions, while a secondary scenario of a replacement with mixed foods saw a net decrease.

In the use of an estimated Life Cycle Assessment (LCA) of diets, GHGE and the water footprint were the most common indicators measured (n = 26 studies; 41.1% of sample). This is consistent with previous reviews in related areas [20,21] which also identified LCA indicators as the most common assessment of dietary patterns. In their systematic review on the estimation of the potential to reduce GHGE and land use demands by varying the composition of the diet, up to 50% of the reviewed papers used GHGE as the indicator for measuring the environmental effect of diets. Environmental management system performance (n = 11 studies; 18.7% of sample) and land use, especially total per capita land requirement (n = 6 studies; 10% of the sample), were the second and third most frequently mentioned environmental indicators. Energy use, use of planetary boundary framework metrics and water use linked with the production and processing of foods were also commonly cited but in <5% of the studies.

Nutrition and Health indicators

Twelve of the studies examined the nutrition and health indicators used for assessing sustainable food systems. Dietary intake assessments which include dietary diversity and dietary quality were the most common nutrition indicators assessed (n = 9 studies; 56.3% of sample). The Dietary Diversity Index, which is defined as the ratio of those obtaining a diverse diet to the overall population, is known as a promising indicator of dietary quality in the field of development economics [22] and, therefore, a relevant tool that could be used in other categories for measuring sustainable food systems. The other common indicators included the outcomes of focus group discussion, diet-related morbidity and mortality statistics, the rate consumption of local/regional foods, and the seasonality and rate of eco-friendly foods.

Socio-economic indicators

The remaining eight studies assessed the socioeconomic indicators of diets at varying micro and macro levels. They focused on the value effects of purchasing power, the socioeconomic and lifestyle determinants, and the consumers' preferences. The Price Index, income, wealth and equity indices were the most common socioeconomic indicators/indices used for measuring sustainable food systems. Most of these indicators identified could be used to measure the poverty index of a population. Research has shown that a sustainable diet is impacted not only by poverty but also by inequality [23]. Although, not part of the review because it is a trade–industry paper, the Sustainability Consortium has used a wide multi-stakeholder process to carry out a comprehensive "hot spot" analysis within the food supply chain and has identified potential societal indicators as affecters of sustainable food systems [24]. Other indicators include the agricultural production on sustainable food systems and the production area index.

Development of harmonized indicators

Existing assessment indicators for measuring sustainable food systems in different categories are shown in Table 1, Table 2 and Table 3. These indicators were categorized by the general process concepts. The development of the harmonized model represents the overall maturation of reasoning behind the internationally recognized assessment models. The predominant idea is that the harmonized indicators were to be based on user involvement, innovation outcomes and the availability of reference standards. The structures of the harmonized indicators regarded as similar have been unified. For example, under environmental indicators, LCA was the main methodological tool for assessing the environmental impact of a product in its life cycle. Carbon footprint, water footprint and ecological footprint are indicators for measuring LCA in any food system and were all selected. Environment management performance indicators and land use were selected because of its frequent use in measuring the environmental impact of food system. Elements missing from one indicator but could be found in the other indicators have been added to the first one. For example, under the socioeconomic indicators in the harmonized tool, income, wealth and equity indicators can be used to obtain all the other indicators in the same category. Fruit and vegetable biodiversity and the nutrient/non nutrient composition of foods were new indicators added in the harmonized indicators because of the lack of published data in their usage in measuring sustainable food systems. The role of these two new indicators in measuring sustainable diets has not been extensively discussed. Azzini et al. [25] emphasized the importance of nutritional quality as an element in dealing with local food sustainability. Barre et al. [26] proposed the need for integrating nutrient bioavailability when identifying sustainable diets.

An assessment and comparison of the sustainability of food production and dietary patterns in different countries could be facilitated by the widespread use of either a single harmonised system as developed in this paper or a standardised set of core indicators.

A tool of this type may be used in two ways: either retrospectively for a review and intercomparison of existing studies or prospectively as the basis for new research. In both cases, the use of a harmonized framework offers a solution to the problem of bridging methods and tools from research undertaken in varying settings.

The field-testing of the framework is recommended to identify any significant omissions or weaknesses. Thus, the limitation of the study was that some of the harmonized indicators have not been field-tested and that the review was limited to only studies that identified indicators that were specifically proposed or used. Further research is proposed to enhance the specificity of certain indicators, as well as to expand the purview of that harmonization efforts to include other methodological approaches.

Although the harmonised framework is intended for a wide application, the development of this tool was intended to investigate sustainable food systems among specific Pacific Island countries and Small Island Developing States. At the time of publication, the method has been deployed in the island state of Kiribati. Also, although the use of these harmonized indicators provides an overall impression of progress, it is not practicable or meaningful to combine all diverse indicator measures into a single index.

2.1.4 Conclusions

The review of the indicators for assessing sustainable food systems and sustainable diet reflects how much work has been done in measuring the environmental, nutritional/health and socioeconomic aspects of sustainable diet. Most of the indicators identified have been applied especially in the developed nations. Therefore, in the context of operationalizing these different aspects when designing sustainable diets, it is important to recognize that the concept of sustainable diets is not limited to food and nutrition but that it is used across multiple fields, which includes environment, agriculture, animal sciences, social and economic sciences. These harmonized indicators are principally intended to communicate and highlight progress in measuring a sustainable food system, to identify specific priority areas where action is required and to inform multi-sectoral policy development to achieve many of the Sustainable Development Goals

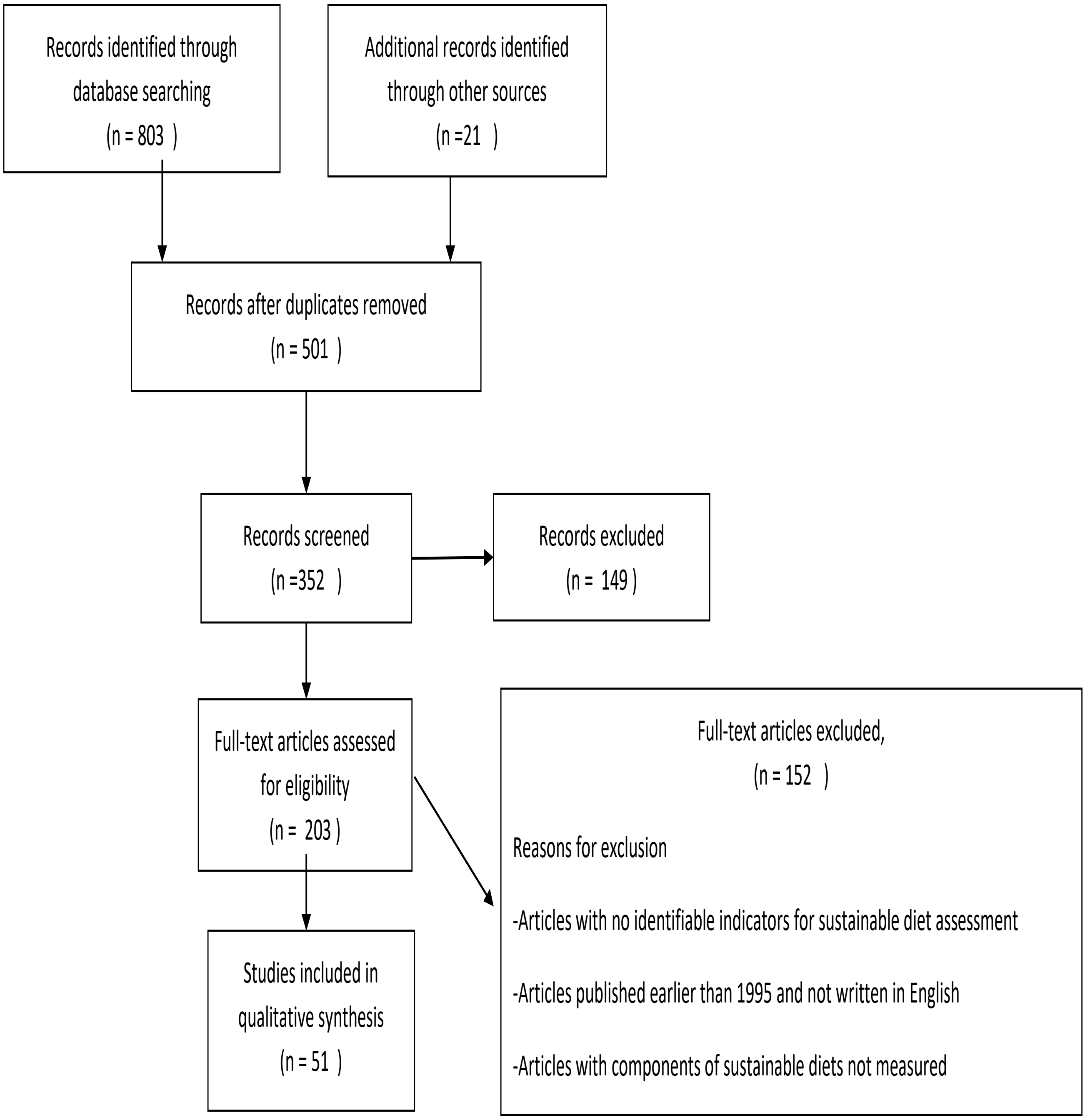

Figure 1. A flow chart of how the articles were selected and included in the review.

Table 1: Environmental indicators used for assessing sustainable diet

Reference	Country	Objective of the paper	Main findings	Main indicators/index identified
Wratten et al. (1997)	New Zealand	Measuring of sustainability in agricultural systems	The 'Selwyn Stewardship Monitoring Scheme' in New Zealand showed that the arable farm were most efficient with meat and farms that deals with dairy were considerably less efficient	Selwyn Stewardship Monitoring Scheme
Carlsson-Kanyama (1998)	Sweden	Determine the outcome of GHGEs on rice, dry pea, carrot, potato, tomato and pork production	Animal rearing and crop management practices were more relevant to environmental outcomes than other areas of the food supply chain	-LCAs -Energy use
Jungbluth et al. (2000)	Switzerland	Assess obstacles and choices for purchase of foods that are environmentally friendly	The largest impact on lowering diet-related GHGEs was not buying air-transported products and meat consumption reduction	-LCA
White (2000)	International	Examines how the role of changes in diet across populations leads to inequality in the delivery of environmental impacts	Inequality in dietary energy distribution is linked with inequality in the use of land to a lesser extent than meat-intensive diets	-Ecological footprint -Gini coefficient -Depth of the Food Deficit -Dietary Energy in Food Supply -Per Capita Food Supply Variability
Gerbens-Leenes, Moll and SchootUiterkamp (2003)	International	The use of environmental indicators for production and sustainability of food systems	Three performance indicators were identified-energy, the total land and water requirement per kilogram of available food to be used by individuals, business sectors and companies	-Depletion of resources -Quality of urban environment -Waste treatment -Environment management system performance
Moldan et al. (2004)	International	To identify and describe composite indicators of environmental sustainability	A number of composite indicators were identified and described which include Environmental Sustainability Index (ESI), Dashboard of Sustainability (DS) and Wellbeing/Stress Index (WI)	- Environmental Sustainability Index - Dashboard of Sustainability - Wellbeing/Stress Index -Ecological footprint -Living Planet Index -Direct Material Consumption (DMC)

Reference	Country	Objective of the paper	Main findings	Main indicators/index identified
Gerbens-Leenes and Nonhebel (2005)	International	Examine the association between the agricultural land use and eating patterns	Eating patterns linked to greater wealth (i.e, cheese, fruits, meats) require more agricultural lands	-Total per capita land requirements
Risku-Norja et al. (2009)	Finland	Determine agricultural GHGE for 4 diet settings and organic production in comparism with industrial production	Organic production has higher GHGE because of more cultivated acreage and the main origin of GHGEs from agricultural production is the soil management practices	-Per capita GHGE (production only)
Stehfest et al. (2009)	International	Measure the effect of dietary shift toward less meat on environment	Emissions of methane and nitrous oxide would permit for increased carbon uptake and consumption of less meat would productively scale down land use	-Integrated assessment model framework
Smedman et al (2010)	Sweden	Evaluate GHGEs from producing different beverages	Milk has the highest GHGEs when compared to GHGEs of the other beverages	-LCA
Carvalho et al. (2012)	Brazil	Evaluate red and processed meat intake and the impact meat consumption has on diet attributes and the environment	Diet quality was inversely associated with meat intake in men. Meat consumption emitted a greenhouse gas emissions of 18071988 tonnes of CO_2 equivalents which represent about 4% of the total CO_2 emitted by agriculture	-Brazilian Healthy Eating Index -24 hour dietary recall -Carbon footprint
Macdiarmid et al. (2012)	United Kingdom	Determine the outcome of varied dietary options on GHGEs	The removal of meats and foods from dairy does not necessarily lead to reduction of diet-related GHGE	-LCA
Scarborough et al. (2012)	United Kingdom	Models the effect of the three environmental scenarios on life loss from cardiovascular disease and cancer	The model showed that in Scenario 1 resulted in 36,910 deaths prevented per year, Scenario 2 caused 1999 deaths averted per year while Scenario 3 resulted in 9297 deaths delayed per year. Nineteen percent, 9% and 3% reduction in GHGE characterised Scenario 1, 2 and 3 respectively.	-LCA

Reference	Country	Objective of the paper	Main findings	Main indicators/index identified
Capone et al (2013)	Italy	Analyse the environmental cost of non-adherence to the Mediterranean dietary pattern in from a water footprint perspective	Reduced total water abstraction is linked to adherence to the Mediterranean dietary pattern	-Water footprint
Liu and Zhang (2013)	China	Proposing a methodological framework for measuring sustainability level of main agricultural regions in China on regional and country levels	The balanced method yields lower sustainable values than the aggregate method and sensitivity analysis	-Land quality index -Resource carrying Index -Ecological risk index -Intensity of land management
Masset et al. (2014)	France	Identify the most frequently consumed sustainable diets by people daily	The diets were categorized into lower carbon diets, higher-quality diet and more sustainable diets. Each of them had beneficial outputs but the more sustainable diets had the best outcome.	-LCA -PANDiet score -Diet cost -Energy density -Energy content
Masset et al. (2014)	France	Identify foods using measures of sustainability dimensions	Foods such as meat and fish had the biggest negative impact on the environment. Low nutritional quality and high price characterised food that had a high environmental impacts.	-LCA -Freshwater eutrophication -Score for the nutritional adequacy of individual foods (SAIN) - Score for disqualifying nutrients (LIM) -2006 KantatWorldPanel French household consumer
Peano et al. (2014)	Italy	To develop an indicator – based tool to monitor sustainability in agric-food systems using the Slow Food Presidia project approach	Slow Food Presidia project increased all dimensions of sustainability and in particular socio-economic and cultural capital by preserving the environmental quality aspects of the food products	-Ecosystem diversity -Species diversity -Genetic diversity -Water quality -Air quality -Erosion index
Van Dooren et al. (2014)	International	Explore the relationship between nutritionally healthy and ecologically sustainable diets	Meat and dairy consumption were mostly responsible for low sustainability scores	-LCA -Land use

Reference	Country	Objective of the paper	Main findings	Main indicators/index identified
EAT, SDSN & CGIAR (2015)	International	Develop integrated indicators for Sustainable Food Systems and Healthy diets in the Post-2015 Development Agenda	Integrated indicators were developed in three thematic categories: Sufficient, nutritional, varied and safe diets; Climate-resilient and environmental sustainable food production; and Resilient and equitable food system	-Per capita protein consumption and per capita land requirement for animal protein -Micronutrient deficiencies -Prevalence of moderate or severe food insecurity, based on the food Insecurity Experience Scale (FIES) -Dietary Diversity Score -Carbon emissions from agricultural land use -Mean Species Abundance (MSA) -Consumptive greenhouse gas emissions from diets in tCO_2eq per year -Area eutrophicated VS total national area -Volume of blue freshwater consumed through diet per week -% of food loss and waste from food production to consumption and % of food waste recycled. -Income of smallholder farmers and fishing communities
Gill et al. (2015)	Brazil, China and India	Evaluate the environmental effects of dietary changes consistent with the nutrition shifts	Increases in cereal supply in China and India and beef production in Brazil increased GHGEs and had effect in the phosphorus and nitrogen cycles, respectively	-National availability indicators - Planetary boundaries framework metrics

Reference	Country	Objective of the paper	Main findings	Main indicators/index identified
Ruini et al. (2015)	Italy	Present the Barilla centre for Food and Nutrition's 'Double Pyramid Model' in order to raise people's awareness of the impact of environment on food	A diet based on the principles of the MD, as suggested by Double Pyramid, generates a lower environmental impact compared to diets that are heavily based on daily meat consumption. Eating lower on pyramid lowers environment.	-Carbon footprint -Water footprint -Ecological footprint
Aleksandrowicz et al. (2016)	International	Review the evidence on changes on sustainable dietary pattern in relation to dietary intake on the environment variables	Animal based restriction was directly related to decrease in environmental footprints and also dietary transition yielded moderate gain in all-cause mortality risk	-LCA - Land use -Water use
Dernini et al. (2016)	International	Assessment of sustainability of diets based on the MD	A standard set of information (definition, methodology, background, data sources, limitations of the indicators and references) was provided for thirteen nutrition indicators identified	-Food biodiversity composition and consumption -Rate of local/regional foods and seasonality -Rate of eco-friendly food production and/or consumption -Adherence to the Mediterranean dietary pattern
Immacolata and Augusto (2016)	Italy	Measured environmental sustainability in the food systems	Application of the method of LCA for the reduction of environmental shocks related to the life of the product chosen (olive oil) and decisions related to interventions on processes, products and activities	Life Cycle Assessment (LCA)
Mertens et al. (2016)	Netherlands	To categorize and summarize the different approaches to operationalise the health aspects of environmentally sustainable diet	Five approaches to operationalize the health aspects of the diet were identified: food item replacement; dietary guidelines; dietary quality scores; diet modelling techniques; and diet related health impact analysis.	-LCA -Eco-indicator -Total ecological footprint -Land use -Energy efficiency -Water footprint
Pires et al. (2017)	International	Evaluate how indicators related to water use and management perform	Twenty four indicators comply with the majority of the sustainability criteria; 59 indicators comply with two sustainability criteria while 86 indicators fulfil just one of	-Water footprint, -Access to safe drinking water

Reference	Country	Objective of the paper	Main findings	Main indicators/index identified
		against a set of sustainability criteria	the four sustainability criteria and one indicator does not fulfil any of the sustainability criteria.	-Existence of legislation advocating for Dublin principles of water -Fresh water living planet index
Pellicer-Martinez and Martinez (2017)	Spain	The use of water footprint (WP) to assess environmental sustainability in water resources at the river basin level	'Blue water' use is not sustainable due to generalized overexploitation of aquifers and also surface water pollution is mainly caused by phosphate concentration	Water footprint
Seconda et al. (2017)	France	Draw up a comparative description of four diets differing in the level of organic food consumption and the adherence to the Mediterranean Diet (MD) using multidisciplinary indicators to assess the sustainability of these diets	The adherence to nutritional recommendations was highest among the organic consumers and Mediterranean diet followers; lower among conventional consumers and Mediterranean diet followers; and lowest among conventional consumers and Non- Mediterranean diet followers	-Diet quality Index based on the Probability of Adequate Nutrient Intake PANDiet -Dietary Diversity Score -mPNNS-GS -Literature-based adherence score of Mediterranean diet
Dooren et al. 2018	Global	Identify a set of important indicators to assess the most pressing environmental impacts of diets	At the global and national level, the planetary boundaries and the footprint approaches were used to identify indicators respectively while the LCA at the product (micro) level.	-Climate impact -GHGE -Land use -Energy footprint -Water footprint -Carbon footprint -Ecological footprint
Kramer et al. 2018	Netherlands	Measure the performance of food products in a sustainable diet based on the balance of their contribution to nutrient intake and environmental impact, within the context of the Dutch diet	Increasing amounts of dairy in the optimized diet were associated with an increase in environmental impact and meat with a steep increase. Bread and breakfast cereals are sources of nutrients with a better environmental performance compared to dairy or meat within the context of the Dutch diet	-Carbon footprint -Nutrient balance metrics -GHGE -Fossil Energy Use -Land Occupation

Reference	Country	Objective of the paper	Main findings	Main indicators/index identified
Barre et al. 2018	France	Assess the impact of nutrient bioavailability and co-production links considerations on dietary changes needed to promote sustainable diet with special focus on meat	‘Fruits and vegetables’ and ‘starches’ quantities increased in all the modelled diets compared to the mean observed French diet.	-Bioavailability estimation -Nutrient calculation using food composition databases -GHGE -Atmospheric acidification -Marine eutrophication -Diet cost analysis
Osita et al. 2018	Japan	Examined the impact of changes in Japanese diet from 1961 to 2011 and the effect of alternative diets on the nitrogen footprints of food.	The 1975 Japanese diet, a balanced omnivorous diet was reported to delay aging, with a protein content similar to the current level, reduced the current food nitrogen footprint (15.2kg N) to 12.6 kg N, which is comparable to the level in the protein diet (12.3kg N)	-Nitrogen footprint

Table 2: Nutrition and Health indicators used for assessing sustainable diet

Reference	Country	Objective of the paper	Main findings	Main indicators/index identified
Schacht et al. (2010)	Norway	Determine consumers' preference of fish with different origins and management practices	Farmed and wild salmon were least accepted while fish fed with feed of plant origin were more accepted compared to others fishes	-Sensory evaluation Index
Pearson (2012)	Australia	Determine the consumers' dietary preferences in choosing organic foods	Greater than half (54%) of the respondents expressed readiness to increase the organic consumption and 3% of them reported a high anticipation in the purchases of organic foods	-Analysis of online questionnaire of self-selected adult food shoppers
WHO (2012)	International	Measured health indicators of sustainable agriculture, food and nutrition security	The health indicators identified and linked to nutritional status, food quality and trade policies and programmes	-Health outcome indicators such as prevalence rates -Food access and dietary quality indicators which include Household Dietary Diversity and prevalence/incidence of food borne disease outbreaks -Food market/trade policies indicators
Dixon and Isaacs (2013)	Australia	Assess consumer views on sustainable and healthy diets	Food purchases decisions were mainly influenced by cost, availability and family responsibility and not necessarily by sustainability or healthy foods	-Focus group results -Ethnography results
Luckett et al. (2015)	Malawi	To estimate and examine the role of household production and market acquisitions in providing dietary diversity to farm households in Malawi	Households further from roads and population centres had lower diversification ($P<0.01$) and spread through comparatively more of their diversity from household production than households closer to market centres ($P<0.01$).	-Nutritional Functional Diversity Score
Harray et al. (2015)	Australia	Assess dietary assessment method of sustainable dietary behaviour using mobile food record (mFR) application	The use of mFR images for assessing fruit and vegetables, eggs, red meat, poultry was developed and tested for validity and reliability	-mobile food record (mFR)

Reference	Country	Objective of the paper	Main findings	Main indicators/index identified
Benedetti et al. (2016)	Italy	Assessment of current dietary patterns among Italians and analyse the effect of socio-economic and lifestyle factors on Mediterranean diet constancy	Of all the socio-economic characteristics, education proved to have a central role in determining adherence to MD. Individuals with at least 8 years of education increased from the lowest (39%) to the highest (44%) category of the Mediterranean score	-Food frequency questionnaire Approach -Mediterranean Composite score
Dernini et al. (2016)	International	Assessment of sustainability of diets based on the MD	A standard set of information (definition, methodology, background, data sources, limitations of the indicators and references) was provided for thirteen nutrition indicators identified	-Vegetable/animal protein consumption ratios -Average dietary energy adequacy -Dietary Energy Density Score -Nutrient density of diet -Food quality -Fruit and vegetable consumption/intakes -Dietary Diversity Score -Diet-related morbidity/mortality statistics -Nutritional anthropometry -Physical activity/physical inactivity prevalence
Benedetti et al. 2018	Italy	Determine the current food patterns of Italians using a composite indicator and to establish which of the indicators had a higher adherence to Mediterranean diet in Italy	Education, tendency to practice sports on a regular basis and ability to have breakfast and lunch at home positively impact people's adherence to the Mediterranean diet.	Mediterranean Diet Index-frequencies of consumption of 14 types of food (12 food groups plus 2 types of oils and/or fats)
Springmann et al. 2018	Global	Examined three different approaches to sustainable diets.	Animal-source replacement with plant based ones were efficient especially in improving nutrient levels, decreasing untimely mortality and lowering the environmental impacts	-Nutrient content calculation -Replacement of 25-100% animal source foods with plant based one at constant total calorie intake

Reference	Country	Objective of the paper	Main findings	Main indicators/index identified
Lachat et al. 2017	Global	Assessed the relationship between food biodiversity and diet quality of women and young children using diet species richness for wet and dry seasons	Dietary species richness showed stronger and more consistent associations with the diet quality indicators (Mean Adequacy Ratios and Dietary Diversity Scores) than Simpson's index of Diversity index and Functional Diversity.	-Simpson's index of diversity (represents number of different species consumed) -Functional diversity -Nutrient adequacy ratios -Mean adequacy ratios -Dietary diversity Score -Minimum Dietary Diversity
Vieux et al. 2018	Europe	Determine if the dietary changes needed to improve diet sustainability are similar across some European countries	Nutritional adequacy was not necessarily associated with reduced GHGE and maximum GHGE reductions attainable filed from 62-78% with a minimal weight change of 2.8 Kg/day from observed diet.	-GHGE -Diet weight -Energy weight -Mean absolute quantity variation of food items

Table 3: Socio-economic indicators used for assessing sustainable diet

Reference		Objective of the paper	Main findings	Main indicators/index identified
FAO (2003)	International	Assess sustainability in the Food and agriculture sector	Sustainability monitoring and assessment routine (SMART) was developed to be used by the companies and agriculture sector	-Investment Index -Vulnerability Index -Product quality and information Index -Local economy Index - Cultural diversity
Jensen and Poulsen (2013)	Denmark	Assess the economic effects for the New Nordic diet consumer compared with an average Danish Diet	The New Nordic Diet was about 17% more expensive than the Average Danish Diet when the energy content of the diet is adjusted and 25% more costly when there is no adjustment.	- Cost Index
Lombardini and Lankoski (2013)	Finland	Assess the consequences of forced food choice restriction in schools on students' diet	The effects manifested in a decrease in number of people who took part in school lunches and in the quantity of food taken to the plate and increase in plate waste	- Food record - Lunch participation rate

Reference		Objective of the paper	Main findings	Main indicators/index identified
Peano et al. (2014)	Italy	Develop an indicator – based tool to monitor sustainability in agric-food systems using the Slow Food Presidia project approach	Slow Food Presidia project increased all dimensions of sustainability and in particular socio-economic and cultural capital by preserving the environmental quality aspects of the food products	- Supply chain - Price - Production Area Index
Barosh et al. (2014)	Australia	Assess the affordability of a typical compared to a healthy and sustainable food basket in Greater Western Sydney, Australia	Healthy and sustainable food basket was more costly than the typical basket in all five socioeconomic neighbourhood studied	- Price Index (price per unit weight of food items)
IOM (Institute of Medicine) and NRC (National Research Council) (2015)	USA	Assess the social and economic effects of the US system	Major classes of social and economic effects that can be linked to characteristics of the U.S. food system were outlined	- Income, Wealth and Equity Indices - Quality of life indicators - Food costs and expenditures indicators - Food security indices - Food quality indices
Gustafson et al. (2016)	USA	Develop a methodology on the concept of sustainable nutrition security using different metrics	Seven metrics for characterizing sustainable nutrition outcomes of food systems were proposed and developed using multiple indicators	- Gender equity - Extent of child labour - Respect for community rights - Animal health and welfare
Barone et el. 2018	Brazil	Investigating the association between sustainability and foods; and to identify consumer's perspective about the characteristics of sustainable and unsustainable foods	The terms 'healthy diet' and 'sustainable production' stood out in the sustainable diets concept. Higher educational level of the participants linked food to natural environment and sustainability while individuals with lower educational levels associated food with source, nutrition and health	Questionnaire with word association, free listing and sentence completion tasks

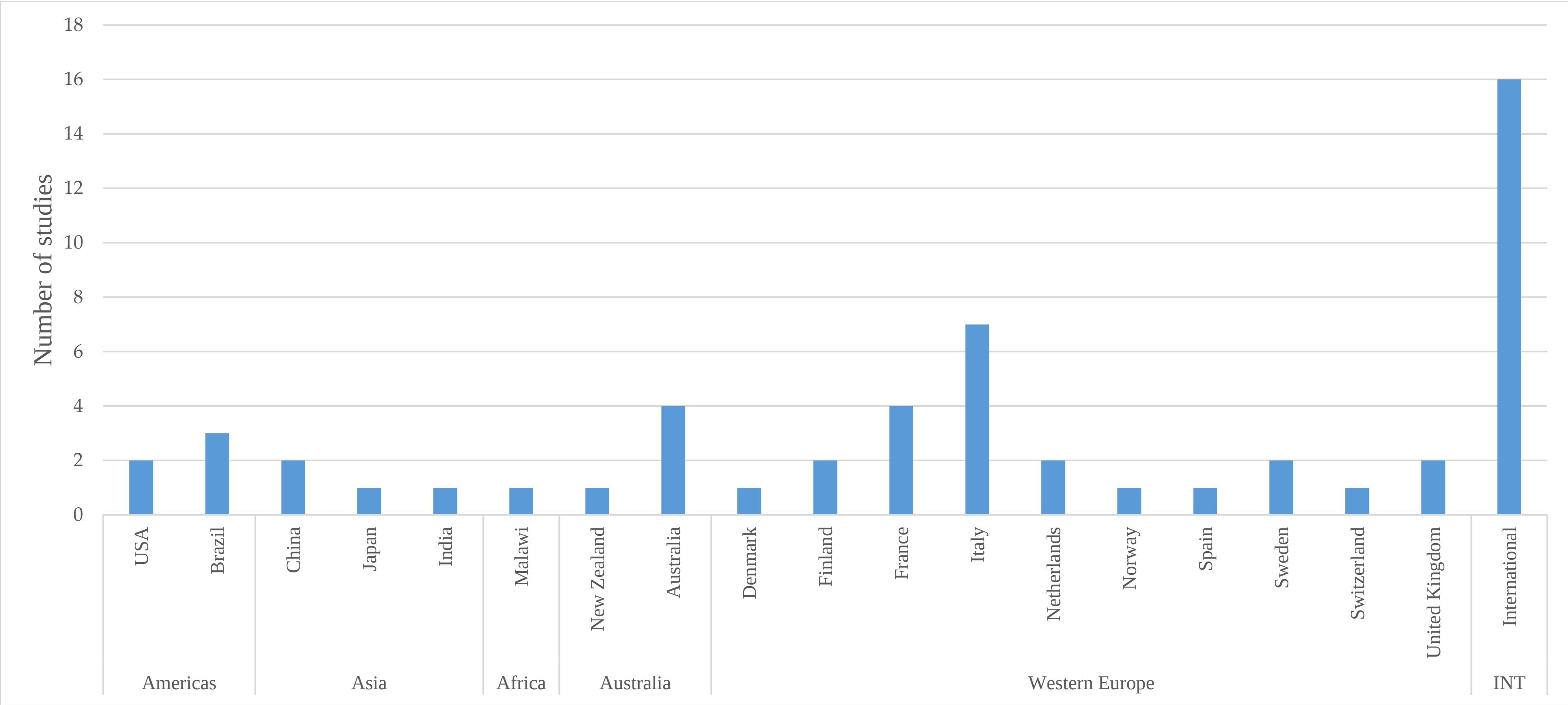

Fig. 2: Distribution of number of studies by countries and continents

Table 4: Harmonized indicators for assessing sustainable food system

Nutrition and Health indicators	Environment indicators	Socio-economic indicators
• Diet-related morbidity/mortality • Dietary Diversity/Nutrient adequacy ratios • Nutritional anthropometry/body composition • Physical activity/inactivity prevalence • Nutrients and Non-nutrient assessment of some commonly consumed foods	• Ecological footprint • Carbon footprint • Water footprint • Rate of local/regional foods and seasonality • Environmental management system performance • Fruits and vegetables biodiversity • Land use	• Income, wealth and equity indicators

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2.2 Indigenous Food Systems: Contributions to Sustainable Food Systems and Sustainable Diets

Abstract

Indigenous food systems are remarkable reservoirs of unique cultural knowledge grounded in historical legacy and spirituality that acknowledge the inextricable link of people with their sustainably managed resources. These sustainable food systems can provide essential understanding about sustainable diets and their importance to many of the Sustainable Development Goals. Unique practices of land and plant and animal management are now threatened by extreme weather and overall climate variability that compound the risks of a long list of environmental assaults upon indigenous lands. Despite vast knowledge of the world's territories and guardianship of 80% of global species diversity, indigenous peoples experience extreme disparities with greater population obesity, undernutrition and micronutrient malnutrition, as well as other health gaps that are grounded in poverty and marginalization. This contributes to the inability of many indigenous peoples to realize sustainable diets known with traditional knowledge. Indigenous food system knowledge is incorporated in both cultivated and wild foods, synergies with the natural environment and biodiversity, adaptation to local conditions and knowledge how these conditions are changing, light carbon footprints, and minimal use of external inputs as fuel and environmentally sensitive technologies. Indigenous food systems across the world demand recognition and protection for their valuable knowledge not only for the benefit of populations of the knowledge holders, but as part of the collective global heritage. Governments, universities, research centers, and United Nations agencies must make Indigenous food systems a priority in their work to document the scientific and cultural benefits of these resources, and to promote more sustainable food systems and, with them, to develop more sustainable global diets.

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2.2.1 Introduction

In recent years, there has been a shift in technical discussions from agriculture production towards food systems. The concept of food systems continues to evolve, encompassing different interpretations. There is an ongoing divide between practitioners, some of whom interpret food systems from the value-chain approach while others advocate for the inclusion of factors such as the environment, by products, energy and cash (FAO, 2017).

The discussion on sustainable food systems and expanding the food base has been fuelled by the challenge of how to feed humankind by 2050 with an estimated population of 9 billion, 70% living in urban areas, and food demand increasing by 40–60%. In an attempt to address the projected demand and supply for food, experts, scientists and policymakers are exploring what makes a food system sustainable. There are several definitions of food systems, for example, the agroecology of food systems, traditional food systems and farmer-based food systems. However, indigenous food systems introduce a series of conceptual considerations accumulated from empiric evidence that render them unique.

For the purpose of this chapter, we refer to indigenous food systems as the set of indigenous peoples' management, knowledge and traditional practices that generate food from their territories. Sustainable diets for indigenous peoples are derived and maintained from indigenous sustainable food systems. As defined by the FAO:

> 'Sustainable diets are those with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources' (Burlingame, 2012).

2.2.2 Indigenous peoples in the world

Ten years have passed since the adoption of the 2007 United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP), marking a turning point in acknowledging the existence and rights of millions of indigenous peoples (UNDRIP, 2007). Despite this recognition, there is no final figure for the number of indigenous people in the world. This is partly due to the fact that different countries are at different stages in terms of recognizing indigenous peoples.

The United Nations Department of Economic and Social Affairs and the United Nations Permanent Forum on Indigenous Issues (UNPFII) estimate indigenous peoples to number more than 370 million (United Nations, 2007). They live in seven regions throughout 90 countries and constitute more than 5000 groups. They speak 4000 out of the 7000 existing languages and make up 15% of the poor, despite being only 5% of the world's population (United Nations, 2007). Their richness in culture, spirituality and traditional knowledge contrasts sharply with their poorness in financial terms. It is generally believed that these estimates are conservative. More precise statistics are difficult to obtain since many countries have not yet included intercultural components in their statistical censuses and surveys.

Whenever intercultural components are included into censuses, new light emerges. For example, India's population census accounted Adivasis and Tribal Peoples at 104.3 million in 2011. While El Salvador in 2014, after years of no recognition, modified its constitution to recognize indigenous peoples for the first time (FAO, 2016). The Sustainable Development Goals approach of 'no one will be left behind' (General Assembly resolution 70/1) (United Nations, 2015) provides a new impetus to include interculturality in the statistics and work of governments, which will improve the overall data on indigenous peoples.

2.2.3 Indigenous food systems

The last few years has witnessed increased attention to indigenous food systems and their holistic approach towards food. An indigenous food system can be described as 'all food within a particular culture available from local natural resources and culturally accepted. It also includes the sociocultural meanings, acquisition/processing techniques, use, composition and nutritional consequences for the people using the food' (Kuhnlein and Receveur, 1996).

> These systems share several important characteristics; for example, they do not exhaust the natural resources base, their main focus is not commercial and they have low access to markets. For instance, Indigenous food systems tend to be people-centered with many resources managed sustainably. They also combine the consumption of produce with the purchase and sale of food, avoiding a fully commercial orientation. Foods with these features have appeared only recently in large distribution chains, through production systems such as organic farming, permaculture and biodynamic agriculture, which reflect to some extent the philosophical approaches of traditional societies. (FAO, 2017: p. 110)

Indigenous food systems do not differentiate between the environment and the people, perceiving that living beings and territory are interconnected, and embedded with spirituality. This holistic view does not place human kind, nor the production of food itself, at the center of the food system. Instead, maintaining the equilibrium between the environment and the beings inhabiting it is the central focus. The key concept is equilibrium between the different parts that make up the system. This is significantly different from other food systems interpretations, which place food production at the center.

Indigenous food systems have characteristics that make them particularly attractive, including the use of both cultivated crops and gathered wild plants, synergies with the natural environment and biodiversity, close adaptation to local conditions, a high level of diversification, a light carbon footprint, fewer 'negative externalities' and reduced use of external inputs. They are closely tied to culture and social and religious activities. (FAO, 2017)

Being highly adapted to their environment, indigenous food systems have the capacity to generate food in soils with low fertility, are resistant to stress factors (reduced rainfall, increased temperatures) and have a low demand for inputs. Some indigenous crops are climate resilient, and their cultivation systems (such as *waru-waru, milpa, terra preta* and shifting or swidden cultivation) contribute to the management of the environment while generating food.

Since most of the foods consumed in indigenous food systems are not cultivated but harvested/hunted or fished, consumption patterns depend on seasonality and on availability, leading to increased sustainability. In addition, over-exploitation results in depletion of the source and eventual disappearance of the food itself. In most indigenous groups, this is considered not only bad practice, but it carries negative spiritual connotations for the community, and is avoided as much as possible. By focusing on the quality and utilization of foods rather than on production quantities, indigenous food systems can influence the reshaping of the current food systems thinking (FAO, 2017, p. 110).

2.2.4 How are indigenous food systems important in the context of Sustainable diets?

The role of the sustainable diets concept in the context of the Sustainable Development Goals (SDGs) is cross-cutting to many of the seventeen goals (UNSDG, 2015). Furthermore, the centrality of sustainable diets was anticipated in the call for action from the Door of Return to achieve several relevant Millennium Development Goals in Africa (AFROFOODS, 2013).

Indigenous peoples' knowledge emanates from their collective experience in managing 22% of the world's ecosystem and land mass and preserving the majority of the planet's biodiversity. Indigenous peoples understand how their local foods are resilient and adapted to their local environments, even when climate challenged. They know the animals and plants that are natural resources in the world's forests, pastures, riverine lands and waters, lakes, and seas, which contain the genetic material of the world's biodiversity. The knowledge of these resources is grounded in their culture, spirituality and historical legacy. Those who can relate and express such knowledge can help us develop, realize and enjoy the benefits of indigenous food systems, which are essential for sustainable diets.

There are three ways in which indigenous food systems can contribute to the present food challenges:

- expand the available food base;
- present empirical evidence of effective food generation capacity while maintaining the resource base in contrasting climatic areas; and
- include indigenous peoples' knowledge in the sustainable food systems debate linked to climate change.

2.2.5 Expanding the present food base

Throughout human history, around 7000 of the approximately 250,000 existing plant species in the world have been either cultivated or gathered for consumption. Of these, 150 are commercial, of which 120 are cultivated and 103 presently provide 90% of human foods on the planet. Wheat, maize, rice and potatoes provide about 56% of global human caloric consumption. The remaining thousands of edible plants are either neglected or underutilized (UNESCO and Tudor Rose, 2015). There is extensive literature relating how agricultural production has contributed over time to prime yield at the expense of diversity. Over time, this has resulted in a drastic reduction of the species food base. The 2007–2008 global food price crisis best illustrated the existing dependency of humankind on the global trade and production of a handful of plant staples that provide the majority of the calorie intake in the world (FAO, 2011).

Recording the world's unique food species use, nutritional properties, and other scientific facets is daunting. This has been identified as a priority by the United Nations Food and Agriculture Organization (FAO) because of the progressive dietary simplification resulting from agricultural industrialization in the world's food supplies at the expense of diversity and micronutrient malnutrition (Demment *et al.*, 2003; Khouri *et al.*, 2014).

In contrast, indigenous peoples' diets are diversified and benefit from the utilization of different non-commercial species. 'While modernizing food systems rely heavily on few edible plant species and varieties, indigenous food systems make use of several hundreds of edible and nutritious plants' (FAO, 2017).

Thanks to the recent work of culinary chefs and organizations such as the FAO and Slow Food, more and more indigenous food items have been incorporated into the menus in several countries. Foods such as quinoa (*Chenopodium quinoa*), moringa (*Moringa* *oleifera*), Amaranthus and bread fruit (*Artocarpus altilis*) have been recently joined by a new wave of other 'super foods'. These items from indigenous communities have become part of the food menu of middle income customers valuing local and diverse products.

Superfoods are generally defined as foods with a low caloric but high micronutrients content. Commercial food systems, driven by yield maximization, have overlooked superfoods, which are produced at small scale, locally and are well adapted to the environment. In most cases, they either grow naturally in the wild or are cultivated in intercropping or shifting cultivation systems.

The bias towards commercial food products and yield maximization has conditioned not only the research agendas of the agriculture centers and universities, but also the seeds and agro-input markets. This focus on quantity and yield at the expense of diversity affects the available genetic pool of species cultivated and therefore the sustainability of the food systems in the context of mounting climate change pressure. This entire trend has a direct impact on the dietary diversity and the nutritional status of consumers.

2.2.6 Generating food while preserving biodiversity and the natural resource base

Indigenous food systems have provided communities with food for millennia. These systems have the ability to generate food and by- products (shelter, clothes, medicines, housing materials) while maintaining the environment, the resource base and biodiversity. In 2016, IUCN and National Geographic completed a map of biodiversity and forests in Central America, clearly documenting the overlap with indigenous peoples' territories. The map identifies 948 recognized terrestrial and marine protected areas. In fact, 39 percent of those areas - some 96,432 square kilometres are also home to indigenous peoples. Forty-four percent of Central American forests are located inside areas inhabited and used by indigenous peoples; much of this land still contains intact ecosystems (IUCN and National Geographic, 2016).

Similar results are found in other regions of the world. This is why it is estimated that indigenous peoples are the guardians of 80% of the remaining global biodiversity. Indigenous territorial management and food systems are closely interrelated, as documented in the GIAHS catalogue of global heritage systems, such as the Ifugao rice terraces and the Andean agriculture systems (FAO *et al.*, 2015).

Shifting or swidden cultivation is a good example of how the management of a territory is linked with the food system. Three characteristics define shifting cultivation: the removal of natural vegetation by cutting and burning; an alternation between short cultivation and long fallow; and the shifting or moving of the fields. Practiced in forested areas by millions of indigenous peoples in Latin America, Africa and Asia, this territorial management technique combines rotation and shifting in the use of the forest with intercropping, harvesting, fishing and hunting as food generation techniques.

Shifting cultivation is one of the most misunderstood and controversial forms of land management (FAO et al., 2015). Stigmatized for the last 70 years for combining fire with the slashing of forest, shifting cultivation is reclaiming new attention by practitioners. Scientists have started to review their perceptions about shifting cultivation, given the fact that areas where it has been practiced are forested years later, whereas other areas under different management techniques are sometimes degraded or deforested.

Although there is need for more research on shifting cultivation and its ability to generate food and preserve the environment, the system itself has changed in recent years. It is believed that demographic growth, market incentives for cash generation, migration of indigenous youth, pressure from extractive industries, and intensive agriculture and livestock have somewhat altered the fallow cycles of shifting cultivation.

Territorial management and the indigenous food system form an interdependent symbiosis. Unfortunately, this linkage between territory and food, along with the difficulties practitioners have had in fully grasping nomadic livelihoods has resulted in insufficient research. Besides the importance of the territory–food linkage, spiritual and cultural practices, community response mechanisms, and traditional knowledge, there are other factors important to preserve ecosystems. These are:

- adaptability to the climate and environment;
- energy use within the system; and
- nodular relationships and 'reticular space'.

Adaptability to the climate and environment

Pastoralists in Central Asia, Inuit and Sami in Arctic regions, hunter gatherers in Central Africa, and agroforestry farmers in the Amazon, all practice a remarkable array of coping strategies to adapt to the extreme weather conditions in which they live. These coping strategies are implemented through changes in the territorial and livelihoods management, use of buffer areas in their territory for times of crisis, or use of 'emergency foods' in certain circumstances. Despite this wealth of accumulated and empirical traditional knowledge, indigenous peoples across the world report that their traditional coping mechanisms are now under threat due to new episodes of climatic variability and extreme weather (FAO, 2008).

Energy use within the system

Indigenous food systems have a low energy use in terms of fossil fuels, coal and other sources of energy. Whereas global agriculture's reliance on nitrogen energy continues to grow 20% growth from 2002 to 2009 (Marsden and Morley, 2014), indigenous systems rely on the capacity of the environment to generate food and on the sun as the primary source of energy from which secondary forms of energy are generated (e.g. firewood, compost, firewood coal, manure). The low use of fossil fuel and other external energy sources is directly linked to the sustainability of indigenous food systems and their success in preserving the environment. At the same time, these systems generate food with a good conversion rate from energy inputs to food output. With externalities accounted for, the conversion rate provided by forests, rivers, oceans and pastures is more efficient than the present global agriculture synthetic substitutes that govern intensive production systems. It is necessary, however, to undertake more research to improve the understanding of energy use in indigenous food systems.

Nodular relations and reticular space

Cartesian systems of borders and relations have not been able to depict the richness of roles, behaviours and management practices that individuals and communities have in place to operate their indigenous food systems. The ‘border view’ approaches the relations between the environment and humans with the constraint of imaginary geographic boundaries. This does not correspond with how indigenous peoples manage their food systems and territories. Even less in cases where the communities are pastoralists, mobile hunters, or nomadic fishers.

The research done by Dr Dounias and colleagues in Central Africa and Asia (Dounias and Bahuchet, 2000; Dounias, 2017) shows how hunters and gatherers have a complex reticular territorial management system composed of several nodular relations that are activated according to a code that is deeply rooted in the community’s traditional knowledge. For instance, hunters manage their territory by combining a network of reticular spaces with different functions (e.g. provision of tubers, harvesting of fruits, hunting areas, sacred and spiritual areas, camping areas, emergency feeding). At the same time, these communities cannot be understood without considering the relations and exchanges, whether through barter or cash, they maintain with neighboring communities.

The reticular spaces and nodular relations are maintained through complex and stratified knowledge-exchange mechanisms between elders, children and adults in reproductive age, with different tasks and knowledge associated to each age group. For instance, the information about which poisonous tubers can be consumed in times of food scarcity and how they should be treated to make them edible is passed from elders to children.

Indigenous peoples' knowledge and the sustainable food systems debate

It is essential to include the wisdom of indigenous peoples on sustainable diets as we address several pressing issues of planetary health.

Indigenous peoples in rural homelands retain the most knowledge and wisdom about food biodiversity in diverse ecosystems, preserved throughout generations by strong cultural identities. The biodiversity of species in indigenous food systems has been recorded in several cultures to contain as many as 390 unique species from their local territory that are recognized, harvested and used (see, for example, Kuhnlein *et al.*, 2009). However, many of these food species, while used and enjoyed in local preparations and dishes, do not yet have scientific identifications or nutrient data (Okeke *et al.*, 2009).

The FAO (through the INFOODS data base), in collaboration with several research institutions and laboratories, is organizing the nutrition composition data of thousands of food items, of which several come from indigenous food systems (INFOODS, 2018).

However, it is important to increase the research on indigenous food systems and enhance the documentation process of food species and traditions. Without documentation, it is not possible to record, share and save this knowledge for future generations, except through cultural intergenerational transfer, which is steadily decreasing.

2.2.7 How Indigenous food systems are lost

Sociocultural factors

Indigenous peoples everywhere are exposed to and adapting to, rapidly changing sociocultural and economic circumstances which invariably affect their decreasing use and transmission of traditional food system knowledge. For examples, see reference to the diverse regions and cultures of the Nuxalk in Canada (Kuhnlein, 1989, 1992) and the Maylayalis in India (Huang et al., 2016). Culture change is manifest in similar ways, including:

- acceptance of the need to pursue income (for clothing, electronics, education, health service, medicines, etc.);
- exposure to and purchase of industrially processed foods stimulated by income generation, with concomitant decline in use of local species;
- rapid advances in media and use of cell phones, advertising and social media, driving ultra-processed food purchasing;
- change in taste preferences by younger generations;
- change in attitudes to food availability and work required to harvest and prepare local foods;
- reduced knowledge transfer about local food species by elders to younger generations.

As is the case for all populations, indigenous peoples also experience urban migration, removing them from the traditional territories where use of local biodiversity is practiced. For these and other reasons, there is gradual and often rapid loss in ecological literacy and the ever increasing untapped potential of local food biodiversity (de Schutter, 2011).

Ecosystem and climate change

Change in use of traditional food systems is also driven by loss of integrity of the rural ecosystems in which indigenous peoples developed their vast cultural knowledge. The long list of environmental assaults to indigenous peoples' traditional lands includes such well-known topics as atomic testing (near small communities in Pacific nation states and New Mexico), oil and gas extraction (Amazon, Arctic), mining (Amazon, all continents), agriculture and processing of illicit drugs (South America), overexploitation of natural populations of fish and birds (Pacific, North Atlantic, New Zealand), drilling and pipelines across traditional lands (Alaska, Canada, US), massive deforestation for timber and agriculture (Amazon, Indonesia), commercial herding over traditional grasslands (Africa, Scandinavia), hydroelectric dams (Japan, US, China, India), land contamination from animal and livestock waste (all continents), industry originated pesticides, organochlorine and heavy metal contamination in lands and waters (Canada, USA, Seychelles, Africa).

All of these concerns and difficulties rest against the background of impending climate change, which is especially noted to affect territories inhabited by indigenous peoples. For example, in small Pacific Island states (rising sea levels) and in the Arctic (unstable land and sea ice), circumstances impede food fishing, hunting and harvest. The resilience of ecosystems that support indigenous peoples and their food systems is all too often stressed beyond legally healthy limits (see, for example, Turner *et al.*, 2013).

2.2.8 What happens when Indigenous Food Systems are Lost

It is paradoxical that, while indigenous peoples still hold a wealth of knowledge on the breadth of food biodiversity on the planet, they experience the greatest disparities in diet and diet-related health circumstances in the countries where they live, largely driven by the poverty and disenfranchisement that indigenous peoples are pushed into.

However, it is abundantly clear that when the diets of indigenous peoples transition from sustainable local resources to include ever-increasing amounts of poor-quality commercial foods purchased with limited income, the nutritional status and health of populations declines (Kuhnlein *et al.,* 2009; Kuhnlein and Burlingame, 2013). This is in part because of the changes that drive loss of traditional food system knowledge and use, urban migration, and climate change affecting ecosystem function.

On the other hand, considerable research reveals that local foods provide many benefits, especially those related to dietary quality and health (Kuhnlein *et al.,* 2004; Golden *et al.,* 2011; Powell *et al.,* 2013).

In high-income countries such as the US, Canada, Australia and New Zealand, indigenous peoples experience poor diet quality with excess energy and greater obesity than the general populations. For example, in the US, the percentage of obese and overweight American Indian and Alaska Natives in 2015 was 81%, in contrast to 69% for all US adults (Centres for Disease Control and Prevention, 2015). In low and middle-income countries (e.g. Brazil and India), it was shown to be indigenous peoples who have greater undernutrition than is experienced in the total population; stunting in Brazilian indigenous children less than 5 years of age was 25.7%, whereas the national population figure was 7% (Anderson *et al*., 2016; Egeland and Harrison, 2013).

Disparities extend beyond obesity and undernutrition. In Australia, about 26% of the Aboriginal and Torres Strait Islander people residing in isolated communities represent 40% of the health gaps in Australia (Vos *et al.*, 2009). Out of the seven top risk factors identified in this health gap, poor nutrition was one of them, which could be attributed to the fact that over 95% of the calorie intake of the indigenous communities was obtained from purchased, poor-quality foods, with the rest from traditional foods gathered through hunting and gathering (Henryks *et al.*, 2017).

Food consumption in remote Australian Aboriginal communities is characterized by highly processed foods containing high levels of sugar, salt and refined grains, and low intakes of fruits and vegetables (Brimblecombe *et al.*, 2013). The low consumption of fruits and vegetables resulted from lack of access due to their high cost (Harrison *et al.*, 2007; Council of Australian Governments, 2009).

Throughout developing regions where indigenous peoples reside, traditional markets are rapidly disappearing and being replaced by commercialized food from infiltration of mega and supermarket food enterprises (Reardon *et al*., 2003). This major source of food in the developing world is being replaced by large convenience store chains that are subsidiaries of multinational companies (Walmart, Shoprite, etc.) (Popkin *et al*., 2012). Indigenous people who migrate to urban areas are exposed, along with all those living in urban poverty, to commercial foods that are highly processed, energy dense and nutrient poor (Asfaw, 2011).

Some countries provide food subsidies to their poor in both urban and rural areas, and while carefully designed subsidy programmes are impactful and can be monitored, some programmes are not without controversy. For example, during the 1970s, the United States food commodity programme of the United States Department of

Agriculture made an unpopular cornmeal food subsidy available to traditional maize-farming American Indian tribes in the Southwest (Calloway *et al.*, 1974).

Political instability and unequal power relationships among indigenous population can impede and create an unbalance in food subsidy initiatives (Holden and Lunduka, 2013; Mason *et al.*, 2013). Some food policies focus exclusively on energy/calorie availability without attention to persistent problems of micronutrient malnutrition and non-communicable diseases (Gómez *et al.*, 2013; Pingali and Sunder, 2017). The use of the Public Distribution System (PDS) in India that distributes rice and sugar to the poor has been criticized for many years for undermining the use of local grains such as millets and sorghum, which have higher nutrient content (FAO, 2016).

2.2.9 Way Forward

Indigenous food systems provide ingenious answers to several of the questions scientists are asking today about what makes a food system sustainable and what makes a diet sustainable – issues such as:

- the ability to generate food while maintaining the resource base, the environment and its biodiversity;
- the ability to use energy within the system in an efficient way; and
- the capacity to generate by-products, medicines, and shelter through multipurpose strategies.

Building activities in indigenous peoples' communities that foster sustainable diets begins with community members and their indigenous values, priorities, and knowledge. Commitment to food system protection for community health and well-being was evident in the twelve case studies highlighted in the CINE-FAO publications (Kuhnlein *et al.*, 2009; Kuhnlein and Burlingame, 2013). In these areas of diverse ecosystems and cultures, the activities developed were also diverse, but with consistent threads to focus on children's and women's health, including elders as respected reservoirs of food system knowledge and seeking support from a diversity of friends and stakeholders. These case-study projects were in rural areas where traditional knowledge was still expressed for the biodiversity of species present in the local ecosystems. It is important to reflect on the capacity of the local ecosystem to make provision for local species and how commercial foods can be part of the sustainable diet dyad of traditional and commercial food. In this regard, indigenous peoples can be a model for exploring how local food and sustainable commercial foods can form sustainable diets for larger populations (Hunter *et al.*, 2016). Problematic issues to be solved within indigenous food systems include generation of cash to purchase high-value goods outside the system (vehicles, cell phones, computers, etc.). In most instances, accumulation processes revolve around the effective management of the natural resource base and its related food system. Whenever an indigenous food system is geared towards accumulating and generating cash, it runs into issues similar to other non-indigenous food systems (FAO and IWGIA, in press).

Another pressing issue is leveraging indigenous food systems to retain the youth in the community. The migration of youth to urban centers in search of education and job opportunities is threatening the intergenerational knowledge transmission that is fundamental for the survival of the indigenous food systems, and indeed, the entire cultural fabric.

Overall, it is accepted that indigenous food systems are at risk of disappearing due to: the destruction of habitats and displacement of indigenous peoples from their territories; the loss of languages and cultures by indigenous communities; the loss of traditional seeds; the shift in food habits; and the decrease of intergenerational exchange coupled with youth migration. When the indigenous food system is abandoned, the health of the community deteriorates, and the traditions and culture associated with food are progressively lost.

The impetus of the spirit of the SDGs of ‘leaving no one behind’ presents an opportunity that cannot materialize unless governments, universities, research centers and UN organizations all make indigenous food systems a priority in their work. A first step would be to make available resources to document traditional food resources through non-governmental organizations and governments at all levels (Hunter *et al.*, 2016). Building on this information to provide livelihoods within their communities is clearly within the mandate of FAO and the Convention on Biological Diversity (CBD) to meet the SDGs (FAO, 2013; UNEP-CBD, 2016).

There is overall acceptance that there is a need for additional research, data and information. Traditional food system information, including scientific identifications, nutrient composition data and ecosystem requirements to maintain the species for defined population levels, needs to be included in data repositories. With critical information on food biodiversity data disappearing from the living knowledge of indigenous peoples, and the world’s food supplies depending on fewer and fewer crops, there is increased demand for this knowledge. In the public sector, advisories for increased dietary diversity should be encouraged by governments to increase demand for diverse and sustainable foods in available food markets. Metrics for measuring the inclusion of more sustainable agricultural species, animals and plants in world food supplies for food security and dietary sustainability should be derived, confirmed and monitored, and food producers nudged by governments to provide more nutritious and affordable commercial food. (Berry *et al.*, 2015; Fanzo, 2017; Lartey, 2016). Indigenous peoples are willing and able partners in the conversation and planning of increasing documentation, agriculture and marketing of their diverse foods.

Governments should be responsive to the need for oversight of the commercial food sector to make provision for diverse supplies of healthy food and to reduce ultra-processed food and food waste, thus ensuring stocks of biodiverse food resources originating from traditional knowledge. With policies like these, there should be a return of livelihood income to the indigenous partners. These goals can be realized with leadership, commitment, and hard work in networking, communication, and partnership.

The FAO, together with Bioversity International, the Center for International Forestry Research and The Indigenous Partnership are collaborating to understand sustainable food systems by profiling different indigenous food systems across the world (forest hunter–gatherers, fishers, shifting cultivators and pastoralists) to recognize the threats and opportunities indigenous food systems present. Policy recommendations based on this understanding can then influence the preservation of these millenary systems. The outcomes of initiatives to protect indigenous food systems will determine not only their survival, but also their ability to contribute to the quest for sustainable diets that are essential in the context of the SDGs

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3 Quantitative estimates of dietary intake in households of South Tarawa, Kiribati

Abstract

Background and Objectives: Malnutrition is a public health problem especially among the Pacific Small Island developing nations. This study assessed malnutrition with dietary intakes in households of South Tarawa, Kiribati, a West Pacific Island Nation State. Methods and Study Design: A cross-sectional community-based study design was used. One hundred and sixty-one households were selected from Betio, Bikenibeu and Teaorereke towns using a systematic random sampling method. About 35% each of the households was selected from Bikenebue and Besio while 30.4% was selected from Teaoraeke. Family (including children) dietary surveys including 24- hour dietary recall were administered to assess adequacy of nutrient intakes and dietary diversity using Household Diet Diversity Scores. A 3-day weighed food record was collected on a sub-sample. Data were analysed using FoodWorks Pro 8 for nutrient intake and Statistical Product for Service Solution (SPSS) version 21 for descriptive statistics. Results: Sixty-one percent of the subjects had the lowest dietary diversity, 36.3% had a medium dietary diversity and only 2.7% had the highest dietary diversity. Based on the weighed food record results (n=29), male subjects of all age groups had adequate intakes of riboflavin, niacin, vitamin C, magnesium, iron and zinc, but had high intakes of protein and sodium; and low intakes of potassium and calcium. Female subjects had adequate intakes of vitamin C, iron, magnesium and zinc, but had high intakes of protein and sodium; and low intakes of potassium and calcium. Conclusions: Across all groups, 61% of the adult Kiribati population studied showed low dietary diversity, and a high prevalence of multiple micronutrient deficiencies.

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3.1 Introduction

Micronesia is a region in the western Pacific Islands comprising approximately 2100 islands with a total land area of 2700 km^2 . It has four main island groups which are the Caroline Islands (Federated States of Micronesia and Palau), the Gilbert Islands (Republic of Kiribati), the Mariana Islands (Northern Mariana Islands and Guam) and the Marshall Islands.1 Kiribati contains a chain of sixteen atolls and coral islands with a population of 110, 136 from the 2015 census population and a GDP per capita as low as US$1,651.[2,3]

It has been suggested that 'the Pacific islands including Kiribati are experiencing nutrition transition'.[4] However, no contemporary data are available, and the current nutrition situation is therefore unclear. A shift in dietary patterns has occurred since the 1980-90s, from reliance on indigenous traditional diets, characterised by the consumption of legumes, tubers, fresh fish and meat, fruit and green leafy vegetables, to westernised diets, based on refined rice, oils, fatty and processed meats, and confectionary.[5,6] Moreover, consumption of pre-packaged, processed and ready-to-eat meals has been on the rise, and is projected to increase.[7] This increases the risk of neglecting traditional food production systems, which in turn increases the population's vulnerability to food insecurity –defined as the state of being without reliable access to a sufficient quantity of affordable, nutritious food. Furthermore, such diets are major contributor to the 'triple burden of malnutrition' (the coexistence of food insecurity, undernutrition, and the state of being overweight or obese) manifesting as non-communicable diseases (NCDs) in the region.[8,9] NCDs cause 70-85% of all deaths in the region[10] and the prevalence of obesity and diabetes is among the highest in the world.[11] Concurrently, the incidences of micronutrient deficiencies continue to be main public health concerns.[12,13]

Beyond the shift in intake patterns, a suboptimal dietary diversity (a defined dietary index used to assess overall diet quality) is often observed.[14] This is a common problem among socioeconomically deprived populations, particularly in low and middle income countries, because their diets are largely dependent on cheap starchy staple foods, with limited amounts of fresh fruits and vegetables. Hence, communities that are socially and economically disadvantaged may be overly-exposed to the effects of unhealthy diets because of greater economic constraints, low levels of awareness and limited access to healthier choices.

The aim of this research was to quantitatively assess dietary patterns, food intake, and dietary diversity of adult householders in South Tarawa, Kiribati. The work is part of a baseline survey for the Kiribati Health Champions (KHC) programme[15] and one of the few studies in Small Island Developing States (SIDS) that reports nutritional status using dietary intakes of households. It is also the only SIDS study in which weighed food records have been used to validate 24-hour dietary recall information in the dietary assessment. The findings from this study provide a benchmark against which progress made by the KHC group in the target communities can be measured.

3.2. Methods

Study area

South Tarawa is the capital of the Republic of Kiribati which is home to approximately half of Kiribati's total population (114,295), and most of the government, commercial and education facilities.[16]

Enumerator composition and training

Enumerators were drawn from all three Catholic Parishes in South Tarawa: Betio, Teraokee and Bikenibue. The enumerators were selected by the Director of the Women's Development Centre, Kiribati and members of the Catholic Parish Women Executives, based on knowledge, fieldwork experience, and community engagement. Ten enumerators were trained and field work was conducted in teams of two. A translator was present during training, fieldwork and initial data cleaning. The training was done for 5 days and it covered best practices, ethical behaviour, sampling protocols and the questionnaire instruments. It also included a field test of some of the instruments and a final revision of the instrument based on the enumerators' field experience. Serving/portion sizes were developed for some of the foods with input from the enumerators for better applicability and understanding of the dietary assessment instruments. These were continuously updated or verified until the end of the survey as new foods/dishes/menus were identified from participant responses.

Sampling methodology

A sample of 161 HHs from Betio, Teraokee and Bikenibue was selected for the baseline survey using systematic random sampling method. About 35% each of the households was selected from Bikenebue and Besio while 30.4% was selected from Teaoraeke. The sampling frame was any household with at least a mother/father and child/dren living in the same building and cooking/eating from the same pot. It is a household study and the individuals were responding on behalf of the households, with the exception of the individual weighed food records, which were recorded at the individual level. After estimating the total number of households at each site, every third household was approached and invited to participate in the study. Respondents were mostly adult female members of the households (HHs) (≥18 years of age) who were involved in cooking/purchasing of the food. In most HHs, these were married women, however, HHs where young unmarried women and men were in-charge of the kitchen were also included. No incentives were provided.

Ethical standard disclosure

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving study participants were assessed and approved as Low Risk under Massey Ethics Committee System with Application No 4000018013. A research permit was also obtained from Kiribati Immigration with RP No 14/2017. Written and verbal informed consent was obtained from all subjects. Verbal consent was witnessed and formally recorded.

Data collection

All data were collected in August and September, 2017, using standardise protocol for 24-h food recall and weighed food record, both of which are instruments of choice in studies of this type.[17] An individual single 24-h food recall survey, using a, was administered by a trained person on a random day to minimise the effects of day-today differences. During the 24-h recall, participating women (118) and men (43) were asked to name all foods and drinks consumed the preceding day as well as the time these foods or drinks were consumed. Names of dishes and all ingredients used were recorded. The amount of food consumed was expressed using common household measures such as a big spoon, a small spoon, a ladle, a cup, a glass and a tea glass. The respondents were shown visual aids (photographs of servings) to assist them with accurate reporting of food intakes. Preparation techniques of the foods and occasions they were consumed were also recorded. The food and drink consumption data was not restricted to any quantity or form for any of the items consumed, and all items were included in the analysis. A three-day weighed food record was obtained from a sub-sample of 8 households with 29 members. Measurements of the food were done using a modified standard procedures.[18,19] In particular, household dietary/food scales were used to weigh all raw food ingredients, all cooked food, and individual food portions per person at each meal. Leftovers and inedible portions of each meal were also weighed. Data obtained were used to validate the 24-h food recall.

Dietary diversity and nutrient adequacy

Dietary diversity (DD), defined as the number of different foods or food groups consumed in the previous day, was measured using Dietary Diversity Score (DDS). DDS for each individual was calculated by summation of the number of food groups recorded on the 24-h food recall.[20] Any quantity of any food group consumed at least once per day was taken into account. Therefore, DDS was calculated without considering a minimum intake for the food group. Eleven food groups were used in this study. Subjects were categorized as Low

DD (consumption of ≤4 food groups), Medium DD (5-6 food groups) and High DD (≥7 food groups).[21]

Nutrient adequacy was measured from the weighed food record through computing the Nutrient Adequacy Ratio (NAR).[22] NAR was calculated for energy and 12 nutrients including vitamin A, vitamin C, vitamin B-1, vitamin B-2, niacin, folic acid, vitamin B-12, calcium, iron, zinc, magnesium, and protein. The mean probability of adequacy across 12 nutrients was calculated using the Recommended Nutrient Intakes (RNIs).[19]

Data analysis

Preliminary dietary analysis was done using FoodWorks 8 Pro, Xyris (2009) Ltd., Australia for the 24-h dietary recall and nutrient intake assessment. All data were entered into SPSS for descriptive analysis involving frequencies, percentages, means and standard deviations. The nutrient intake assessments of the subjects were compared with the FAO/WHO/UNU[23] requirements and the Nutrient Reference Values for Australia and New Zealand.[24]

3.3 Results

The response rate for this study was 98.2%, 73% were women, and the majority of respondents were aged between 25-55 years (Table 1). Most respondents (over 60%) had secondary school education as their highest formal education.

The majority of subjects (more than 95%) consumed sugar, cereals food crop and fish and sea foods (Figure 1). Only a small proportion of participants consumed dairy products (12%), vegetables (10%) and fruits (5%). Over a 24 h period, 90% of the subjects had consumed rice-based dishes, 78% consumed flour-based dishes, 33% consumed breadfruit based dishes and only 3% consumed cassava-based dishes (Figure 2).

Only 3% of subjects (four individuals) showed the highest dietary diversity score of seven or more food groups (Figure 3). By contrast, at the other end of the scale, 61% (98 individuals) fell into the lowest dietary diversity category (four or less food groups). The remaining 36% (59 people) had medium dietary diversity.

Estimated protein, vitamin and nutrient intakes for men and women are presented in Table 2 (based on 24-hour dietary recall) and Table 3-4 (based on weighted food records). Tables 2-4 also show average intakes compared with nutrient reference values.

On average, both male and female subjects consumed below the recommended nutrient intake (RNI) for the following vitamins: vitamin B-1 (61.7% and 56.4%, respectively), vitamin B-2 (52.1% and 53.6%) and vitamin A (RE) (46.7% and 37.5%). They had adequate intake for niacin (119.2% and 109.1%) and vitamin C (122.0% and 165.0%) (Table 2). Of the minerals, both male and female subjects consumed below recommended intake values for: potassium (49.4 and 57.1%), magnesium (57.9 and50.6%), calcium (26.5 and 20.51%), iron (86.1 and 31.3%) and zinc (45.6 and 62.6% respectively); and above the recommended intake for sodium.

The male subjects of all age groups showed adequate intakes of vitamin B-1, B-2 and C; niacin; iron; magnesium and zinc, but had high intakes of protein and sodium and low intakes of potassium and calcium (Table 3). Female subjects of some age groups had adequate intakes of vitamin C, magnesium, iron and zinc, but had high intakes of protein and sodium and had low intakes of potassium and calcium (Table 4).

3.4 Discussion

Both a low dietary diversity and high prevalence of multiple micronutrient deficiencies exist in Kiribati adults. The majority of subjects consumed non-traditional diets predominantly consisting of refined rice and flour-based products. The limited availability and affordability of nutritious foods is likely to have a major bearing on both obesity and micronutrient malnutrition.

Aspects of these findings confirm a trend suggested in earlier work. The 2006 STEPwise survey showed that average consumption of fruit and vegetables in Kiribati was well below internationally recommended levels.25 The 2015 STEPwise survey showed that 98.4% adults ate less than 5 servings of fruit and vegetables per day indicating little has changed since 2006. In spite of this, vitamin C intakes were largely adequate as a result of whole breadfruit and pumpkin consumption.

Kiribati is not perceived to have chronic hunger or food insecurity,[26] but the preference for, and increasing dependence on, imported foreign food such as white rice, refined sugar and tinned meat raise issues for both current nutritional adequacy and future food and nutrition security. The heavy reliance on imported foods is likely to cause a gradual but progressive loss of local food production knowledge and capacity. This may be exacerbated by the impacts of climate change, which may include loss of productive land through higher sea levels, and soil erosion, tree damage and crop losses through a higher frequency of severe storm events.[27]

A high consumption of sugar and refined cereals, and low intake of fruits and vegetables, represents inadequacies in Kiribati diets. A common practice (noted in 24-hr dietary recall results) was to add sugar to nearly all meals. Many studies have indicated deleterious effects of added sugar to human health. As examples, added sugar was found to be correlated with increased risk of metabolic syndrome in adolescents in the National Health and Nutrition Examination Survey (NHANES) (even after controlling for total energy intake and the BMI z-scores)[28] and in other works has been linked to hypertension and elevated uric acid levels.[29,30] A global epidemiological econometric analysis revealed that changes in sugar availability are predictive of changes in prevalence of diabetes, independent of poverty, physical activity, obesity, urbanization or ageing.[31] The low consumption of fruits and vegetables, as identified from the 24 hour dietary recall, have additional negative irreversible consequences. In particular, many studies indicate that fruits and vegetables eaten as part of the daily diet can decrease the risk of coronary heart disease,[32] stroke[33] and some cancers.[34] Increased consumption of refined rice and flour based dishes among the studied population is of concern. These foods are imported and subsidised by the government, unlike their more nutritious counterparts, i.e. fruit and vegetables. ‘Modern’ dietary patterns, portrayed by high consumption of foods such as potato chips, cake, rice, instant noodles, and low intakes of indigenous traditional diets, have been shown to be associated with an increased prevalence of metabolic syndrome.[35] In contrast, ‘traditional’ Pacific Island dietary patterns, high in fresh fish and seafood, as well as other local foods, such as coconut-based dishes, taro and papaya, have been associated with reduced prevalence of metabolic syndrome, increased HDL cholesterol and reduced waist circumference.[35] A heavy dependence on poor-quality imported foods is aggravating the perceived genetic predisposition of people in Pacific Island countries to obesity.[36]

Low DD in 61% of the households is of concern. Low DD has been associated with increased prevalence of NCDs. Possible reasons include increasingly limited access to a diverse traditional food supply, and/or poor nutritional knowledge and/or a personal preference toward unbalanced dietary practices.[37] It would also affect the gut microbiome, which in turn may have profound effects on the immune system and resulting NCDs. Our study shows that low energy and protein intakes are not nutritional problems in South

Tarawa, Kiribati. Instead, attention should be given to the inadequate intakes of micronutrients such as magnesium, potassium, calcium and vitamin A as observed in both the 24 hour dietary recall and weighed food record. Sodium intakes for all age groups in both males and females was significantly higher than their requirements and requires attention.[38] Debate has emerged about the level of dietary sodium intake that is associated with risk of adverse outcomes. Some questions about whether the reference figures may have been set too low – given that 95% of the world may exceed them, and sodium is homeostatically regulated.[39] An Institute of Medicine Panel on dietary Reference Intakes has been charged to review the recommended intakes for all population for sodium.[40] Reduced salt intake and increased consumption of fruits and vegetables have been associated with beneficial effects in lowering blood pressure,[41] atherosclerosis,[42] type 2 diabetes[43] and oxidative damage to cells.[44] The consequences of micronutrient malnutrition could take a long time to manifest, but effects can be irreversible. An intergenerational cycle of malnutrition could occur if adequate measures are not implemented. At a cellular level, these include altered epigenetic characteristics. Each of these changes can lead to adult cardiovascular disease or render the individual more susceptible to the effects of environmental stressors such as obesity arising in later life, placing a substantial health and economic burden on both the government and the people.[45]

The limitations of our study were that dietary data were collected for only one recall period, in one season and at a time of plenty. However, in theory this should have resulted in increased dietary diversity, as more foods are available to select from. This implies that the results of this work may in fact underestimate the problem.

In conclusion, this paper has attempted to assess information on nutrition/dietary characteristics of households in South Tarawa, Kiribati. Specifically, it provides baseline values for indicators in a wide range of areas including food security (dietary diversity), and nutrition (nutrient intake).

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Table 1. Socio-demographic characteristics of the 161 respondents representing the households

Variables	Frequency	Percentage (%)
Sex		
Men	43	26.7
Women	118	73.3
Age (years)		
18-25	9	5.6
26-35	37	23.0
36-45	56	34.8
46-55	44	27.3
>55	15	9.3
Highest level of formal education		
No formal education	3	1.9
Primary school	41	25.5
Secondary school	98	60.9
Tertiary/Higher school	7	4.3
No response	12	7.5

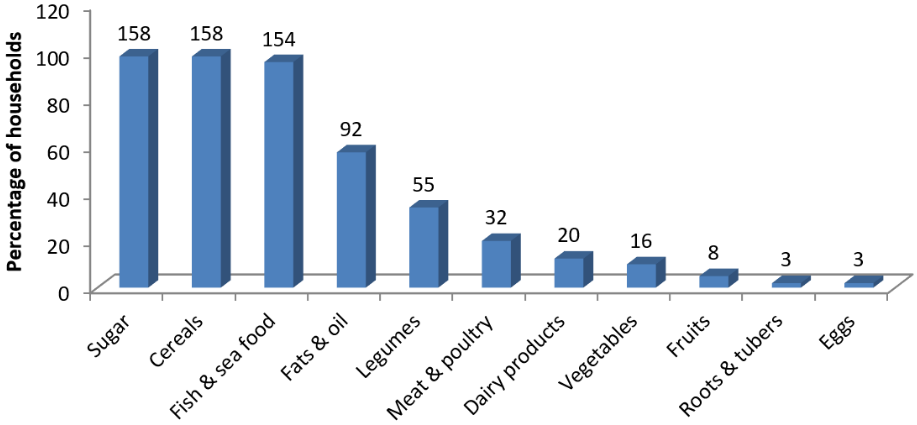

Figure 1. Food groups consumed by the subjects in a 24-h dietary recall (Number above each bar is number of households)

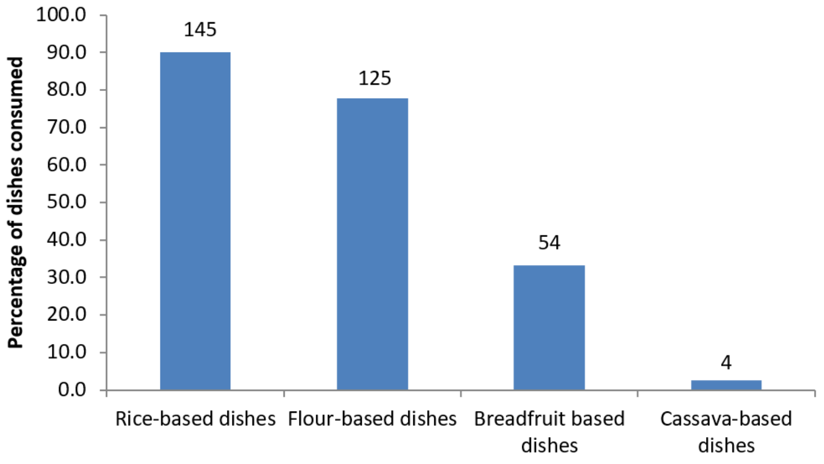

Figure 2. Dishes consumed by the subjects in a 24-h dietary recall (Number above each bar is number of households)

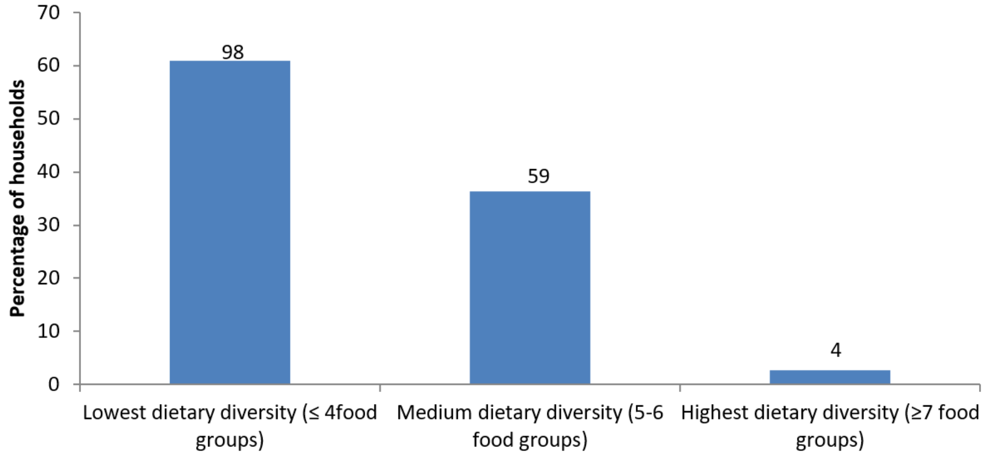

Figure 3. Dietary diversity of the subjects (Number above each bar is number of households)

Table 2. Calculated daily nutrient intakes of the subjects (19- 65 years) based on 24-hour dietary recall data, and comparison to reference intakes (RNIs)

	Protein (mol/d)	Vit. B-1 (mg/d)	Vit. B-2 (mg/d)	Vit. B-3 (mg/d)	Vit. C (mg/d)	Vit. A (total μg/d)†	Sodium (mg/d)	Potassium (mg/d)	Magnesium (mg/d)	Calcium (mg/d)	Iron (mg/d)	Zinc (mg/d)
Men (N=43)												
Average	87.0	0.7	0.7	19	55	280	1920	1880	232	265	7	6.4
(SD)	(34.8)	(0.4)	(0.6)	(8)	(89)	(311)	(1210)	(1570)	(104)	(201)	(3)	(3)
RNI	84.8‡	1.2	1.3	16	45	600	920-460‡	3800‡	400	1000	8	14.0
(%) RNI	103	61.7	52.1	119	122	46.7	209-418	49.4	57.9	26.5	86.1	45.6
Women (N=118)												
Average	66.8	0.62	0.59	15.3	74.3	225	1450	1600	202	205	6.0	5.0
(SD)	(37.2)	(0.60)	(0.40)	(8.2)	(133)	(667)	(1075)	(1056)	(118)	(209)	(4.1)	(3.5)
RNI	47.5‡	1.10	1.10	14.0	45.0	600	460-920‡	2800‡	400	1000	18	8.0
(%) RNI	141	56.4	53.6	109	165	37.5	158-315	57.1	50.6	20.5	31.3	62.6

†Calculated as retinol equivalents (REs).
‡Values obtained from Nutrient Reference Values of Australia and New Zealand.

Table 3. Calculated daily nutrient intake of the male subjects compared with WHO/FAO requirements for different age groups/sex obtained using weighed food record.

	Protein (mol/d)	Vit. B-1 (mg/d)	Vit. B-2 (mg/d)	Vit. B-3 (mg/d)	Vit. C (mg/d)	Vit. A (total µg/d)[‡]	Sodium (mg/d)	Potassium (mg/d)	Magnesium (mg/d)	Calcium (mg/d)	Iron (mg/d)	Zinc (mg/d)
Male (1- 3 yrs)[2†]												
Average (SD)	52.8 (1)	0.9 (0.1)	0.7 (0.1)	11 (1)	49 (2)	165 (4)	1590 (14)	1100 (9)	205 (5)	287 (1)	7 (1)	5.9 (2)
RNI	12.0[§]	0.5	0.5	6	30	400	200-400[§]	2000[§]	60	500	4	4.1
(%) RNI	440	180	140	183	163	41.3	399-797	54.6	342	57.4	175	144
Male (4-6 years)[1]												
Average (SD)[¶]	80.4 (-)	0.6 (-)	0.8 (-)	12 (-)	44 (-)	71 (-)	2560 (-)	764 (-)	227 (-)	403 (-)	5.7 (-)	8.1 (-)
RNI	16.0[‡]	0.6	0.6	8	30	450	300-600[§]	2300[§]	73	600	4	5.1
(%) RNI	503	100	133	150	147	15.8	426-853	33.2	311	67.2	143	159
Male (7-9 years)[2†]												
Average (SD)	53.5 (0.5)	0.6 (0.0)	0.8 (0.1)	15 (2)	92 (2)	131 (4)	2070 (10)	1410 (11)	290 (6)	258 (4)	10 (1)	8.4 (1)
RNI	16.0[§]	0.9	0.9	12	35	500	300-600[§]	3000[§]	100	700	6	5.1
(%) RNI	334	66.7	88.9	125	263	26.2	344 -689	46.9	290	36.9	167	165
Adult (19-65 years)[10†]												
Average (SD)	92.8 (5)	1.1 (0.2)	0.8 (0.1)	18 (2)	49 (3)	71 (5)	3080 (15)	1220 (21)	301 (16)	331 (10)	10 (2)	7.8 (1)
RNI	84.4[§]	1.2	1.3	16	45	600	460-920[§]	3800[§]	260	1000	9	7
(%) RNI	110	91.7	61.5	113	109	11.8	335-670	32.1	116	33.1	111	111

[†]Number of subjects in each age category.
[‡]Calculated as retinol equivalents (REs).
[§]Values obtained from Nutrient Reference Values of Australia and New Zealand.
[¶]Values that do not have SD because it contains only one subject

Table 4. Nutrient intake of the female subjects compared with WHO/FAO requirements for different age groups/sex obtained using weighed food record.

	Protein (mol/d)	Vit. B-1 (mg/d)	Vit. B-2 (mg/d)	Vit. B-3 (mg/d)	Vit. C (mg/d)	Vit. A (total µg/d)‡	Sodium (mg/d)	Potassium (mg/d)	Magnesium (mg/d)	Calcium (mg/d)	Iron (mg/d)	Zinc (mg/d)
Females (4-6 years)1†												
Average (SD) ¶	48.7 (-)	0.4 (-)	0.4 (-)	9 (-)	1 (-)	37 (-)	1410 (-)	499 (-)	129 (-)	179 (-)	4 (-)	4.1 (-)
RNI	16.0§	0.6	0.6	8	30	450	300-600§	2300§	73	600	4	5.1
(%) RNI	304	66.7	66.7	112.5	3.3	8.2	235 -471	21.7	177	29.8	100	80.4
Female (10-18 years)1†												
Average (SD) ¶	49.1 (-)	1.0 (-)	1.0 (-)	16 (-)	51 (-)	138 (-)	3150 (-)	1181 (-)	265 (-)	212 (-)	12 (-)	7.5 (-)
RNI	35.1§	1.10	1.00	16	40	600	400-800§	2600§	230	1300	21	7.8
(%) RNI	140	90.9	100	100	128	23.0	393-787	45.4	115	16.3	57.1	96.2
Adult (19-65 years)12†												
Average (SD)	69.5 (6.5)	0.8 (0.3)	0.6 (0.1)	13 (1)	25 (3)	76.6 (6)	2170 (21)	818 (10)	212 (5)	256 (7)	7 (1)	6.0 (2)
RNI	47.5§	1.1	1.0	14	45	500	460-920§	2800§	220	1000	20	4.9
(%) RNI	147	72.7	60.0	92.9	55.6	15.3	236 -472	29.2	96.4	25.6	35.0	122

†Number of subjects in each age category.
‡Calculated as retinol equivalents (REs).
§Values obtained from Nutrient Reference Values of Australia and New Zealand.
¶Values that do not have SD because it contains only one subject

Supplementary Material for Chapter 3

NARs and protein intakes: clarification of the approaches

Nutrient adequacy ratios (NARs) defined by the INDDEX Project (2018) as equal to the ratio of an individual's nutrient intake to the current Recommended Nutrient Intake (RNI) were derived from the weighed food records. In this chapter, the NARs were calculated for energy and 12 nutrients (vitamins A, C, B-1, B-2, B-12, niacin, folic acid, calcium, iron, zinc, magnesium, and protein).

The FAO/WHO (2003) Recommended Nutrient Intake were used. Table 2 shows (page 100) for men, Vitamin B1 average intake was 0.7mg/day. Using the RNI of 1.2mg/day the NAR was calculated as (0.7/1.2) * (100/1) = 61.7%.

Using the EAR (ANHMRC & NZMH, 2015), the average intake of 0.7 UNITS was divided by the EAR was 1.1UNITS providing a NAR of (0.7/1.1)* (100/1) = 63.6%.

The same method was used to calculate the NAR for other nutrients (Protein, Vitamin B2, Vitamin B3, Vitamin C, Magnesium, calcium, Iron and Zinc) for both men and women for Table 2 -4. Adequate Intake values were used for Sodium and Potassium because there are no EAR value for them.

The unit of protein was expressed in mol/d to meet the requirements of the journal that published the article however protein is now expressed as g/day in Tables 2-4 below.

Supplementary Table 2. Calculated daily nutrient intakes of the subjects (19- 65 years) based on 24-hour dietary recall data, and comparison to reference intakes (EARs)

	Protein (g/day)	Vit. B-1 (mg/d)	Vit. B-2 (mg/d)	Vit. B-3 (mg/d)	Vit. C (mg/d)	Vit. A (total µg/d)[†]	Sodium (mg/d)	Potassium (mg/d)	Magnesium (mg/d)	Calcium (mg/d)	Iron (mg/d)	Zinc (mg/d)
Men (N=43)												
Average (SD)	87.0 (34.8)	0.7 (0.4)	0.7 (0.6)	19 (8)	55 (89)	280 (311)	1920 (1210)	1880 (1570)	232 (104)	265 (201)	7 (3)	6.4 (3)
EAR	52	1.1	1.1	12	30	625	920-460[‡]	3800[‡]	350	840	6	12
NAR	167	63.6	63.6	158	183	44.8	209-418	49.4	66.3	31.6	116.6	53.3
Women (N=118)												
Average (SD)	66.8 (37.2)	0.62 (0.60)	0.59 (0.40)	15.3 (8.2)	74.3 (133)	225 (667)	1450 (1075)	1600 (1056)	202 (118)	205 (209)	6.0 (4.1)	5.0 (3.5)
EAR	37	0.90	0.90	11.0	30	500	460-920[‡]	2800[‡]	265	840	8	6.5
NAR	181	68.9	65.5	139.1	247.7	45.0	158-315	57.1	76.2	24.4	75.0	76.9

[†]Calculated as retinol equivalents (REs).
[‡]Values obtained from Nutrient Reference Values of Australia and New Zealand (ANHMRC & NZMH, 2015).
NAR Nutrient Adequacy Ratio

Supplementary Table 3. Calculated daily nutrient intake of the male subjects compared with Estimated Average Requirement (EAR) for different age groups/sex obtained using weighed food record.

		Protein (g/day)	Vit. B-1 (mg/d)	Vit. B-2 (mg/d)	Vit. B-3 (mg/d)	Vit. C (mg/d)	Vit. A (total µg/d)‡	Sodium (mg/d)	Potassium (mg/d)	Magnesium (mg/d)	Calcium (mg/d)	Iron (mg/d)	Zinc (mg/d)
Male (1- 3 yrs)[2†]													
	Average (SD)	52.8 (1)	0.9 (0.1)	0.7 (0.1)	11 (1)	49 (2)	165 (4)	1590 (14)	1100 (9)	205 (5)	287 (1)	7 (1)	5.9 (2)
	EAR	12.0	0.4	0.4	5	25	210	200-400§	2000§	65	360	4	3.0
	NAR	440	225	175	220	196	78.6	399-797	54.6	315	79.7	175	197
Male (4-6 years)[1]													
	Average (SD) ¶	80.4 (-)	0.6 (-)	0.8 (-)	12 (-)	44 (-)	71 (-)	2560 (-)	764 (-)	227 (-)	403 (-)	5.7 (-)	8.1 (-)
	EAR	16.0	0.5	0.5	6	25	275	300-600§	2300§	110	520	4	5.0
	NAR	503	120	160	200	176	258	426-853	33.2	206	77.5	143	162
Male (7-9 years)[2†]													
	Average (SD)	53.5 (0.5)	0.6 (0.0)	0.8 (0.1)	15 (2)	92 (2)	131 (4)	2070 (10)	1410 (11)	290 (6)	258 (4)	10 (1)	8.4 (1)
	EAR	16.0	0.7	0.7	9	28	445	300-600§	3000§	110	800	6	5.0
	NAR	334	85.7	114	167	329	29.4	344 -689	46.9	264	323	167	168
Adult (19-65 years)[10†]													
	Average (SD)	92.8 (5)	1.1 (0.2)	0.8 (0.1)	18 (2)	49 (3)	71 (5)	3080 (15)	1220 (21)	301 (16)	331 (10)	10 (2)	7.8 (1)
	EAR	52	1.1	1.1	12	30	625	920-460‡	3800‡	350	840	6	12
	NAR	179	100	72.7	150	163	11.4	209-418	49.4	86	39.4	167	65

†Number of subjects in each age category.
‡Calculated as retinol equivalents (REs).
§Values obtained from Nutrient Reference Values of Australia and New Zealand (ANHMRC & NZMH, 2015).
¶Values that do not have SD because it contains only one subject
NAR Nutrient Adequacy Ratio

Supplementary Table 4. Nutrient intake of the female subjects compared with Estimated Average Requirement (EAR) for different age groups/sex obtained using weighed food record.

	Protein (g/day)	Vit. B-1 (mg/d)	Vit. B-2 (mg/d)	Vit. B-3 (mg/d)	Vit. C (mg/d)	Vit. A (total µg/d)[‡]	Sodium (mg/d)	Potassium (mg/d)	Magnesium (mg/d)	Calcium (mg/d)	Iron (mg/d)	Zinc (mg/d)
Females (4-6 years)[1†]												
Average (SD)[¶]	48.7 (-)	0.4 (-)	0.4 (-)	9 (-)	1 (-)	37 (-)	1410 (-)	499 (-)	129 (-)	179 (-)	4 (-)	4.1 (-)
EAR	16.0	0.5	0.5	6	25	275	300-600[§]	2300[§]	110	520	4	5.0
NAR	503	80	80	150	4.0	13.5	426-853	33.2	117	34.4	100	82
Female (10-18 years)[1†]												
Average (SD)[¶]	49.1 (-)	1.0 (-)	1.0 (-)	16 (-)	51 (-)	138 (-)	3150 (-)	1181 (-)	265 (-)	212 (-)	12 (-)	7.5 (-)
EAR	35.1	0.9	1.1	11	28	485	400-800[§]	2600[§]	300	1050	8	6
NAR	140	111	90.9	146	182	28.5	393-787	45.4	88.3	20.1	150	125
Adult (19-65 years)[12†]												
Average (SD)	69.5 (6.5)	0.8 (0.3)	0.6 (0.1)	13 (1)	25 (3)	76.6 (6)	2170 (21)	818 (10)	212 (5)	256 (7)	7 (1)	6.0 (2)
EAR	37	0.90	0.90	11.0	30	500	460-920[‡]	2800[‡]	265	840	8	6.5
NAR	188	68.9	65.5	139.1	247.7	45.0	158-315	57.1	76.2	24.4	75.0	76.9

[†]Number of subjects in each age category.
[‡]Calculated as retinol equivalents (REs).
[§]Values obtained from Nutrient Reference Values of Australia and New Zealand (ANHMRC & NZMH, 2015).
[¶]Values that do not have SD because it contains only one subject
NAR Nutrient Adequacy Ratio

4 Are households in Kiribati nutrition-secure? A case study of South Tarawa and Butaritari

ABSTRACT

Background and Objectives: This study assessed the nutritional status among householders in urban South Tarawa and rural Butaritari in Kiribati. **Methods and Study Design**: In this cross-sectional study we assessed energy and nutrient intakes, food variety scores and dietary diversity scores of men and women from 468 households randomly selected in South Tarawa (n=161) and Butaritari (n=307) using a 24-h dietary recall. Nutrient adequacy ratios and mean adequacy ratios of selected nutrients were also determined from 3-day weighed food records collected among subjects living in a further 28 households from South Tarawa (n=29) and Butaritari (n=44). **Results**: Based on the 24-h dietary recall, the average energy intake for men and women was 2536 kcals and 2068 kcals respectively. CHO, Fat and Protein intakes for men and women were 332.5g, 76.5g and 130.4g and 291.7g, 55.1g and 103.5g, respectively. The mean and standard deviation of household Food Variety Score and Dietary Diversity Score was 3.90±1.25 and 5.44±1.92 respectively. Intakes of vitamin A, calcium, and iron, and zinc were notably deficient in both locations, with the urban subjects having lower intakes of vitamin B-1, vitamin B-2, magnesium, and potassium than their rural counterparts. Mean sodium intakes exceeded recommendations for all age groups in South Tarawa except children aged 4-6 years. **Conclusions:** Food consumption patterns of the households in South Tarawa and Butaritari reflected high consumption of non-traditional diets and refined foods, which manifested in inadequate micronutrient intake estimates and low dietary diversity: strong risk factors for non-communicable diseases such as obesity and diabetes.

4.1 Introduction

As a consequence of global nutrition transition, once self-sufficient countries have become economically and food dependent on developed countries including most Pacific Island Countries (PICs). This, at least in part, explains the increase in nutrition insecurity and unhealthy diets in many PICs, with resultant high rates of obesity and both communicable and non-communicable diseases[1]. The extent of diversity in the food supply with available macronutrients and micronutrients is a major underlying factor of nutrition security.[2,3] Although, malnutrition causes are complex, a leading cause is suggested to be the simplification of diets, which is linked to reduced dietary diversity, and decline in nutrition quality. An emerging body of evidence linking food and nutrition insecurity to a spectrum of adverse outcomes has focused the importance of dietary diversity as an important indicator of good nutritional status.[4] These outcomes include iron-deficiency anaemia and increased chronic diseases [5], long term physical health problems [6] and poor mental health.[7] The recent trend is to determine diet quality in characterizing dietary patterns, as measured by food variety (FV) and diet diversity score (DD).[8] Dietary diversity is calculated as the number of food groups consumed compared to a standard number of food groups.[8,9] Many studies have assessed the quality of diet using the measures of food variety and dietary diversity, especially for developing countries.[10,11,12] A lack of dietary diversity has been found to adversely impact adults and children of rural households living in poor-resource communities, e.g., in Sub-Saharan Africa.[13,14,15]

Few studies have been conducted in Small Island Developing States (SIDS). A study in Fiji, which measured diet composition, hair and breath isotopic composition, showed that dietary and tissue isotopic values provide a basis for determining and validating dietary regimes.[16] Another study in Papua New Guinea showed that malnutrition was positively associated with poor socio-economic factors.[17] No such studies have been conducted in Kiribati, a west Pacific island state, which consists of chain of sixteen atolls and one coral island with a population of 110,136 (2015 Census) population and a GDP per capita of only US$1,651.[18] A transition of dietary patterns in Kiribati and other Pacific regions is demonstrated by increased demand for packaged imported foods such as canned meats, instant noodles, rice and sugar-sweetened beverages, and subsequently, reduced consumption of traditional indigenous plants and animals, thereby leading to food and nutrition insecurity and a high incidence of diet-related non-communicable diseases.[19,20] The Global Nutrition Report 2018 for Kiribati showed a worsening scenario for adult obesity, diabetes and anaemia. The underlying determinants of malnutrition such as availability of fruits and vegetables, total calories obtained from non-staples, sanitation and drinking water coverage, and female secondary education enrolment has not significantly improved.[21]

The aim of this research was to measure the nutrient intake, food variety and dietary diversity of adult householders in South Tarawa (ST) and Butaritari (BT), Kiribati. The work is part of a baseline survey for the Kiribati Health Champions (KHC) programme [22] and one of the few studies in SIDS that reports nutritional status using dietary intakes of households. The purpose of the 24h recall was to assess the energy, macronutrients, micronutrients, food variety score (FVS) and dietary diversity score (DDS) of the households and weighed food record was carried out to provide prospective quantitative dietary information. The findings from our study provide a benchmark against which progress made by the KHC group in the target communities can be measured.[22]

4.2 Materials and methods

Study Area

South Tarawa is the capital of the Republic of Kiribati which is home to approximately half (50, 182) of Kiribati's total population, and most of the government, commercial and education facilities. Butaritari is the second most northerly of the Gilbert Islands, formerly called Makin Atoll by the US Military, with a population of 4,346 people inhabiting twelve villages.[18]

Enumerator composition and training.

Enumerators were drawn from communities in ST and BT. The enumerators were selected based on their knowledge, fieldwork experience, and community engagement. Ten enumerators each from ST and BT were trained and field work was conducted in teams of two. A translator was present during training, fieldwork and initial data cleaning. Training was undertaken for five days in each location and covered best practices, ethical behaviour, sampling protocols and the questionnaire instruments. Reliability tests were conducted on the instruments. It also included a field test of all of the instruments (24-h dietary recall and the weighed food record templates) and a final revision of the instruments based on the enumerators' field experience. Serving/portion sizes were developed for some of the foods with input from the enumerators for better applicability and understanding of the dietary assessment instruments. These were continuously updated or verified until the end of the survey as new foods/dishes/menus were identified from participant responses.

Sampling methodology

A sample of 468 households (161 and 307 from ST and BT respectively) was selected for the survey using a systematic random sampling method. The inclusion criterion was any household with at least a mother/father and child/dren living, cooking and eating in the same household. No exclusion criteria were applied. It is a household study and the individuals were responding on behalf of the households, with the exception of the individual weighed food records, which were recorded at the household level. The list of households was obtained from National Statistics Office, Tarawa. After estimating the total number of households at each site, every third household was approached and invited to participate in the study. The respondents were mostly adult (≥18 years of age) female members of the households who were involved in cooking/purchasing of the food. No incentives were provided.

Ethical Standard Disclosure

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving study participants were assessed and approved as Low Risk under Massey Ethics Committee System with Application No 4000018013. A research permit was also obtained from Kiribati Immigration with RP No 14/2017**.** Written and verbal informed consent was obtained from all subjects. Verbal consent was witnessed and formally recorded.

Data collection

Data collection was completed in September 2018 using a standardised protocol for the 24-h food recall and the 3-day weighed food record, both of which are instruments of choice in studies of this type.[23] The 24-h food recall was administered in Gilbertese (local language) using common local measures used in their homes for better recall. These local measures were standardized and converted into metric measures.

24-h recall

A trained person administered an individual single 24-h food recall on a random day to minimise the effects of day-to-day differences. During the 24-h food recall, participating women (320) and men (148) were asked to describe all foods and drinks consumed the preceding day as well as the time these foods or drinks were consumed. Names of dishes and all ingredients used were recorded. The amount of food consumed was expressed using common household measures such as a big spoon, a small spoon, a ladle, a cup, a glass and a tea glass. These local measures were standardized and converted into metric measures. Portion sizes were estimated using visual aids (photographs of food portion sizes). Preparation techniques of the foods and occasions they were consumed were recorded. The food and drink consumption data was not restricted to any quantity or form for any of the items consumed, and all items were included in the analysis. Energy, macronutrient and micronutrient intakes were estimated using the Pacific Food Composition Database (2004 version) in FoodWorks 9 Professional Software, Xyris (2009) Ltd.

Dietary diversity and nutrient adequacy

Dietary diversity (DD), defined as the number of different foods or food groups consumed in the previous day, was measured using a Dietary Diversity Score (DDS). For each individual DDS was calculated by summation of the number of food groups recorded on the 24-h food recall [24]. Eleven food groups (fish/sea foods, cereals, sugar, fats/oil, meats/pork, roots & tubers, fruits, dairy products, vegetables, eggs, and legumes & nuts) were used in the study. Any quantity of any food group consumed at least once per day was taken into account. Therefore, the DDS was calculated without considering a minimum intake for a food group. Although we assessed individual dietary diversity using 24 hr recall, we consider that they are representatives of their households (as most householders eat the same food). On that basis, we further analysed and categorised this as HDDS. Subjects were categorized as having Low DD (consumption of ≤4 food groups), Medium DD (5-6 food groups) and High DD (≥7 food groups).[24]

Food Variety Score

The food variety score (FVS) approach was adapted and modified from Clausen and colleagues [8] and obtained from the 24-h dietary recall. The scoring system was based on the daily intake. One point was given for each consumed food item in each meal and was then categorized. A total of nine categories of foods with 89 food items were selected for inclusion in the calculation of FVS with scores ranging between 0 and 9 points. These nine categories of foods were: rice, noodles and breads; cereals, cereal products and tubers; vegetables; fruits; fish, poultry and meat; legumes and nuts; milk and milk products; fat, oils, sugar and salt; non-alcoholic beverages. The FVS was then categorised into Low (1-3 points), Medium (4-6 points) and High (>7 points)

Estimation of misreporting

The proportion of possible under or over reporting was calculated from total energy intake (EI) from reported food intake with individual estimated basal metabolic rate (BMR_{est}), calculated using the Harris-Benedict equations revised by Mifflin et al.[25]. The equation for men is (10 x weight in kg) + (6.25 x height in cm) – (5 x age in years) + 5 x physical activity level (PAL) while the equation for women is (10 x weight in kg) + (6.25 x height in cm) – (5 x age in years) -161 x PAL. Cut-off points were applied using the methods described by Goldberg, identified as the optimal method in a review based on the ratio between El: BMR_{est} for a particular PAL [26]. Under-reporting was defined as El: BMR_{est}<1.10 and El: BMR_{est} >2.19 was used to define over-reporters [27].

To check for the impact of misreporters, a sensitivity analysis was undertaken of the proportion of subjects from ST and BT with an EI-BMR of between 1.10 and 2.19 who met the Nutrient Reference values (NRV) for Australia and New Zealand for intake of macronutrients by sex (Table 2).

Three-day weighed food record

A three-day weighed food record was obtained from a sub-sample of 28 households with 73 individual household members in ST and BT. There were 29 household members in ST (15 males and 14 females) and 44 household members in BT (24 males and 20 females). Measurements of the foods consumed were conducted using modified standard procedures.[28] In particular, household dietary/food scales were used to weigh all raw food ingredients, all cooked food, and individual food portions per person at each meal. Left-overs and inedible portions of each meal were also weighed. Food items were analysed by coding all the food and drinks recorded by the participants using FoodWorks 9 Professional software, Xyris (2009) Ltd. Data obtained were used to support the 24-h food recall. Weighed food records are often used as a reference method in validation studies of other dietary assessment methods. [29,30]

Nutrient Adequacy Ratio

Nutrient adequacy was measured from the weighed food record by computing the Nutrient Adequacy Ratio (NAR).[31] NAR was calculated for energy and 12 nutrients including vitamins A, B-1, B-2, B-3, B-12 and C, folic acid, calcium, iron, zinc, magnesium, and protein. The mean probability of adequacy across the nutrients was calculated using the Recommended Nutrient Intakes (RNIs).[32] Mean adequacy ratio (MAR) of the micronutrients (vitamin A, iron and zinc) was calculated to reflect the overall micronutrient adequacy of the diets. This index quantifies the overall nutritional adequacy of a population based on an individual's diet using the current recommended nutrient intake for a group of nutrients of interest. [31]

Statistical analyses

Data were normally distributed and entered into IBM statistical tool SPSS version 21 for descriptive analysis involving frequencies, percentages, means and standard deviations. The nutrient intake assessments of the subjects were compared with the recommended nutrient intake (RNI) for protein, thiamin, riboflavin, niacin, vitamin C, vitamin A, magnesium, calcium, iron and zinc [33] and sodium and potassium was compared using the Nutrient Reference Values for Australia and New Zealand.[34] The nutrients were adjusted for sex and energy and independent t-tests were used to assess the differences in nutrient intake, FVS and DDS between males and females and participants from ST and BT. Values of $p<0.05$ were considered statistically significant.

4.3 Results

24 hour recall study

For the 24 hour recall study, the mean age of the respondents was 40.7 years. Seventy-three percent and 59% were women in ST and BT respectively, and the majority of respondents were aged between 25 to 55 years. Most respondents (over 60%) had a secondary school education as their highest formal education in ST and more than half (55.6%) had a primary school education as their highest formal education in BT.

Energy intakes and major dietary components

A prominent feature of the 24 h recall results are higher total energy intakes in BT than ST, which are evident in both men and women (Table 1). On average over both men and women, BT participants consumed 1.8 times more energy. Despite this, and differences in foods consumed, the relative proportions of major dietary components between ST and BT were similar. Estimated as percent energy, the mean contributions from carbohydrate and protein intake were both 10% higher in BT than ST, and fat was 20% higher (Table 1).

Sensitivity analyses

For ST, excluding those whose mean EI suggested potential misreporting EI-BMR_{est} <1.10 and >2.19) made a 3% difference to the estimated intake of CHO, a 2% difference to the intake of protein and an 8% difference in the intake of fat. For BT this made 7%

difference to the intake of CHO, 5% difference to the intake of protein and 8% difference in the intake of fate. Exclusion of results for these participants resulted in significantly higher intakes for protein, fat and CHO. The results in Table 2 indicate that although the majority of the misreporters were over-reporting their intakes, the approximate proportions of energy adjusted macronutrient intakes were credible.

Nutrient and mineral intakes

On average, both male and female subjects in ST consumed below the recommended nutrient intake (RNI) for the following vitamins: vitamin B-1 (61.7 and 56.4%, respectively), vitamin B-2 (52.1 and 53.6%) and vitamin A (RE) (46.7 and 37.5%). They had adequate intakes for niacin (119 and 109%) and vitamin C (122 and 165%) (Table 1). Of the minerals, both male and female subjects in ST consumed below RNI values for: potassium (49.4 and 57.1% of RNIs), magnesium (57.9 and 50.6%), calcium (26.5 and 20.5%), iron (86.1 and 31.3%) and zinc (45.6 and 62.6% respectively); and above the RNI for sodium (1600 mg/d). Male and female subjects in BT consumed below the RNI for total vitamin A (22.6% and 24.5% respectively). On average male and female subjects consumed adequate amounts of niacin (206% and 196% respectively), vitamin B-1 (125% and 123% respectively), vitamin B-2 (100% and 100% respectively) and vitamin C (662% and 644% respectively) (Table 1).

A focus on mean values can obscure the significance of variation between individuals, which should also be considered for nutrients that appear deficient. For BT, the percentage of total subjects estimated to meet the RNI was in descending order: zinc (77%) > iron (61%) > calcium (47%) > vitamin A (24%) and for ST: zinc/vitamin B_1 (58%) > potassium (55%) > vitamin B_2 (53%) > magnesium (52%) > iron (46%) > vitamin A (40%) > calcium (22%).

Food groups and dishes

Over 80% of the households reporting consuming fish/seafood, cereals and sugar in both ST and BT. Few of the households in either location consumed fruit and dairy products, and no households in BT consumed vegetables or eggs (Figure 1). In terms of food groups consumed in the previous 24 h the two locations showed reported very similar results for fish (consumed in 96% and 93% of households in ST, and BT, respectively). The main difference between the two locations was higher relative cereal, sugar, and fat/oil reliance in ST. With respect to the base of dishes consumed, Figure 2 shows that households in BT had high recourse to breadfruit (75%) followed by rice-based (64%) dishes, whereas those in ST drew more heavily on rice (90%), followed by flour-based (77%) dishes. One-third (33.5%) of households in ST consumed a breadfruit-based dish in the previous 24 h, compared with three quarters of households in BT. For flour-based dishes the pattern was reversed: these were consumed by 77% of households in ST compared with 22% in ST. Only 2% of households in ST and 10% of those in BT reported consumption of taro-based dishes.

Dietary diversity and food variety

Across both locations over 60% of households had Dietary Diversity Score (DDS) and Food Variety Score (FVS) of 1-3, and almost all had scores below 6 (Figure 3).

Mean FVS (5.44±1.92) was higher than the mean DDS (3.90±1.25). The median DDS for both locations was 4. Between locations, The FVS and DDS was significantly higher in ST than BT ($p<0.0001$). This difference was substantial with the ST/BT ratio of mean scores being 1.26 for FVS and 1.34 for DDS. Figure 4 shows for BT and ST (respectively): 49.2% and 20.7% of households had a low DDS; 48.8% and 75.7% had a medium DDS; and 2.3% and 3.8% had a high DDS.

<u>Weighed food record study</u>

Nutrient adequacy ratios (NARs) and mean adequacy ratios (MARs) of selected nutrients by age group obtained from the weighed food record are shown in Table 4. Over 60% of participants in both locations were adults, of whom most were either fisher-folk, farmers or civil servants.

Data for the three youngest age groups in Table 4 should be interpreted with caution due to the low sample numbers. However, for most nutrients results are generally consistent across these three age groups (1-3 y, 4-6 y and 7-9 y) at each location, suggesting some degree of reliability. The one exception appears to be results for the two 7-9 year olds in BT which indicate lower micronutrient scores. This flowed through to a lower MAR in this age group for the aggregate of proteins and micronutrients. Results for 10-18 y olds in ST should also be treated with caution as these only represent one subject.

Sample sizes for adults (>18 years) were larger and more evenly split (22 in ST and 24 in BT, Table 4); and more comparable to the larger 24 h food recall survey results; although it should be noted that subjects were not matched.

In ST, adults involved in the weighed food records study showed (on average) adequate but not excessive intakes of protein, vitamin B_3, magnesium and zinc. In BT, only vitamin C showed up as adequate. In both locations, average sodium intakes were excessive.

A focus on mean values can obscure the significance of variation between individuals, which should also be considered for nutrients that appear deficient. For BT, the percentage of subjects estimated to meet the RNI follows the order (most to least): protein (95%) > vitamin B-3 (80%) > magnesium (78%) > zinc (64%) > vitamin B-1 (56%) > potassium (48%) > vitamin B-2 (43%) > iron (38%) > calcium (31%) > vitamin A (5%). For ST, the order is vitamin C (87%) > vitamin B-1 (82%) > iron (73%) > vitamin B-2 (61%) > potassium (31%) > calcium (29%) > vitamin A (14%).

4.4 Discussion

Major dietary components and problem areas

Based on minimum mean macronutrient distribution requirements per person per day, diets in ST and BT met or exceeded the minimum of 15%, 20% and 45% energy from protein, fat and carbohydrates, respectively[34]. Subjects from BT had significantly higher consumption of energy, fat, carbohydrates and protein for both sexes than their counterparts in ST. Rice, flour-based dishes and sugar were the main contributors to energy and carbohydrate in ST and BT.

Food intake patterns observed showed that the majority (>80%) of households in both locations consumed rice and sugar during the preceding 24 hours. These findings are not unique, either to Kiribati or to developing countries. Reporting on dietary intakes in Malaysia, Norimah and Mohaideen[35] found out that 97% of subjects consumed *nasi putih* (cooked rice) and sugar twice daily; while Badri *et al*.[12] reported daily consumption of rice and sugar as 99.7% and 92%, respectively. This trend has also been observed in developed nations such as Japan[36] and South Korea[37]. We observed the consumption of rice-based dishes was also high among the households studied. Rice is the staple food for I-Kiribati population and a major contributor of energy for the households in this study. A key contributory reason for this is that imported rice is subsidised by the Kiribati government[38] making it both affordable and available. In addition to limited land available for planting crops, the relatively dry environment and coarse soil contributes to low traditional crops production.

Sugar is also a source of energy in ST and BT diets as reflected in the average daily intake of 49.5 g, double the WHO recommended daily intake limit for sugar of 25 g.[39] High sugar intake leads to increased prevalence of dental caries, micronutrient deficiencies, diabetes, obesity and heart disease,[40] and there is no reason to expect that health effects of this type would not also be being experienced by Kiribati households. Dental caries are prevalent in the Pacific Islands;[41] dietary sugar consumption is linked to the presence of specific bacteria and sugar fermentation on the teeth.[42,43] The low consumption of fruits, dairy products, vegetables and eggs observed (especially in BT) may be explained mainly by their cost—rather than limits to their availability. These foods are perceived as expensive and are most often sold by the people who produce them for income. Lower consumption of these foods leads to increased intakes of cheaper foods that are higher in energy and fat. According to the Secretariat of the Pacific Community, fruit and vegetable intakes in the Pacific Island Countries and Territories (PICTs) are well below the recommended level of five servings per person per day.[44] Low consumption of fruit and vegetables is often attributed to poverty and food insecurity in developing nations.[45]

Micronutrient Intakes

For both locations, both dietary assessment methods showed marked low intakes of vitamin A and calcium. Vitamin A intakes were at their lowest prevalence in BT, where by 24 h recall 76% of subjects did not achieve the RNI (rising to 95% by weighed food records). In ST the corresponding figure was 60% (86% by weighed food record). For calcium 53% of BT and 71% of ST subjects did not meet the RNI based on 24 h recall; corresponding figures from weighed food records were consistent with these results at: BT 69%, and ST 78%. Other micronutrients for which more than 30% subjects showed intakes below the RNI based on 24 h recall were: iron and zinc (both locations), and vitamin B-1, vitamin B-2, potassium and magnesium (ST).

In keeping with these results the 24-h dietary recall showed that mean intakes of men and women in ST at below their recommended levels for vitamin A, vitamin B-2, vitamin B-3, potassium, magnesium, calcium, iron and zinc. Diets in BT showed four fewer deficient nutrients (on average) compared to those in ST. Mean intakes in BT were low in vitamin A, calcium, iron and zinc. This variation can be linked to the consumption of more local traditional foods in BT, including breadfruit, coconut and a wider variety of seafood such as crab, eel fish and octopus.

As discussed above (and shown in Tables 1 and 4), for all age groups in both locations, vitamin A and calcium intake were inadequate; and the requirement for dietary iron intake was not met for those 10 years and over for both sexes. These nutrients are of public health significance. Vitamin A deficiency is a well-known problem in Pacific Island states as it causes night blindness and increase the vulnerability to other disorders such as iron deficiency.[46] Vitamin A deficiency can be targeted through promotion of specific varieties of yellow-flesh bananas that are rich in pro-vitamin A. [47] Calcium deficiency causes bone mass reduction by increasing bone resorption to preserve the level of ionised calcium in the extracellular fluid.[48] In the absence of available dairy products dried and ground fish bones provide a valuable alternative to increase calcium intakes. Iron deficiency has been shown to be linked to impaired cognitive and physical performance, even in the absence of anaemia.[49] Mild and moderate zinc deficiency may manifest in reduced sense of taste, reduced sperm counts, chronic liver disease, chronic renal disease and malabsorption syndrome.[50] Sodium intakes were excessive - high sodium intake is recognized as a risk factor for osteoporosis because it alters calcium metabolism by increasing urinary calcium excretion. [51]

Vitamin A deficiency in Kiribati has been established in several studies.[52,53] Work carried out in the 1990s showed a high proportion of children manifesting clinical vitamin A deficiencies in the form of xerophthalmia and xerosis. Although our study was based on dietary and not clinical assessment, our results highlight that three decades later, dietary intakes of vitamin A in Kiribati are likely to remain critically low. In addition, they are likely to be accompanied by moderate to severe deficiencies in several other micronutrients.

Dietary diversity and food variety

The median DDS of 4 and the mean FVS of 5.4 of the study population were low, indicating an overall poor diet quality. The scores were similar to those of other studies conducted among adult householders in East and West Africa; and Middle East.[3,54,11] The use of DDS as a measure depends on the number of food groups assessed, for instance, in a study done among Kenyan households the median DDS was 6 but this was out of 12 food groups.[55] Care must also be taken when comparing dietary scores from different studies because food groups may be sorted by food use, food origin, or nutritional value. In this study about half of the subjects had a monotonous diet with a notably low DDS of only two to four food groups per day. These subjects consumed a diet containing cereals, fish/seafoods and usually sugar or oil. These results are similar to findings reported from rural Burkina Faso and Tanzania, where the subjects had a low DDS of only two or three food groups consumed.[3,11]

Subjects from ST had a significantly higher DDS and FVS than those in BT, which could be attributed to their higher socioeconomic status. ST is the commercial hub of Kiribati and a more economically viable centre where many more of the subjects had a secondary school education, compared to BT. Many studies have shown the influence of socioeconomic variables such as income and education on the consumption patterns and food choices of populations. Some studies in developing countries have found households in middle income groups spend more on foods with higher palatability and diversity[56] and work from the United States[57] to Portugal[58] has demonstrated a positive effect of education on the selection of food varieties. The higher DDS and FVS in ST than BT is likely to reflect greater purchasing power, and the availability of specific non-indigenous options, or non-availability of many traditional foods. Notably this did not reflect to more adequate nutrient intakes in ST than those in BT. As an overall average across both 24 h and weighed food record results, only protein, vitamin C and Vitamin B-3 show up as being at adequate mean intake levels in ST diets. Whereas mean potassium and magnesium intakes in BT would be sufficient, in ST they are deficient—on average 3.1 and 1.6 times lower than the mean BT intakes. Mean calcium intakes are also low in both locations, but 1.5 times lower in ST than BT.

This apparent paradox of higher DDS in ST being accompanied by lower nutritional content can be explained by the nature of increased food diversity in ST, which involves a higher reliance on refined and ultra-processed foods. This in turn highlights the limitations of using DDS and FVS as proxies for assessing likely nutritional adequacy. Such limitations may apply particularly to developing counties where an increase in DDS and FVS may reflect the transition between a relatively balanced traditional diet of low diversity and the wider range of an incoming westernized diet. The dietary diversity instrument does not address ultra-processed food types. While some of these would be relatively simple to include in the instrument (*e.g.* bakery goods or biscuits under the high carbohydrate food product category), they would most often currently be included in the same broad category as more healthy foods, such as rice or oats.[59]

Strengths and Limitations

This is the only SIDS study in which weighed food records have been used to support 24-hour dietary recall information in the dietary assessment. On Kiribati's sixteen atoll islands we only studied two; thus, this study alone cannot be generalized to either represent the broader Kiribati community or represent the exact situation on any of the other fourteen islands. However, our results are indicative of the likely state of urban and rural populations in Kiribati and it is unlikely that the marked micronutrient deficiencies we have found in urban ST and rural BT would not be more widely spread. A second limitation was that dietary data were collected for only one recall period, in one season and at a time of plenty or harvest. However, in theory this should have resulted in increased dietary diversity, as more foods are available to select from. This implies that the results observed may in fact underestimate the problem. Dietary assessment must be treated with some caution. While the training and attention given to adherence of protocol attempted to ensure a quality dietary assessment an accurate assessment of nutrition status requires a combination of dietary, anthropometric, biochemical and clinical measures.[60] We also chose not to restrict analysis to only participants with potential misreporting EI-BMR_{est} <1.10 and >2.19.

4.5 Conclusion

Food consumption patterns of subjects in ST and BT reflect a high reliance on non-traditional diets and refined foods, along with refined sugar. These are evident at both locations but more pronounced in the urban (ST) where intakes of rice and flour-based dishes are higher than the rural (BT) location, and where consumption of traditional foods such as breadfruit and taro is higher in rural (BT) than ST. Reliance on refined foods along with high intakes of sugar and salt has resulted in low intakes of several micronutrients strong risk factors for non-communicable diseases such as obesity and diabetes.

Intakes of several micronutrients—in particular vitamin A, calcium, and iron, and zinc—were notably deficient in both urban (ST) and rural (BT) Kiribati households. Overall the subjects consumed a low diversity of foods. However, it is essential to consider not only diversification of diets but also the quantity and frequency of food intake of different food groups in order for an individual to attain nutrient adequacy.[15] Despite higher DDS and FVS scores evident in the urban location, a greatest number of deficient nutrients were observed. In this Pacific Island state, DDS and FVS appear to be unreliable as indicators of nutritional adequacy and instead reflect the increased food choices that can characterise the influx of a westernised diet.

Malnutrition will continue to be a major concern in Kiribati if nutrient intake is not improved through diet diversification towards more traditional and healthy foods. Exploration of the potential for food-based dietary interventions is recommended. These could include policies or programmes to enhance the use of indigenous fruits and vegetables, and promotion of specific indigenous or Pacific Islands foods using locally available resources to target specific areas of concern

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Table 1: Daily macronutrients and micronutrient intakes of the participants based on 24-h dietary recall and proportion of men and women who met the RNI.

Variable	Men (N=151)				Women (N=317)				differences between ST and BT (*p*-values)		
	ST (N=43)		BT (N=108)		ST (N=118)		BT (N=199)		Men[e]	Women[f]	All[g]
	Mean±SD	RNI/RNI(%)	Mean±SD	RNI/RNI(%)	Mean±SD	RNI/RNI(%)	Mean±SD	RNI/RNI(%)			
Energy (Kcal)	1897±201	1800[c]/105	3175±304	1800[c]/176	1418±356	1800[c]/78.7	2718±431	1800/151	<0.0001	<0.0001	<0.0001
EI:BMR_{est}	0.6		1.8		0.6		1.8				
CHO (g/d)	233±159	-	432±240	-	5	-	9	-	<0.0001	<0.0001	<0.0001
CHO % energy	49.1%[d]		54.4%[d]		53.0%[d]		58.2%[d]		0.031	0.021	0.037
Fat (g/d)	68.5±46.8	-	84.5±72.9	-	44.3±32.4	-	65.8±52.9	-	<0.0001	<0.0001	<0.0001
Fat % energy	32.5%[d]		23.9%[d]		28.1%[d]		21.8%[d]		0.002	0.004	0.001
Protein (g/d)	87.0±34.8	84.8/ 103	173.8±96.3	84.8/204	66.8±33.2	47.5/141	140.2±93.7	47.5/295	<0.0001	<0.0001	<0.0001
Protein % energy	18.4%[d]		21.9%[d]		18.8%[d]		20.6%[d]		0.03	0.045	0.021
Vit. B-1 (mg/d)	0.7±0.4	1.2/61.7	1.5±0.9	1.2/125	0.62±0.6	1.10/56.4	1.4±0.3	1.10/123	0.124	0.006	0.002
Vit. B-2 (mg/d)	0.7±0.6	1.3/52.1	1.3±0.4	1.3/100	0.59±0.4	1.10/53.6	1.1±0.5	1.10/100	0.033	0.024	0.004
Vit. B-3 (mg/d)	19±8.0	16/119	33±3.2	16/206	15.3±8.2	14.0/109	27±4.6	14/45	0.046	<0.0001	<0.0001
Vit. C (mg/d)	55±8.9	45/122	298±67.2	45/662	74.3±13.3	45.0/165	290±112	45/644	<0.0001	<0.0001	<0.0001
Vit. A (µg/d)[a]	280±31.1	600/46.7	136±43.2	600/22.6	225±66.7	600/37.5	147±61.1	600/24.5	<0.0001	0.039	0.001
Sodium (mg/d)	1921±1210	1600[b]/120	2660±102	1600[b]/166	1450±1075	1600[b]/90.6	1937±107	1600[b]/121	0.001	<0.0001	<0.0001
Potassium (mg/d)	1878±1570	3800[b]/49.4	6639±673	3800[b]/178	1600±1056	2800[b]/57.1	6928±876	2800[b]/247	<0.0001	<0.0001	0.343
Magnesium (mg/d)	232±104	400/57.6	737±79	400/183	202±118	400/50.6	734±61.2	400/183	<0.0001	<0.0001	<0.0001
Calcium (mg/d)	265±201	1000/26.5	530±41.1	1000/53	205±20.9	1000/20.5	439±15	1000/43.9	<0.0001	<0.0001	<0.0001
Iron (mg/d)	7±3.2	8/86.1	7.6±1.1	8/95.0	6±4.1	18/31.3	7.7±3.2	18/43	<0.0001	<0.0001	<0.0001
Zinc (mg/d)	6.4±3.3	14/45.6	8.6±3.1	14/61	5±3.5	8/62.6	6.9±1.4	8/86.3	<0.0001	<0.0001	<0.0001

Table 1 footnotes: EI:BMR, ratio of energy intake to estimated BMR (BMR estimated using Harris-Benedict equations), excludes energy use from physical activity; [a]Calculated as retinol equivalents (RE values); [b]Values obtained from Nutrient Reference Values of Australia and New Zealand. Sodium reference values are given as a Suggested Dietary Target and potassium reference values as an Adequate Intake; [c]The average minimum energy requirement per person per day by FAO (2014); [d]% Energy; [e] p-value between ST and BT for men; [f]p-value between ST and BT for women; [g]p-value between ST and BT over all participants.

Table 2: Proportion of subjects from ST and BT with an EI-BMR of between 1.10 and 2.19 who met the Nutrient Reference values (NRV) for Australia and New Zealand for intake of macronutrients.

Dietary component	**ST**		**BT**		**p-values**	
	Men N (%)	Women N (%)	Men N (%)	Women N (%)	Between men & women	Between ST & BT
Energy from CHO, 45-65%	3 (75.0)	10 (62.5)	27 (47.4)	51 (46.4)	0.678	0.112
Energy from Protein, 15-25%	3 (75.0)	9 (56.3)	29 (50.9)	42 (38.2)	0.432	0.324
Energy from Fat, 20-35%	1 (25.0)	1 (6.3)	7 (12.3)	9 (8.2)	0.213	0.217

Table 3: Age, location and gender distribution of the subjects that participated in the weighed food records.

	ST		**BT**	
Age (years)	Male	Female	Male	Female
1-3	2	1	2	2
4-6	1	-	2	2
7-9	2	-	2	-
10-18	-	1	6	4
19-65	10	12	12	12
Totals	15	14	24	20

Table 4: Nutrient adequacy ratios (NARs) and mean adequacy ratios (MARs) of certain nutrients for different age groups obtained using weighed food record (N=73). Numbers in parentheses are standard deviations.

	1-3 years (N=7)		**4-6 years (N=5)**		**7-9 years (N=4)**		**10-18 years (N=11)**		**>18 years (N=46)**	
	ST (N=3)	BT (N=4)	ST (N=1)	BT (N=4)	ST (N=2)	BT (N=2)	ST (N=1)	BT (N=10)	ST (N=22)	BT (N=24)
NARs (%)										
Protein	440 (1.4)	484 (10.2)	404 (-)	363 (11.2)	334 (0.5)	315 (3.8)	140 (-)	137 (11.2)	129 (21.1)	95 (10.1)
Vitamin B-1	180 (0.1)	107 (5.2)	83 (-)	100 (4.3)	67 (0.0)	56 (2.1)	91 (-)	37 (13.2)	82 (10.5)	56 (5.1)
Vitamin B-2	140 (0.1)	97 (3.8)	100 (-)	95 (2.3)	89 (0.1)	44 (7.1)	100 (-)	30 (2.1)	61 (13.2)	43 (2.1)
Vitamin B-3	183 (1.2)	182 (2.9)	131 (-)	143 (8.7)	125 (1.5)	92 (5.6)	100 (-)	50 (4.1)	103 (3.4)	80 (11.2)
Vitamin C	163 (1.7)	73 (1.8)	75 (-)	93 (6.5)	263 (2.3)	77 (2.3)	128 (-)	27 (1.1)	87 (12.1)	109 (12.4)
Vitamin A	41 (3.5)	19 (2.1)	12 (-)	18 (0.9)	26 (3.5)	10 (1.0)	23 (-)	2 (1.1)	14 (3.6)	5 (0.8)
Sodium	159 (22.3)	102 (11.3)	284 (-)	89 (12.1)	207 (48.2)	85 (14.1)	137 (-)	69 (4.5)	114 (12.1)	47 (5.2)
Potassium	55 (8.6)	67 (3.2)	28 (-)	53 (4.5)	47 (11.2)	35 (2.7)	45 (-)	22 (2.4)	31 (2.3)	48 (2.4)
Magnesium	342 (5.1)	302 (12.7)	244 (-)	224 (16.2)	290 (6.4)	148 (11.2)	115 (-)	72 (5.3)	106 (11.6)	78 (15.2)
Calcium	57 (1.4)	40 (2.6)	49 (-)	34 (4.2)	37 (4.2)	18 (3.6)	16 (-)	12 (2.1)	29 (2.7)	31 (4.3)
Iron	175 (1.1)	126 (10.1)	122 (-)	128 (3.8)	167 (1.4)	82 (2.7)	57 (-)	38 (6.5)	73 (8.1)	38 (3.6)
Zinc	144 (1.5)	101 (4.5)	120 (-)	85 (6.2)	165 (8.4)	85 (4.6)	96 (-)	52 (2.6)	117 (24.1)	64 (4.5)
MAR values (%)										
Protein & micronutrients	173	141.7	137.7	118.8	151.4	84.3	87.3	45.7	78.8	57.8
Vitamin A, iron and zinc	120	82	84.6	77	119.3	59	59	31	68	37

Figure 1.
(Food groups consumed by the subjects in the 24 h dietary recall by location.)

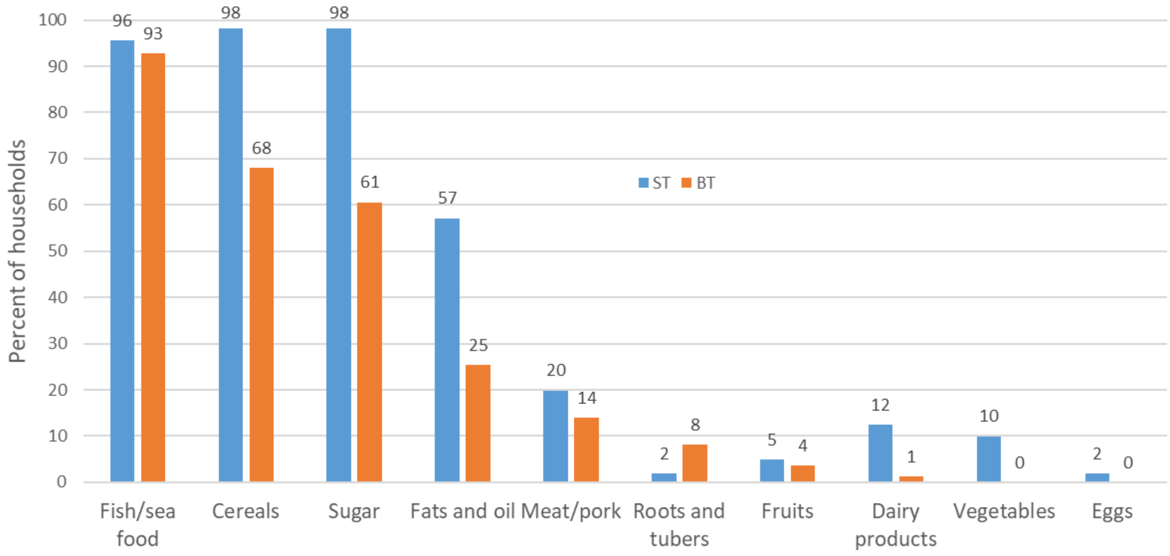


Figure 2.
(Dishes consumed by the subjects in a 24-h dietary recall by location.)

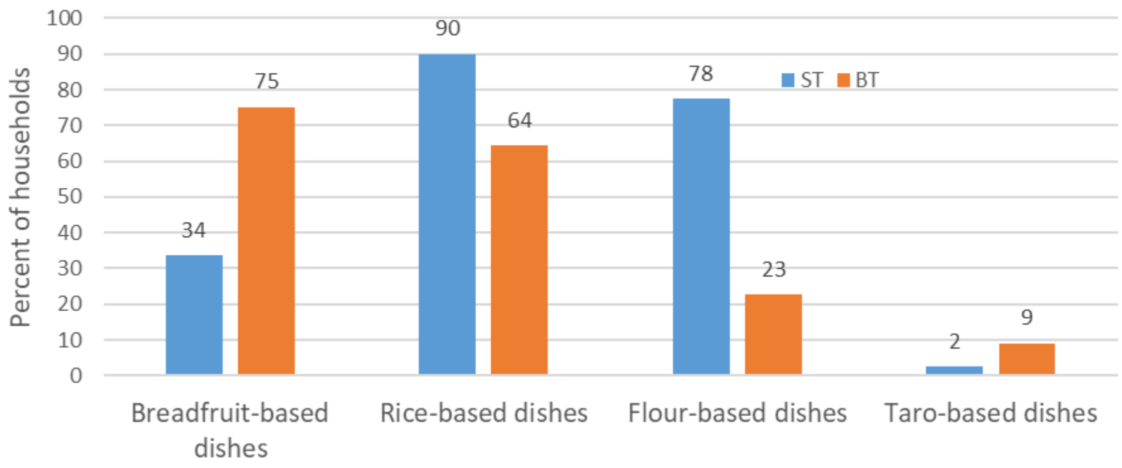


Figure 3.
(Distribution of the number of households according to FVS and DDS by location. (Note that the total number of households differ between locations: 161 for ST; 307 for BT.))

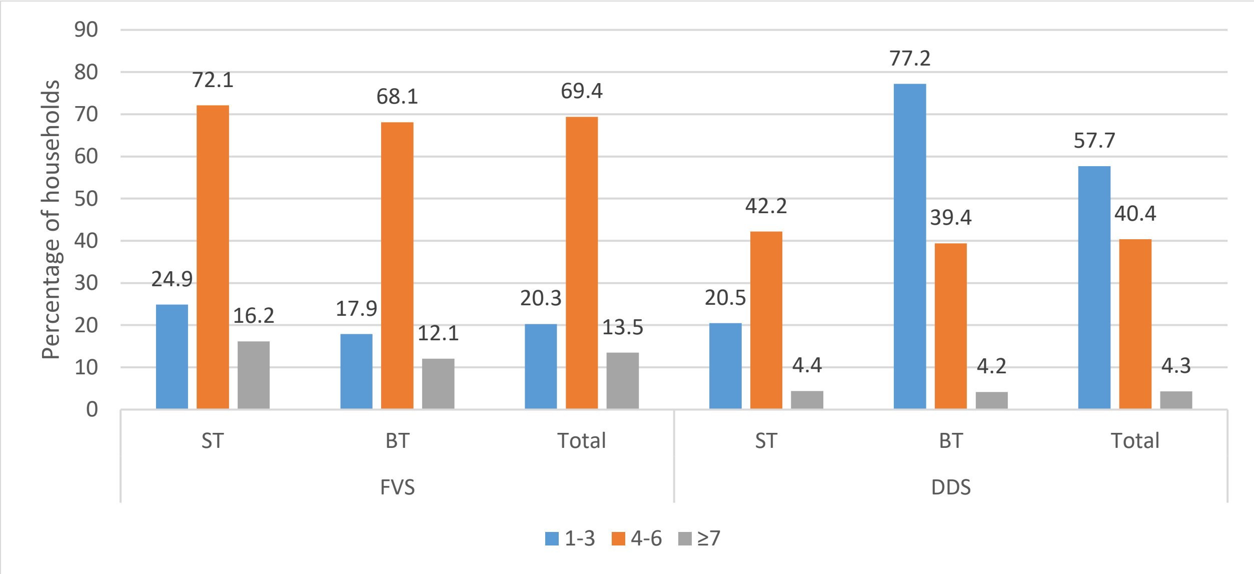
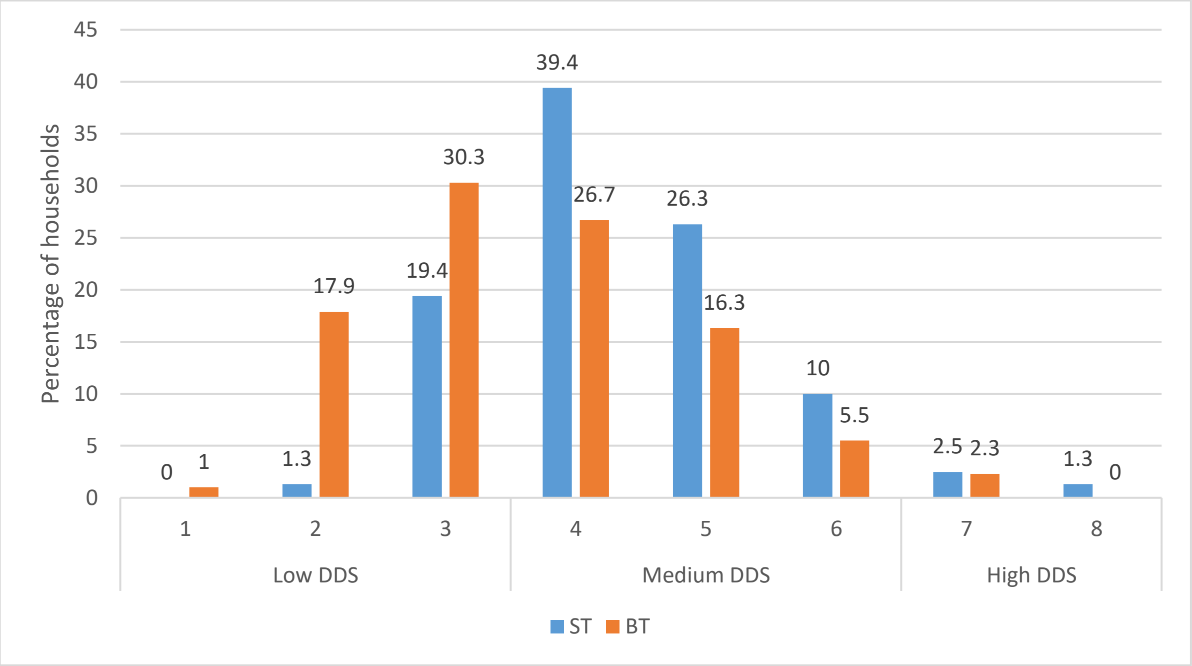


Figure 4.
(Categories of DDS by location)



Supplementary Material for chapter 4

NARs and protein intakes: clarification of the approaches

Nutrient adequacy ratio (NAR) defined by the INDDEX Project (2018) as equal to the ratio of an individual's nutrient intake to the current Recommended Nutrient Intake (RNI) were derived from the weighed food records and the 24-h dietary recall. In this chapter, the NARs were calculated for energy and 12 nutrients (vitamins A, C, B-1, B-2, B-12, niacin, folic acid, calcium, iron, zinc, magnesium, and protein) but expressed as %RNI in table 1 (published article).

The FAO/WHO (2003) Recommended Nutrient Intake were used. Table 1 shows (p. 133) for men, Vitamin B2 average nutrient intake was 0.7mg/day. Using the RNI of 1.3mg/day, the NAR was calculated as (0.7/1.3) * (100/1) = 52.1%.

Using the EAR (ANHMRC & NZMH, 2015), the average nutrient intake was 0.7 UNITS was divided by the EAR of 1.1 providing a NAR of (0.7/1.1)* (100/1) = 63.6%.

The same method was used to calculate the NAR for other nutrients (Protein, Vitamin B2, Vitamin B3, Vitamin C, Magnesium, calcium, Iron and Zinc) for both men and women for Table 1. Adequate Intake values were used for Sodium and Potassium because there are no EAR values for them.

The unit of protein was expressed in mol/d to meet the requirements of the journal that published the article however protein is now expressed as g/day in Tables 1 below.

Commentary around definitions and use of FVS and DVS

Food variety score (FVS) was calculated as the summation of each consumed food item in each meal (Clausen et al., 2005). Only food items that were consumed by the households in the 24-hour dietary recall contributed to the FVS. The word ‘variety’ indicates that a range of foods from each food group should be consumed. For example, instead of choosing one cereal product to eat, it is better to choose a selection of cereal products and alternate. It is recommended that a variety of foods be consumed because the nutritional content of each food is very different even for foods of the same group.

Dietary diversity scores were calculated based on the number of food groups consumed by individuals (Swindale & Bilinsky, 2006). In chapter 4 although I assessed individual dietary diversity scores using the 24-hr recall, I consider that the respondents are representatives of their households (as most householders eat the same food).

On that basis, I further analysed and categorised this as HDDS and subjects were categorized as having Low DD (consumption of ≤4 food groups), Medium DD (5-6 food groups) and High DD (≥7 food groups) as seen in figure 4 of Chapter 4.

Supplementary Table 1: Daily macronutrients and micronutrient intakes of the participants based on 24-h dietary recall and proportion of men and women who met the EAR.

Variable	**Men (N=151)**				**Women (N=317)**				**t-test results for differences between ST and BT (*p* -values)**		
	ST (N=43)		BT (N=108)		ST (N=118)		BT (N=199)		Men[e]	Women[f]	All[g]
	Mean±SD	EAR/EAR(%)	Mean±SD	EAR/EAR(%)	Mean±SD	EAR/EAR(%)	Mean±SD	EAR/EAR(%)			
Energy (Kcal)	1897±201	1800[c]/105	3175±304	1800[c]/176	1418±356	1800[c]/78.7	2718±431	1800/151	<0.0001	<0.0001	<0.0001
$EI:BMR_{est}$	0.6		1.8		0.6		1.8				
CHO (g/d)	233±159	-	432±240	-	187.9±122.5	-	395.4±240.9	-	<0.0001	<0.0001	<0.0001
CHO % energy	49.1%[d]		54.4%[d]		53.0%[d]		58.2%[d]		0.031	0.021	0.037
Fat (g/d)	68.5±46.8	-	84.5±72.9	-	44.3±32.4	-	65.8±52.9	-	<0.0001	<0.0001	<0.0001
Fat % energy	32.5%[d]		23.9%[d]		28.1%[d]		21.8%[d]		0.002	0.004	0.001
Protein (g/d)	87.0±34.8	84.8/ 103	173.8±96.3	84.8/204	66.8±33.2	47.5/141	140.2±93.7	47.5/295	<0.0001	<0.0001	<0.0001
Protein % energy	18.4%[d]		21.9%[d]		18.8%[d]		20.6%[d]		0.03	0.045	0.021
Vit. B-1 (mg/d)	0.7±0.4	1.1/63.6	1.5±0.9	1.1/136	0.62±0.6	0.9/68.9	1.4±0.3	0.9/156	0.124	0.006	0.002
Vit. B-2 (mg/d)	0.7±0.6	1.1/63.6	1.3±0.4	1.1/118	0.59±0.4	0.90/65.5	1.1±0.5	0.9/122	0.033	0.024	0.004
Vit. B-3 (mg/d)	19±8.0	12/158	33±3.2	12/275	15.3±8.2	11.0/139.1	27±4.6	11/246	0.046	<0.0001	<0.0001
Vit. C (mg/d)	55±8.9	30/183	298±67.2	30/993	74.3±13.3	30/247.7	290±112	30/967	<0.0001	<0.0001	<0.0001
Vit. A (µg/d)[a]	280±31.1	625/44.8	136±43.2	625/218	225±66.7	500/45.0	147±61.1	500/29.4	<0.0001	0.039	0.001
Sodium (mg/d)	1921±1210	1600[b]/120	2660±102	1600[b]/166	1450±1075	1600[b]/90.6	1937±107	1600[b]/121	0.001	<0.0001	<0.0001
Potassium (mg/d)	1878±1570	3800[b]/49.4	6639±673	3800[b]/178	1600±1056	2800[b]/57.1	6928±876	2800[b]/247	<0.0001	<0.0001	0.343
Magnesium (mg/d)	232±104	350/66.3	737±79	350/211	202±118	265/76.2	734±61.2	265/277	<0.0001	<0.0001	<0.0001
Calcium (mg/d)	265±201	840/31.6	530±41.1	840/63.1	205±20.9	840/24.4	439±15	840/52.3	<0.0001	<0.0001	<0.0001
Iron (mg/d)	7±3.2	6/116.6	7.6±1.1	6/127	6±4.1	8/75.0	7.7±3.2	8/42.8	<0.0001	<0.0001	<0.0001
Zinc (mg/d)	6.4±3.3	12/53.3	8.6±3.1	12/71.7	5±3.5	6.5/76.9	6.9±1.4	6.5/106	<0.0001	<0.0001	<0.0001

Table 1 footnotes: EI:BMR, ratio of energy intake to estimated BMR (BMR estimated using Harris-Benedict equations), excludes energy use from physical activity; [a]Calculated as retinol equivalents (RE values); [b]Values obtained from Nutrient Reference Values of Australia and New Zealand (ANHMRC & NZMH, 2015). Sodium reference values are given as a Suggested Dietary Target and potassium reference values as an Adequate Intake; [c]The average minimum energy requirement per person per day by FAO (2014); [d]% Energy; [e] p-value between ST and BT for men; [f]p-value between ST and BT for women; [g]p-value between ST and BT over all participants.

5 When knowing is not enough: the disconnection between nutrition-related knowledge, attitudes and practices among households in Kiribati

Abstract

Background and aim: Malnutrition and non-communicable diseases are highly prevalent in Kiribati with nutritional factors being strong predictors of these public health problems. We assessed food-related knowledge, attitudes and dietary practices of households in two islands of Kiribati: urban South Tarawa (ST) and rural Butaritari (BT). **Methods:** A cross-sectional mixed methods study was used. Quantitative information was collected from 160 ST and 160 BT households using a modified FAO questionnaire, comprising two sections: sociodemographic characteristics, and knowledge, attitudes and practice towards healthy eating. For the qualitative study, two focus groups, using an interview guide, among men and women were conducted in both locations, with 8-10 respondents in each group. **Results:** Fifty-nine percent and 46.3% of the respondents from BT and ST respectively had either 'good' or 'fair' knowledge of nutrition. Similarly, majority (76.9% and 65.5%) of BT and ST respondents demonstrated 'good' attitudes towards healthy nutrition. Mean attitude scores (on a scale of 5-40) were 31.5±0.7 (BT) and 26.7±1.2 (ST). No association was found between knowledge scores and location, gender, age range, BMI, education, or attitude score. Qualitative results from focus group participants provided insights that were consistent these findings. **Conclusions:** Although Kiribati people generally show good knowledge and attitudes towards nutrition, these are not adequately reflected in their nutritional practices. Our results suggest that educational initiatives in Kiribati may be limited unless they are linked to sustainable initiatives that drive nutritional outcomes, in particular the affordability and availability of a diverse range of foods.

5.1 Introduction

Kiribati, which is part of the Pacific Island region (22 countries and territories) contains a chain of sixteen atolls and coral islands with a population of 110,136 (2015 census) and a GDP per capita of only US$1,651 [1].

The transition towards urbanization in Kiribati has resulted in changes in food intake patterns, decreased physical activity, and increased salt and fat consumption, which has contributed to increased prevalence of nutrition-related non-communicable diseases (NCDs) [2]. In particular, NCDs now account for between 60-80% of all deaths in the Pacific Island region and the incidence of malnutrition and vitamin and mineral deficiencies continue to be major public health concerns [3] [4][5].

Nutrition is a modifiable lifestyle factor associated with chronic conditions such as diabetes, obesity, cancer and cardiovascular diseases. However, the factors affecting nutrition behaviour in the Pacific Island region are not well studied. Nonetheless, knowledge and attitudes regarding nutrition are generally regarded as important factors [6].

There have been no previous studies examining knowledge, attitude, and practice (KAP) towards nutrition in Kiribati. The aim of this work was to fill this gap by assessing this in two representative areas of Kiribati – urban South Tarawa (ST) and rural Butaritari (BT), with the ultimate goal of guiding the development of effective and sustainable interventions to improve the nutritional status among Kiribati households.

5.2 Materials and methods

Study area

South Tarawa (ST) is the capital of the Republic of Kiribati, which is home to approximately 50,182 people (2010 data) or half of Kiribati's total population, and most of the government, commercial, and education facilities. Butaritari (BT) is the second most northerly of the Gilbert Islands, with a population of 4,346 people (2010 data) inhabiting twelve villages [7]. Although the terms are relative, in the context of Kiribati, ST is urban, and BT is rural. The indicators used for classifying ST and BT as urban and rural areas respectively were based on World bank indicators i.e. access to infrastructures, population densities and distance to large cities.

Design

A mixed-method study was conducted, involving a (quantitative) questionnaire and (qualitative) focus groups. The aim of the qualitative study was to provide additional information to help interpret some of the quantitative results. Work was undertaken during August 2017 for ST and August 2018 for BT, as part of a larger investigation of dietary intakes and nutritional status of the people of Kiribati [8]. Ten research enumerators were trained to administer the FAO KAP questionnaire and undertake the focus group discussions.

Participants and Recruitment

For the KAP questionnaire, 160 households in ST and 160 households in BT were selected using a systematic random sampling method. The sampling frame was any household with at least a mother/father and child/dren living in the same building and cooking/eating shared meals. This is a household-level study and the individuals responded on behalf of their households. For the quantitative study, after estimating the total number of households at each site, every third household was approached and invited to participate. Respondents were mostly adult females (≥18 years of age) who were involved in cooking/purchasing of the food. In most households, these were married women; however, households where young unmarried women and men were in-charge of the kitchen were also included. No incentives were provided.

For the focus group study, the recruitment sites that were targeted were those most likely to enable successful use of the quota technique, which involved recruiting approximately equal numbers of males and females from each of the selected interest areas in the present study. Participants were subsequently randomly selected from these sites in ST and BT. All recruiters and recruitment materials provided potential participants with information on the purpose, duration (60 minutes), and procedures (audio-taped discussions) of the focus groups.

Separate focus groups were conducted for men and women aged between 18- 65 years with the rationale of accommodating cultural values, and ensuring that participants were comfortable in expressing their experiences and opinions. In each location (ST and BT), the adult male focus group comprised 10 men, and these were mainly labourers and unemployed. Each female focus group comprised 8 women and these were mainly housewives and cleaners. *The mean age of* adult focus group participants was 37.6 y (SD=5.2 y). All the participants in the adult focus groups were financially independent and not living with their parents.

Questionnaire

We used a modified FAO KAP model questionnaire [9], which was modified into 35-item questions (selected from module 5, 6, 9 and 11) with topics on under-nutrition, iron-deficiency (anaemia), food safety, and water and sanitation [9]. Eighteen items were knowledge questions, 10 items were questions on attitude and 7 questions were on nutrition practice. This was adapted by translating the questionnaire into the local Gilbertese language and further changes were made to improve comprehension, conceptual coverage and meet cultural values of the participants.

The questionnaire contained two sections: participant sociodemographic characteristics and their knowledge, attitudes and practice towards healthy eating. The scoring system for the knowledge and the attitude questionnaire was undertaken according to the method described by Oli et al. [10]. Nutrition knowledge was determined based on nutrition knowledge scores. Scores were coded as 1 for a correct and 0 for an incorrect response. The number of correct responses determined the overall knowledge score for each respondent. We categorized KAP scores into three categories based on the percentage of the maximum possible scores: “poor” (0%-50%), “fair” (51%-75%), or “good” (76%-100%) [10]. Attitudes towards good nutrition were scored based on a scale of 5-40. A Likert scale was used to assess attitudes. ‘Easy’ was allocated 5 point; ‘somewhat easy’, 4 points; ‘indifferent’, 3 points; ‘difficult’, 2 points; and ‘very difficult’, 1 point. For incorrect statements, the ranking was reversed. Respondents that scored 5-25 were graded as having poor attitude while those that scored 26-40 were graded as having good attitude towards good nutrition [10]. The knowledge and the attitude items were presented as aggregate scores while items of practice were presented individually.

Focus groups

For the focus groups we used an interview guide, which was administered by trained focus group leaders, and aimed to obtain information about traditional food use, consumption and knowledge linked to non-communicable diseases. The interview guide was based on Stewart and Shamdasani’s [11] recommendations regarding focus groups, including asking open-ended questions, asking broad questions first and then gradually narrowing the focus of next questions, and building rapport in the group before beginning to ask questions. The materials were translated to the local language (Gilbertese).

Focus group discussions were conducted in a standardized manner: the moderator introduced the research team and welcomed the participants who introduced themselves. The facilitator then explained the purpose of the meeting and set the discussion rules. The facilitator started by asking the first question of the focus group discussion guideline. Although the guideline questions were followed as closely as possible, efforts were made to ensure a natural flow of conversation, without losing the purpose of the discussion. Efforts were also made to ensure a balanced discussion by encouraging shy or quiet members of the group to participate. Domination of discussion by individual participants was discouraged. At the end of the discussion the facilitator responded to questions or pertinent issues raised during the discussion.

Anthropometric measurements

Body composition was measured using a single frequency bio impedance analyser system (BC-549, Tanita Corp, Illinois, USA). The subject's gender, age and height were entered and subjects wore minimal clothing. After the measurement was taken, body weight and body fat percentage (BF%) were recorded for each subject. One Tanita BC-549 was used to reduce the interrater precision error. The reliability and validity of this system in measuring body fat percent has been previously established in multiple ethnicities [12][13]. Height was measured using a stadiometer and was recorded to the nearest 0.1 cm, consistent with methods described by Jellife [14]. BMI, [weight (kg) / height (m^2)] was used to classify underweight (<18.0 kg/m^2), normal (18 – 24.99 kg/m^2), overweight (25- 29.9 kg/m^2), obesity class 1 (30-34.99 kg/m^2), obesity class II (35-39.99 kg/m^2) and obesity class III (≥40.0 kg/m^2) [15]. All measurements were taken between 9.00–13.00 hours and subjects did not engage in vigorous activity during the preceding 12 hours of the measurement.

Data analyses

Quantitative data was analysed using SPSS version 22. In addition to summary statistics, chi-square tests were used to test assess significant differences ($p<0.05$) between selected variables. Transcripts of focus group discussions were assessed by thematic analysis.

Ethical Standard Disclosure

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving study participants were assessed and approved as Low Risk under Massey University Ethics Committee System with Application No 4000018013.

A research permit was also obtained from Kiribati Immigration with RP No 14/2017**.** Written or verbal informed consent was obtained from all subjects. Verbal consent was witnessed and formally recorded.

5.3 Results

Questionnaire data

The response rate for the quantitative study was 98.2%. Respondents were mostly women, 73% and 59% in ST and BT, respectively, and the majority of respondents were aged between 25-55 years (**Table 1**). In ST most respondents (over 60%) had a secondary school education as their highest formal education whilst in BT more than half (55.6%) had primary school as their highest formal education.

Table 2 shows the mean knowledge scores by gender, age, educational achievement, BMI, and attitude rating. At 95% confidence level, the mean knowledge scores has no significant association with gender, age, educational achievement, BMI or attitude rating however the mean knowledge scores of the respondents in Butaritari were higher than those of South Tarawa.

Fig. 1 shows that among the 320 respondents, only a few (10% and 15.6%) of the respondents from ST and BT had a good knowledge of nutrition. The majority (over 80%) of respondents in ST and BT lacked the knowledge that healthy eating includes consumption of foods that are low in sugar and fat, as well as eating fresh foods and whole grains.

The majority (76.9%) of the respondents in BT had good attitudes towards nutrition with a mean attitude score of 30.49±7.21 on a scale of 5-40, which was higher than the mean score (28.56±7.47) in ST. Less than a quarter (21.1% and 16.4%) of the respondents in ST and BT respectively often read nutrition facts on labels of grocery items. Over 65% of the respondents in BT versus only 28.6% in ST agreed that they consume five servings of fruits and vegetables daily.

In the last seven days prior to the interview, respondents in ST and BT respectively chose foods low in sugar (29.2% and 41.2%) and ate snacks after dinner (14.9% and 27.7%). Another 65.9% and 36.7% in ST added sugar into coffee or tea and while cooking food and/or after it is served, while 53.5% each in BT added sugar into coffee or tea and while cooking food and/or after it is served. Less than 30% each in ST and BT drank at least 1.5 litres of plain water daily (**Fig 2**).

Focus Group - Men

Source and types of foods consumed

All the participants indicated that they obtain their foods from local produce, shops/supermarkets and home gardens. The participants listed the foods in order of priority - fish, lobster and octopus and their main form of cooking and preservation technique - frying, salting, drying and freezing.

A 29 year old policeman from Butaritari reported '*When cooking most of our fishes, we remove the gills and the interior parts before boil or preserve in the fridge to boil later for consumption'*

The participants indicated that they eat most parts of any tree as foods, especially the leaves. They did not mention any tree plant where they eat its barks and roots. They consumed sweet potatoes with their leaves, 'ruku' old and young leaves, taro (babai) and its leaves especially the young leaves.

Consumption of traditional fruits and vegetables and special foods

The participants indicated that they consumed traditional fruit and vegetables, though these are limited in variety because of the nature of the soil, lack of rain and unavailability/inaccessibility of organic manure. The participants from South Tarawa listed breadfruit, pawpaw and fig trees (bero) as most commonly consumed while their counterparts listed breadfruit, sweet potatoes, bwabwai (taro), cassava, pawpaw as the most commonly consumed. Participants plant and cultivate these fruits and source from local markets.

The participants agreed that “all foods are special foods because they are consumed in all periods” and most foods are allowed to be eaten in special periods except for pregnancy when split pandanas fruit and left-over fish bait should not be eaten by pregnant women.

Traditional foods and NCDs

The participants from both South Tarawa and Butaritari listed traditional foods as- crabs, mamoto (young coconuts), whale, *bwabwai* (taro), dogs (especially pregnant dogs) and a ‘balanced diet’. They believed these foods have healing properties but could not articulate what these properties were.

The participants outlined the following explanations for excess consumption of rice and sugar: intake of imported food stuffs, lack of exercise, and genetics.

- A 42-year-old man from South Tarawa, a kitchen assistant said “e bon ira nanona n amarake ao eaki kabatia te marurong” meaning “the person eat whatever he/she wants without considering his/her health.”
- Another participant said the cause of NCDS is “boni iai te marika are bon man te utu” meaning “Being fat means people get it from the family.”

The solutions outlined by the participants were drinking plenty of water, walking and jogging.

Focus Group - Women

Source and types of foods consumed

All participants agreed they obtain their foods by going out fishing in the sea and the lagoon; picking up vegetables and fruit around the area and in the bush; on request from the neighbourhood and relatives, and by buying food from the store or supermarket when there is enough money from the sales of fish and farm produce.

The participants listed breadfruit, pumpkin, cassava, tuna fish, red fish and *ibo* as the main indigenous crops/foods. They suggested ways of cooking and preserving them as follows:

'Breadfruit - boil until soft and then mash it; spread the mashed breadfruit under the sun for 3 days and then package in a container for later use. Pumpkin - just boil or mix it with rice and sugar and coconut cream. The leftover should be kept in the refrigerator. Cassava - boil with sugar. To make it last long, keep it in the freezer. Tuna fish - fry, boil, roast, steam and eaten raw. This is preserved by slicing it in small sizes, then adding salt all over, and drying it under the sun. Red fish - boil, fry, grill, roast, and steam. They use the same preservation technique as used for tuna fish and also preserve in the freezer. Ibo - boil and grill. It is preserved by soaking it in salt water for 20 minutes, after which it is placed in the sun for drying by dehydration'.

The participants reported that they consumed the leaves, flowers, fruits and stems of pumpkin; leaves and roots of kumara; fruit of breadfruit and fruit of cabbage.

Consumption of traditional fruits and vegetables and special foods

Participants reported breadfruit, banana (locally grown), pawpaw fruit and pumpkin as traditional fruit and vegetables commonly consumed. They all reported that breadfruit and pawpaw are obtained from plants at home, purchased from the market and by request at the market. It is important to note that pawpaw fruit can be picked up around the area unlike breadfruit. One of the participants reported that she obtained pumpkin from her garden and also buys it from the stall. The major forms of consumption are raw and boiled.

The participants reported that they use pork to celebrate marriage, all kinds of foods except meat for Easter (Good Friday), 0.5 copra or 1 piece of cracker for the whole day within 3 days of menstruation (first period). Catholics were not allowed to eat meat on Good Friday (Easter) and fish and meat were avoided during menstruation (first period).

Traditional foods and NCDs

Participants viewed the causes of high NCD prevalence in the country as being linked to eating imported foods, *i.e.* flour, rice, and canned food. They expressed a view that the only way to solve this problem is by consuming small amount of these imported foods and also sticking with their own local foods such as breadfruit, babai, pandanus fruit, fish, seafood and shell fish.

- "A woman who has anaemia must eat foods which are rich in protein i.e. fish, egg, meat to replace loosing blood" reported by a 55 year old, seamstress from South Tarawa.

5.4 Discussion

The results of this study showed that a greater percentage of the respondents in the quantitative study were women, which suggests that women play an important role in food choices and women's nutrition knowledge, is a key influence on the quality of households' diets.

The overall nutrition knowledge of the respondents was moderate and acceptable, though surprisingly, higher among rural (BT) than urban households (ST). This may reflect that traditional knowledge transferred from generation to generation which may lead to good nutrition knowledge. Another attributable factor may be that developmental health programmes are more targeted to rural settings like BT and may have a positive effect on knowledge among these households. Overall nutrition knowledge was however lower than previously found in Western Kenya where more than 60% of respondents had excellent nutrition knowledge [16]. In the current study more than half (55%) of the respondents had positive attitudes towards good nutrition. These included consuming five daily servings of fruit and vegetables for themselves and their children and reading nutrition facts on grocery item labels. The mean attitude score of the respondents (both ST and BT) was 28.43±1.24 out of a maximum score of 40, similar to a previous study in Mazini, Swaziland where the mean attitude score was 24±2.8 out of a maximum score of 36 [17]. Among the Canary Island population, Lainez et al. [18] estimated knowledge and attitudes toward eating in relation to health and found nearly half (46.7%) of participants considered their knowledge of food and nutrition to be sufficient. Although the association between nutrition knowledge and eating a healthy diet is not strong; nutritional knowledge has the potential to contribute to improvement of dietary quality [19].

About 47% and 6 % of the respondents in BT and ST respectively reported they consumed fruit and vegetables daily. The higher consumption in BT than ST can be attributed to the availability and access to fruit and vegetables. Some studies showed that low fruit and vegetable consumption is more prevalent among those who are disadvantaged and tends to increase with age and decrease with income [20] [21]. The daily consumption of fruit and vegetables by at least half of the respondents in BT is higher than observed in Maiduguri, Borno State where 27% of the respondents reported eating fruit and vegetables daily [22]. We found over 70% of the respondents in ST and BT did not drink at least a litre of water daily, which is the average requirement of water for a sedentary adult. They consumed more traditional drink made from local tea and a lot of sugar.

While over 50% of the respondents in ST and BT reported they considered health benefits when choosing foods and wash their fruit(s) each time they want to eat them, some less desirable nutritional practices were seen. More than half of the respondents added at least two tablespoons of sugar into coffee or tea and food while cooking and/or after it is served. The common practice of using large quantities of sugar need to be discouraged due to deleterious effects to human health [23] [24] [25].

There was no significant association between gender, age, education, BMI and attitudes with the knowledge scores of the respondents. Therefore, educational initiatives in Kiribati may not be effective unless they are linked to sustainable initiatives that drive nutritional outcomes. The immediate causes of malnutrition include food intake and disease occurrence. Inadequate food intake refers to both quantity and quality of the food. The quality of diet is reflected by the dietary diversity and the micronutrient content of the diet. Disease can be a cause and consequence of malnutrition, for instance, the risk of a child being stunted at 2 years of age increases with the incidence of diarrhoea [26]. Addressing food security at the individual and household level and providing a healthy food environment is fundamental to tackling immediate and underlying causes of malnutrition. Examples of nutrition-sensitive interventions that could address these immediate and underlying factors that contribute to malnutrition in this population include social safety nets, women's empowerment, access to portable and clean water, health and family planning services. These initiatives will be more effective and result-driven than mere nutritional education programmes.

The focus group results showed that all the participants identified frequently consumed foods in ST and BT were breadfruit, rice, pumpkin, taro and fish and the access to these foods depended on the location where the participant lived. Different species of fish and their method of preparation were also mentioned by the participants. A 50-year-old fisherman from Butaritari reported '*My family and I eat a lot of seashells (te kima and te angwere types of seashell mentioned). We usually boil it and sometimes dry to preserve'*. Fish is an essential staple food in most Pacific Island countries and territories, and subsistence and commercial fishing activities contribute much to both household and individual food security, particularly in rural areas. Reliance on fish for protein is particularly high in rural areas where there is limited access to other sources of protein, such as imported meats, and in areas where animal grazing and husbandry is not viable [27] [28]. Strategies such as increasing "nearshore fish aggregating devices" (to concentrate fish) have shown promise in increasing the availability of tuna and other large pelagic fish that can help provide proteins needed by communities for food security and nutrition [29].

Some of the respondents in the qualitative study had a good level of knowledge on how to prevent non-communicable diseases. *"A sick person who has diabetes should be given food which are balance, that contains no fat, no starch such as breadfruit, cassava, sea foods and cabbage leaves"* Reported by 32-year-old female cleaner from South Tarawa. Another female respondent from Butaritari stated *"A sick person who has diabetes should be given food which drink plenty of water in a day, eat little amount of rice and do exercise everyday"*. It appears the most important factor in implementation of healthy eating practices among households is a good knowledge especially for women who take on the role of food preparation. Nutritional education with focus on available food resources is a practical solution to improving nutritional status at urban and rural household level. Preparing instructions for proper nutrition, as an effective factor to social, economic and cultural characteristics, can also play critical role in nutritional knowledge of people.

5.5 Conclusions

The results from the study show the majority of respondents had good knowledge and attitudes towards good nutrition, however, these are not adequately reflected in their nutritional practices. Agriculture offers an opportunity to address the availability and accessibility of diverse nutrient dense foods in poor rural communities. The promotion of household and community food gardens should be encouraged. Nutrition education should be part of the designed solutions to these problems and thus integrated in household training programmes. The link between, water, food, nutrition and health should be strengthened through multidisciplinary interventions.

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Table 1: Population characteristics

Variables	South Tarawa n (%)	Butaritari n (%)
Gender		
Men	43 (26.7)	66 (41.2)
Women	117 (73.3)	94 (58.8)
Age (years)		
18-25	9 (5.6)	26 (16.3)
26-35	37 (23.0)	42 (26.3)
36-45	56 (34.8)	28 (17.5)
46-55	44 (27.3)	36 (22.4)
>55	15 (9.3)	28 (17.5)
Highest level of formal education		
No formal education	3 (1.9)	20 (12.5)
Primary school	41 (25.5)	89 (55.6)
Secondary school	98 (60.9)	49 (30.6)
Tertiary/Higher school	7 (4.3)	2 (1.3)
No response	12 (7.5)	-

Table 2: Mean knowledge scores by gender, age, educational achievement, BMI class and attitude class.

Survey component	Grouping	South Tarawa			Butaritari			P-value
		N	Mean	Std dev	N	Mean	Std dev	
Gender	Men	43	51.5	17.6	66	56.3	15.6	0.087
	Women	117	51.2	14.6	94	55.4	16.1	0.092
	All	160	51.2	15.4	160	55.7	15.9	0.102
Age (y)	18-25	8	48.0	9.1	19	56.8	17.1	0.364
	26-35	40	52.4	18.1	47	56.1	15.1	0.121
	36-45	57	53.2	14.7	28	54.0	15.4	0.124
	46-55	40	47.9	13.4	29	60.9	18.2	0.241
	>55	15	51.7	18.1	37	52.1	14.0	0.197
Highest educational achievement	No formal education	23	53.4	17.8	48	55.9	16.3	0.219
	Primary school	49	50.7	14.7	45	54.5	14.0	0.225
	Secondary school	83	51.2	14.8	67	56.4	16.9	0.220
	Tertiary/higher school	5	48.4	23.8	0	-	-	-
BMI category	Underweight (< 18.0 kg/m^2)	1	45.0	-	0	-	-	-
	Normal (18-24.99 kg/m^2)	6	49.3	10.3	34	55.7	15.9	0.067
	Overweight (25-29.99 kg/m^2)	36	52.0	18.8	45	55.6	14.7	0.061
	Obesity class I (30-34.99 kg/m^2)	50	51.7	13.5	29	60.2	17.9	0.094
	Obesity class II (35-39.99 kg/m^2)	39	51.8	15.2	20	56.2	18.3	0.060
	Obesity Class III (>40 kg/m^2)	28	49.4	16.1	5	51.4	7.3	0.714
Attitudes to healthy nutrition	Not determined	0	-	-	27	51.7	14.5	0.218
	Poor	55	50.9	16.4	37	57.3	16.4	0.319
	Good	105	51.4	15.0	123	55.3	20.3	0.341

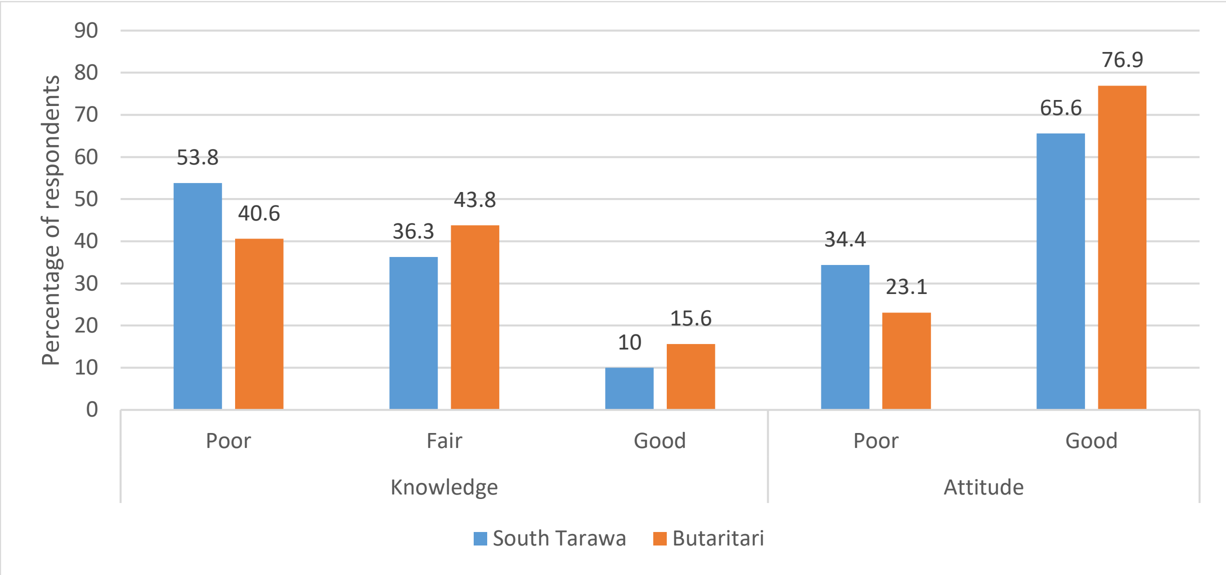

Fig. 1: Overall knowledge and attitude of good nutrition among the respondents in ST and BT

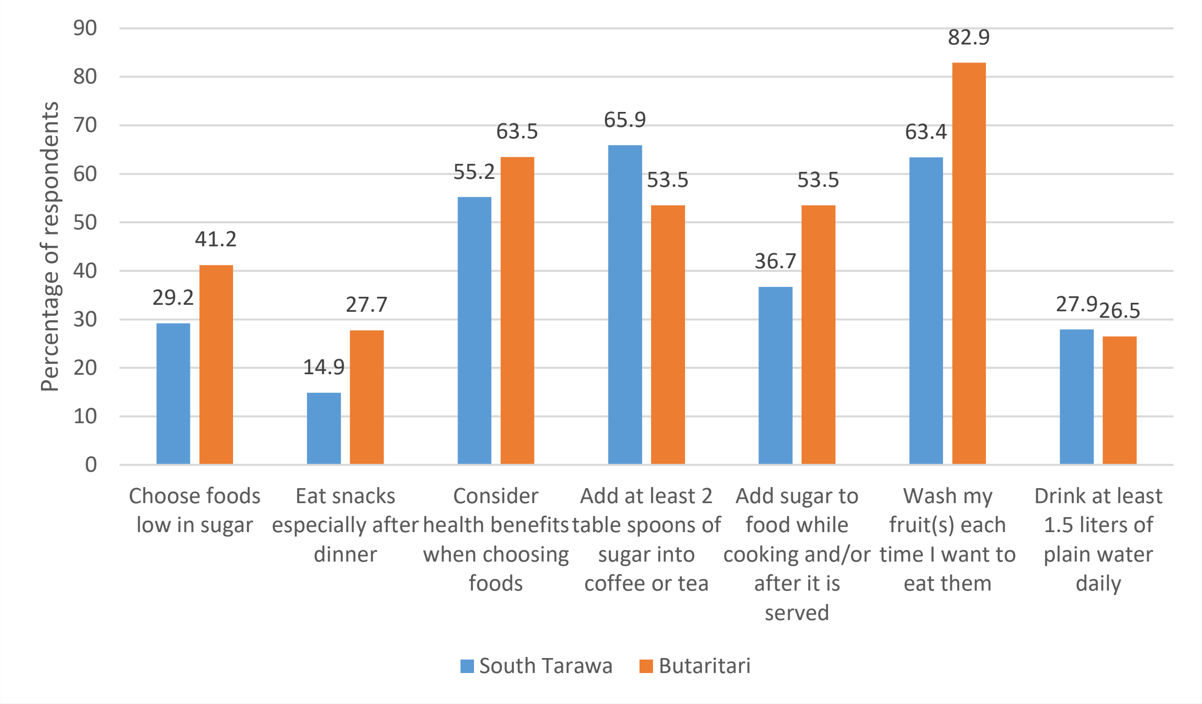

Fig. 2: Nutritional practices of the respondents in South Tarawa and Butaritari

6 Prevalence of obesity and the relationship between Body Mass Index and Body Fat percentage among adults in South Tarawa and Butaritari, Kiribati.

Abstract

This study assessed obesity and the relationship between body mass index (BMI) and body fat percentage (BF%) among adults in Kiribati. A cross-sectional study was undertaken among 483 adults randomly selected from South Tarawa (urban) and Butaritari (rural). Weight, height, BF% and physical activity level (PAL) was measured using standard methods. Linear and quadratic regression analyses were conducted to assess the association between BF% and BMI whilst controlling for age and gender. Approximately 75% of participants were obese using standard BMI and BIA cut-offs, with the highest prevalence observed in South Tarawa. BF% was significantly ($p<0.001$) and positively associated with age (males, $r=0.78$; females, $r=0.67$; $p<0.000$) and BMI. Based on ROC-curve analyses the BMI cut-offs for predicting high BF% among I-Kiribati people were 24.5kg/m^2 for males and 32.9 kg/m^2 for females. In conclusion, the majority of adults in Kiribati were either obese or overweight and had high BF%.

6.1 Introduction

The prevalence of overweight and obesity has increased considerably in the past few decades, and has become a significant public health problem globally, with current estimates indicating that 600 million adults are obese and 1.9 billion are overweight.[1] Adult obesity prevalence in Pacific Small Island Developing State (PSIDS), including Nauru (61%), Marshall Islands (52%), Kiribati (46%), Fiji (30%) and Vanuatu (24%) are among the highest in the world.[2]

Many studies have shown that obesity, especially central body fatness, is linked with increased risk of morbidity and mortality. In particular, it has been associated with risk factors for coronary heart disease including type 2 diabetes, insulin resistance, and hypertension; cancer; sleep disorders; and anxiety.[3,4] A significant decrease in physical activity levels and energy expenditure, combined with an increase in energy intake are the main factors contributing to obesity.[5]

There are many methods to assess adiposity including measurements of waist circumference, waist-hip ratio, waist-to-height ratio, skinfold calliper measurements, body mass index (BMI), bioelectrical impedance analysis (BIA), under-water weighing (densitometry), near infrared reactance (NIR), magnetic resonance imaging (MRI) and dual-energy X-ray absorptiometry (DEXA).[6] BMI is inexpensive, relatively easy to calculate and therefore most commonly used, but it does not distinguish between fat and lean body mass. The World Health Organization (WHO) recommends BMI as the most useful population-level measure of overweight and obesity (independent of sex and age), and cut-offs of >25kg/m^2 and >30kg/m^2 are now commonly applied as a definition of overweight and obese, respectively.[7] Body impedance analysis (BIA), a relatively simple, quick, affordable, non-invasive, and reliable body composition method, is widely used to measure percentage body fat (BF%), but is dependent on height and cannot be evaluated independently from fat free mass.[8,9] The validity of BIA has previously been established for different ethnic groups.[10,11]

Previous studies found a significant positive association between BMI and BF (%).[12,13,14] However, the majority of studies were conducted in high-income countries, with only few studies from low-income countries and none from the Pacific region. [13,14] As a consequence, results from previous studies may not be generalizable to other ethnic populations.

In this study, we measured, in a sub-population of Pacific Island adults from two atoll Kiribati Islands (one predominantly urban and the other rural), the prevalence of adiposity, and assessed the association between BMI and BF% (using BIA) whilst taking into account age and sex.

6.2 Materials and Methods

Study Area

South Tarawa (ST) is the capital of the Republic of Kiribati and is predominantly urban. It is home to about half of the total Kiribati population and most of the government, commercial and education facilities. Butaritari (BT) is the second most northerly of the Gilbert Islands, formerly called Makin Atoll by the US Military, and is rural with a population of 4,346 people inhabiting twelve villages.[15]

Participants and design

This was a cross-sectional survey of a household-based sample of adults aged ≥18 years using a multi-stage sampling technique. A total sample of 483 adults (171 from ST and 312 from BT) were recruited using a systematic random sampling method. In particular, in each location, every third house at each site was approached and invited to participate in the study. Ethical approval was obtained from the Massey University Research Ethics Committee (No: 4000018013). We also obtained a research permit from Kiribati Immigration (RP No-

14/2017). Written/oral consent was obtained from each participant, and data was collected by locally trained research assistants, which took place from August to September, 2018.

BMI and body fat percentage (BF%)

Height was measured using a stadiometer and was recorded to the nearest 0.1 cm. Measurements were taken with the subjects bare footed, standing erect with feet parallel, and heels put together in line with methods described by Jellife.[16] Weight (in kg) was measured using a calibrated electronic scale with digital readout (seca 808, Germany) to the nearest 0.1 kg. BMI, [weight/height^2] was used to classify underweight (<18.0 kg/m^2), normal (18 – 24.99 kg/m^2), overweight (25- 29.9 kg/m^2), obesity class 1 (30-34.99 kg/m^2), obesity class II (35-39.99 kg/m^2) and obesity class III (≥40.0 kg/m^2; WHO, 2000). Body composition measurement (corrected for sex, age and height) was carried out using a single bio-impedance analyser system (BC-549, Tanita Corp, Illinois, USA) as per international guidelines.[10] BF% was categorised (low, normal, high, very high) using criteria described by Gallagher et al.[17] All measurements were taken from 9.00–13.00 hours and participants were asked not to engage in vigorous activities 12 hours prior to the measurements.

Physical Activity

The short form of the New Zealand Physical Activity Questionnaire (NZPAQ-SF) was used to assess the duration and frequency of brisk walking, and moderate- and vigorous-intensity activities performed in the last seven days. The NZPAQ-SF, an adaptation of the International Physical Activity Questionnaire (IPAQ), was validated against heart rate monitoring in a multi-ethnic population, including Pacific Islanders, and demonstrated acceptable validity (r=0.25, p<0.001).[18] Based on frequency (days/week) and average daily duration (min/day) of walking, and moderate and vigorous-intensity activities, metabolic equivalent (MET) values were calculated as follows: METS for walking, moderate- and vigorous-intensity activity (3.3, 4.0, and 8.0, respectively) were multiplied by duration of each activity, summed, and expressed as MET-min/week based on scoring criteria established by the IPAQ Committee for Physical Activity Level (PAL).[19]

Statistical Analysis

All analyses were conducted using SPSS version 20. Linear regression was used to assess associations between BMI and BF%. In addition, we conducted quadratic regression to assess whether the association between BMI and BF% was predominantly linear or curvilinear, similar to other international studies.[12,13] All regression analyses were controlled for age and stratified by sex (unless indicated otherwise). ROC curve analyses were used to assess whether for the Kiribati population alternative BMI cut-off points for obesity may be needed with improved sensitivity (true positive rate) and specificity (true negative rate). *P*-values ≤ 0.05 were used to indicate statistical significance.

6.3 Results

Table 1 shows the population characteristics. Weight, BF% and BMI of participants in South Tarawa were significantly ($p<0.05$) higher than that of participants from Butaritari.
In excess of 70% of all participants in both locations had high BF% and were classified as obese based on BMI results, with again the highest proportion of obese in South Tarawa.

BMI and age were both consistently and positively associated with BF% for both males and females (Table 2). PAL was inversely associated with BF%, but this was statistically significant only in females, and after controlling for other variables this was no longer significant. In multivariate regression (mutually adjusting for all other variables) the regression coefficient (RC) of BMI for males increased from 1.21 to 1.49, but in females it decreased from 0.86 to 0.72.

Visual inspection of the scatter plot (Fig. 1) confirmed the positive association between BF% and BMI, which appeared linear in nature and curvilinear towards higher BF% values. Comparing the explained variance between linear and quadratic regression analyses (see figure 1) showed only a slight difference i.e. 95% versus 96% in men and 98% versus 98% in women, suggesting that the model fit of the quadratic regression model was not necessarily better than that of linear regression models.

Fig. 2 shows the area under the ROC curves predicting BF% for obesity in men and women based on BMI. The AUCs to predict BF% for obesity reached 0.94 (0.90 to 0.99 with 95% CL) in men, which corresponds to a BMI cut-off value of 24.5kg/m^2 (97.4% sensitivity and 64.0% specificity) ($P<0.000$) (Fig. 2a). In women, the AUC obtained was 0.95 (0.91 to 0.98 95% CL), which correspond to a BMI cut-off value of 32.9 kg/m^2 (93.3% sensitivity and 86.0% specificity) ($P<0.000$) (Fig. 2b).

6.4 Discussion

The study was conducted in two atoll Islands that are reasonably representative of the Southern and Northern I-Kiribati population. The prevalence of obesity based on BMI and BF% were 74.8% and 91.2% in ST, and 46.8% and 64.1% in BT, respectively. The mean obesity prevalence using the BMI classification was higher than the national average of 46% reported in

2016,[2] suggesting that the prevalence of obesity in Kiribati may be on the rise. Urgent interventions are therefore needed to curb this increasingly important public health problem.

The examination of BF (%) utilizing BIA was chosen because of the effortlessness of the outputs, the high inter- and intra-assessor accuracy, and the insignificant distress during the measurement, just as the accommodation of working in the field.[20] However, the use of BIA has its limitations which include the difficulty in measuring the body composition directly, but rather predicting it from measurements of body properties, and its further validation in many populations.

Our study confirmed a significant positive association between BMI and BF%, which has been demonstrated previously. A study by Rush and colleagues in New Zealand between 1990 and 2004 showed a positive significant relationship between BMI and BF% among Europeans, Maori, Asian adults and Pacific Islanders.[21] Another study by Jackson et al. [22] among Caucasian adults from four clinical centres in US and Canada also showed a significant association between BMI and BF%. Also in agreement with previous studies, our study found that BF% is greater in women [22] and in older age groups[21]. Furthermore, multiple regression analysis showed that sex and age affected the association between BMI and BF%. Therefore, and based on other studies showing similar results,[12,25] this strongly supports that BMI values for predicting BF% need to take into account gender and age (as well as ethnicity as discussed below).

Our study showed the relationship between BMI-BF% was linear in nature but develops curvilinear towards higher BF% values, based on a visual inspection (although a significantly better model fit using quadratic regression was not shown). This is supported by Meeuwsen et al.,[13] but differs from results reported by Gallagher et al,[23] which showed a predominantly curvilinear association. Curvilinearity was mainly observed when participants had a BMI of 35 kg/m^2 or greater indicative of obesity.[13] The same was shown in a study by Jackson et al,[22] which showed that quadratic (curvilinear) effect became most pronounced at BMI levels of $\geq$35 kg/m^2. This was also the case for women, and less pronounced in men, in another body composition study from the USA in which half of the subjects had a BMI >35 kg/m^2.[24]

The use of BMI cut-off values (based on studies of predominantly European and American Caucasians) to define overweight and obesity for different populations is controversial. In particular, there are several studies showing that the relationship between BMI and BF% differs among ethnic groups; for example, studies with Indian [17], Indonesian [17], Tongan [26], Australian [27] and Jamaican [28] populations have established that BMI represents different values of fat percentage for different populations. This is likely due to differences in energy balance and body build between ethnic groups.[21,25] The present study showed the optimal cut-off points for predicting high BF% among I-Kiribati people were 24.5kg/m^2 for men and 32.9 kg/m^2 for women. These values vary considerably from the BMI cut-off value derived from American and European Caucasian populations which is 30 kg/m^2 for both genders.[27] Applying international BMI cut-points in Kiribati (and other countries in the Pacific) may therefore lead to severe misclassification, which may have significant public health implications, and is why BMI cut-off points for obesity need to be population-specific.[29]

This study had several limitations. The sample was taken from two different atoll Islands of much disparity in access to health and education facilities and data may therefore not be generalizable to all I-Kiribati. The small population size is another limitation, but being the first of such study in the country and one of only very few in Pacific Island countries, it could serve as a reference. We were unable to control some of the BIA assessment imperatives as we depend on information given by the subjects e.g. despite insurances to the opposite, some may have engaged in vigorous activity in the 12 hours prior to when measurement were taken.

In conclusion, our results showed that there is high prevalence of obesity in the two atoll Islands of Kiribati using measures of both BMI and BF%. It also demonstrate that BMI is strongly associated with BF% and that this was affected by age and gender. Therefore, our findings support controlling for age and gender when using BMI as a predictor of BF%. Based on our analyses we suggest that ethnic-specific BMI cut-points to define obesity for the population of Kiribati (i.e. 24.5kg/m^2 for males and 32.9kg/m^2 for females) may be more appropriate than the currently used international cut-points.

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Table 1: Population characteristics

	South Tarawa (N=171)	**Butaritari (N=312)**	**Total (N=483)**	**P-value**
Age (yrs)(Mean±SD)	40.8±9.4	40.4±13.6	40.6 ±12.2	0.740
PAL(Mean±SD)	1.5±0.2	2.5±1.4	2.2±1.2	P<0.0001
Height (m) (Mean±SD)	162.0±7.3	161.3±8.2	161.6 ±7.9	0.374
Weight (kg) (Mean±SD)	88.6±17.8	78.5±15.2	82.1±16.9	P<0.0001
Body fat, % (Mean±SD)	38.4±7.8	32.3±11.4	34.5±10.7	P<0.0001
Body mass index, kg/m^2 (Mean±SD)	33.7±6.2	30.4±6.6	31.6±6.7	P<0.0001
Males (%)	38(26.0%)	108 (74.0%)	146 (30.2%)	0.005
Females (%)	133 (39.5%)	204 (60.5%)	337 (69.8%)	
BF% Classification (BIA)				
Low (%)	1 (0.6)	2 (0.6)	3 (1.0)	
Normal (%)	14 (8.2)	110 (35.3)	124 (25.7)	P<0.0001
High (%)	35 (20.4)	104 (33.3)	137 (28.4)	
Very High (%)	121 (70.8)	96 (30.8)	217 (44.9)	
Classification of BMI (kg/m^2)				
Underweight (%)	1 (0.6)	-	1 (0.2)	
Normal (%)	6 (3.5)	64 (20.5)	70 (14.5)	
Overweight (%)	36 (21.1)	102 (32.7)	138 (28.6)	
Obesity Class I (%)	50 (29.2)	80 (25.6)	130 (26.9)	P<0.0001
Obesity Class II (%)	39 (22.8)	47 (15.1)	86 (17.8)	
Obesity Class III (%)	39 (22.8)	19 (6.1)	58 (12.0)	

Table 2: Regression models showing the association between BF% and BMI, age, PAL and location stratified for males and females.

	Males		Females	
	Regression coefficient (95% confidence level) (univariate analysis)	**Regression coefficient (95% confidence level) (multivariate analyses)#**	**Regression coefficient (95% confidence level) (univariate analysis)**	**Regression coefficient (95% confidence level) (multivariate analysis)#**
BMI	1.21 (1.055-1.372)***	1.48 (0.451-1.721)***	0.86 (0.788-0.932)***	0.72 (0.598-0.792)***
Age	0.19 (0.074-0.296) ***	0.18 (0.098-0.240) *	0.09 (0.034-0.149) ***	0.09 (0.04-0.12) ***
PAL	-0.89 [-2.49- (-0.706)]	-0.49 [-0.61- (-0.25)]	-0.80 [-1.327-(-0.280)]	-0.22 [-0.39- (-0.16)]
Location (ST/BT)	6.43 (3.310-9.543) ***	2.04 (1.234-3.210)	4.30 (2.931-5.664) ***	1.92 (1.03-2.61) ***
R^2		0.681		0.683

BMI: Body mass index, PAL: Physical activity level; R^2: explained variance; # Mutually adjusted for all other variables; * p≤0.05, ** p≤0.01, *** p≤ 0.001

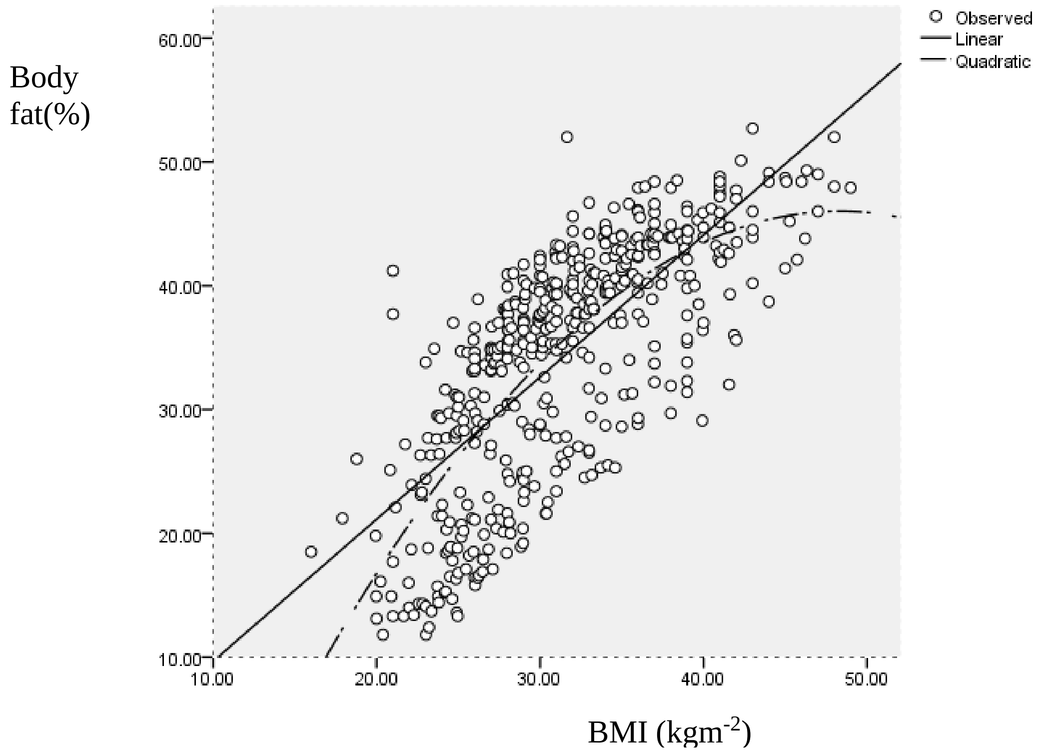
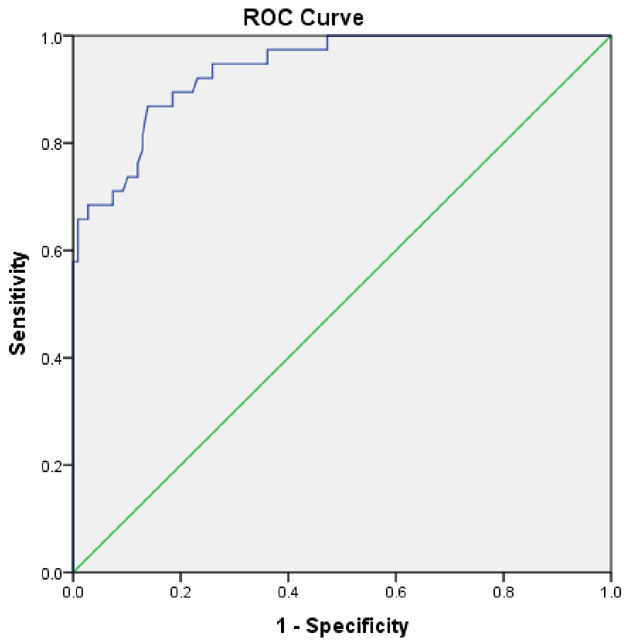
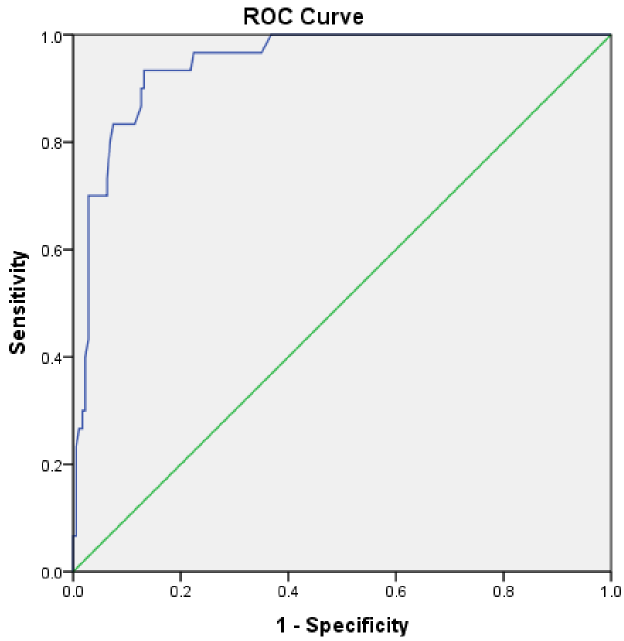


Fig. 1 Scatter plot showing linear and quadratic relationship between Body Mass Index (BMI) and body fat percentage (BF%) of I-Kiribati men and women (Linear regression models: BF% male= (BMI x 1.213) + (0.183 x age) - 18.154; BF% female= (BMI x 0.716) + (0.94 x age) + 11.008; Polynomial (quadratic component) regression models: Males (R2=0.614, SEE 5.5%, p<0.000); Females (R2 = 0.666, SEE 5.4%, p<0.000).



Area under curve (AUC) for male =0.938, P<0.000

(2a)



Area under curve (AUC) for female =0.946, P<0.000

(2b)

Fig 2: ROC curve in males (2a) and females (2b) showing the performance of BMI in predicting BF% in men and women.

7 Assessment of body adiposity of secondary school students in Butaritari Island, Kiribati

Abstract

Objective: This study assessed obesity prevalence using different anthropometric measures among adolescents in Butaritari Island, Kiribati. **Methods:** One hundred and ninety-four adolescents aged 12 to 16 years were selected from the only Junior Secondary School in the Island. Ethical approval and informed consent were obtained. Weight, height, mid-upper arm circumference (MUAC), waist circumference and hip circumference were obtained from the subjects using standard methods. Biomedical impedance (BIA) was used to measure body fat percentage of the subjects. Data was analysed using SPSS version 21 for descriptive and inferential statistics and $p<0.05$ was set to be significant. **Results**: Females were significantly higher in weight, MUAC, WC, HC, WHR, BF% and BMI than males. The subjects aged 16 years had the highest values for Ht, Wt, MUAC, WC, HC and BMI. The prevalence of obesity amongst the adolescents for the different measures were 7.3%, 2.1%, 10.8%, 44.3% and 17.5% for WC, BF %, BMI, WHR and WHTr respectively. **Conclusion**: Obesity prevalence among the adolescents was low based on BMI and BF % criteria.

7.1 Introduction

Adolescent obesity is on the rise worldwide as a major public health problem reaching widespread magnitude (Wang and Lobstein, 2006). The Pacific Islanders especially those in the Small Island Developing States suffer higher prevalence of dominant obesity-related medical issues, together with hypertension (Hawley and McGarvey, 2015), type II diabetes (Karter et al., 2013) and cancer (Liu et al., 2013). Some studies have shown that obese young people have higher likelihood to be overweight or obese (Serdula et al., 1993; Tanjasiri et al; 2018). Adolescents are at risk of obesity in their transition from adolescence to adulthood (Gordon-Larsen et al., 2009; Eme et al., 2016). The time of dynamic swinging and changes in body adiposity which happen in childhood and adolescence are believed to be the crucial stages for the evolvement of obesity (Gordon-Larsen et al., 2009; Eme et al., 2016). The high pervasiveness of weight among adolescents guarantee the need for accurate methods for measuring adiposity. There are currently many measures of obesity. The Body Mass Index (BMI), though it has many constraints, has become the most common indicator of overweight and obesity. Nonetheless, waist circumference (WC), waist-hip ratio (WHR) and waist-to-height ratio (WHtR) are utilized as intermediary measures for visceral adiposity and as predictors of obesity-related health exposures (Van Snijder et al., 2006). Body impedance analysis (BIA), a moderately straightforward, fast and non-intrusive composition method, is simple to perform and is generally used to assess body composition (Seyed-Taghi et al. 2011).

We examined an I-Kiribati population of adolescents located in one of the poor-resource hard-to-reach atoll islands for their predominance of obesity using different anthropometric indices Adolescent groups of this type and context are commonly overlooked in studies of predominance of obesity.

7.2 Materials and methods

Study Area

Butaritari is the second most northerly of the Gilbert Islands, formerly called Makin Atoll by the US Military with a population of 4346 people inhabiting twelve villages (National Statistics Office, 2015). The respondents were for the most part from poor-asset families in poorly-resourced households. Guardians of the selected students had almost no formal education and worked largely as fishermen, farmers and traders.

Sampling

An explanatory cross-sectional investigation of 193 students aged 12 to 16 years was carried out in August, 2018. The study was done in the only Junior Secondary School in the island. The students were evenly selected from the different classes and represent 94% of the school's student total population. Students incorporated in the study were obviously healthy.

Measurements

Anthropometric assessment of weight and height of the subjects were taken. Body composition measurement was carried out using a commercially available single frequency bio-impedance analyser system (BC-549, Tanita Corp, Illinois, USA) by asking subjects with negligible clothing and dry feet to stand on the estimating stage after the subject's gender, age and height had been entered into the machine. 'Visitor' mode was utilized all through the time of this examination since it enables the analyst to program the unit for a one-time use without resetting an individual information number. Each student participant was told not to stand on the estimating stage until 0.0 was shown. The student was approached to step onto the estimation stage inside ~30 seconds after 0.0 showed up. After the estimation was taken, readings were consequently shown in the request for body weight and BF%. Readings were recorded for each subject. One Tanita BC-549 was utilized to lessen the interrater precision error. The reproducibility and legitimacy of this framework in estimating muscle-to-fat ratio percent has been recently established in different ethnicities (Pietrobelli et al., 2004; Sluyter et al., 2010). McCarthy et al. (2006) sorted muscle-to-fat ratio of the children utilizing the muscle versus fat reference curves for children.

Height was estimated utilizing a stadiometer and was recorded to the closest 0.1 cm. Estimations were taken with the subjects uncovered footed, standing erect with feet parallel, and heels set up together in accordance with techniques outlined by Jellife (1996). BMI [weight (kg)/height (m^2)] was utilized to categorize the subjects into underweight, overweight and obesity among the subjects utilizing the cut-points of BMI-for age (WHO, 2006). All estimations were taken during long periods of 0900–1300 hours and the subjects did not have any rigorous activity in the 12 hours prior to the estimation. Arm circumference (MUAC) was estimated in the left arm utilizing a non-stretchable tape placed firmly round the midpoint of the upper arm with the point hanging freely by the side**.**

Waist circumference (WC) was estimated at the tightest part of the trunk, between the lower costal edge and the iliac peak (Taylor et al., 2000). Hip circumference (HC) was estimated at the broadest part of the hip at the degree of the greater trochanter (Bacopoulou et al., 2015). All estimations were finished with a tape that was situated at a level parallel to the floor in centimeters (cm) to the closest 0.1 cm. Waist-hip ratio (WHR) was determined by dividing the WC by HC and the Waist-Height ratio (WHtR) was estimated as the proportion of WC by height (Skrzypczak et al., 2007). Three different indices were used to assess obesity. By these methodologies, subjects may be classified as 'obese' when: WC of >88.0 cm, WC 80-87.9 cm with a WHR of >0.85(WHO, 1998); and/or WHtR of ≥0.5 (Kuczmarski et al., 2000).

Statistical analyses

Mean and standard deviation statistics were calculated for values of weight, height, WC, HC, BMI, WHR and WHtR. Chi-square and independent t-tests were also applied to decide the contrast between the variables of gender. Significance was set at p<0.05.

7.3 Results

Table 1 shows that the average ages of males and females were 13.2 and 13.5 respectively. Females were significantly higher in weight, MUAC, WC, HC, WHR, BF% and BMI. Males had higher values for height and WHR.

Table 2 shows the anthropometric measurements of the subjects by age. All the measures increased from age 12 to 14 years and decreased at 15 years except BF% which was the same with that of age 14 years. The subjects aged 16 years had the highest values for Ht, Wt, MUAC, WC, HC and BMI.

The prevalence of obesity amongst the adolescents for the different measures were 7.3%, 2.1%, 10.8%, 44.3% and 17.5% for WC, BF%, BMI, WHR and WHTr respectively. About 3% of the females were obese based on BF%, 12.2% and 9.7% of the males and females were overweight based on BMI, and no subjects were obese based on MUAC (**Fig 1**).

Only 2.9% of the females were obese based on the WC, 30% and 55.3% of the males and females were obese based on WHR; and 11.1% and 23.3% of the males and females were obese based on WHTr (**Fig. 2**).

7.4 Discussion/conclusion

Various benchmarks have been utilized to assess the prevalence and patterns of obesity among young people. Estimates may be based on direct measurements such as on serum fat mass or by inference or based on anthropometric records. Anthropometric estimation has a significant role in characterizing overweight and obesity among youths, particularly in underdeveloped nations (Fiorentino et al., 2013; Eme et al., 2016). Characterising overweight and obesity prevalence can help to forecast health dangers and provide information about drivers and correlations between populaces (Jackson et al., 2007; Johnson et al., 2016).

Female subjects were significantly bigger and had higher average estimates of WC, BMI and BF% compared with their male counterparts. This finding is in agreement with those of previous studies (Amuta and Houmsou, 2009; Senbanjo et al., 2009). These investigations were completed among adolescents in North Central and South West, Nigeria, and reported that female students were significantly higher in WC and BMI than their male counterparts. Possible reasons for this could be the earlier onsets of the pubertal developmental spurt in girls than boys. Many studies have established that females by and large have a higher body fat percentage than males (Cole et al. 2002; Onimawo and Ukegbu, 2005), which was likewise seen in this study. The higher body fat in girls could be linked to the fact that adolescent girls set down more subcutaneous fat layer than young men during the development spurt at pubescence (Osisanya et al., 2002).

The prevalence of obesity amongst the adolescents based on the different measures were 7.3% (WC), 2.1% (BF%), 10.8% (BMI), 44.3% (WHR) and 17.5% (WHTr).. Obesity based on the BMI measure was higher than the prevalence reported for Iranian young people (5%) (Dorosty et al., 2002) but lower than then of Indian young people (14.2%) (Chhatwal et al., 2004). In general, the subjects in this investigation also had lower BF% and BMI compared with their American and Indian counterparts as reported by Dehmukh et al. (2006) and Mukhopadhyay et al. (2005).

It was also observed in this study that mean estimations of WHR and WHTr were higher in females than males. This could be credited to the fact that adolescent females generally have a gynaecoid fat distribution *i.e.* a greater distribution of lower body fat. This outcome conflicts with some past investigations that reported higher WHR and WHTr in males (Moleno et al., 1998; Freedman et al., 2007). The prevalence of central obesity was 7.3% and the WHR was higher at 47% in this study. Regardless of this, an examination demonstrated that in males, WC, as opposed to WHR is the record that most reliably predicts the appropriation of fat tissue in the stomach area (Khan et al., 2008), by and by it has been demonstrated that WHR conjectures vascular endothelial capacity in healthy overweight adults (Brook et al., 2001). Another examination has demonstrated that WC and WHR are indicators of cardiovascular diseases including a substantive worldwide relationship between WHR and risk of localized myocardial necrosis (Yusuf et al., 2005). The WHR are provided for completeness but should be treated with some caution with respect to the extent they may indicate excess weight. This is because use of WHR to assess obesity in female adolescents who have not reached the post-purbertal stage of sexual maturation is compromised because of the natural growth and development in them (Malina et al., 2009). The clinical importance of WHR as diagnostic tool in adolescents can be addressed, since WC, one of the measures it depends on, shows higher relationship and a higher likelihood of diagnosing accurately in both gender. WHR has recently been demonstrated to be less important as indicative test for central fatness in prepubertal children (Goran et al., 1998) and adolescents (Taylor et al., 2000).

All the anthropometric measures showed an increasing trend with age until 14 years and then decreased. A possible reason for the increase could be the physical changes that occur due to growth and development throughout childhood and adolescence. Some studies observed that WHR and WHTr of all their subjects decreased with age (Wang, 2001; Chao-Yang et al., 2006). Any interventions designed for these adolescents may need to be age-specific and result-oriented to reach their goals.

The aim of this study was to determine the prevalence of obesity among a rural adolescent population living in hard-to reach communities of Butaritari Islands. The focus of many health interventions are mostly to adult populations. Although some of these may encourage changes to family eating habits and reach younger people that way, it would be beneficial to consider developing interventions specific to adolescents, because this group is the nearest to transitioning to adulthood. There were limitations in this study. One of them was that it was carried out in a junior secondary school of Butaritari. Its results may not necessarily generalize the school adolescent population in Kiribati. In addition the study sample size was small. This can be attributed to the fact that there is only one junior secondary schools on the island, which was the school that was studied.

In conclusion, this is the first extensive study in which diverse anthropometric measures have been used to evaluate the prevalence of obesity in the I-Kiribati population for adolescents aged 12-16 years. Among all the anthropometric indices used, WHR gave a higher percentage of those who were obese. We propose that this study could be carried out in a larger population of adolescents selected from different islands to give data about the prevalence of obesity across the atoll islands.

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Table 1: Age and body measurements of the respondents.

	Male Mean±SD	**Female Mean±SD**	**p-value**
Age (y)	13.2±1.1	13.5±1.0	0.023
Height (m)	157.3±9.5	156.6±5.6	0.539
Weight (kg)	50.2±11.6	54.3±9.5	0.008
MUAC (cm)	17.8±2.8	18.78±2.5	0.012
Waist circumference (cm)	68.4±8.6	71.5±8.3	0.013
Hip circumference (cm)	78.2±8.6	83.1±7.0	<0.000
Waist-hip ratio	0.88±0.1	0.86±0.1	0.072
Waist-height ratio	0.44±0.1	0.46±0.1	0.003
Body fat, %	12.9±4.2	26.3±5.8	<0.000
Body Mass Index, kg/m^2	20.0±2.8	22.1±3.1	<0.000

Table 2: Anthropometric measurements of the subjects presented by age.

Age, y	N	Height, cm	Weight, kg	MUAC, mm	Waist, cm	Hip, cm	Body fat, %	BMI, kg/m^2
12	46	151.8±7.1	46.0±9.5	17.1±2.6	67.8±8.3	76.8±7.7	18.0±7.3	19.8±3.0
13	62	156.4±7.0	50.4±8.9	17.9±2.4	69.4±8.7	79.8±8.2	19±7.8	20.5±2.6
14	56	160.0±6.6	57.3±11.2	19.4±2.7	72.0±9.0	84.0±7.9	22.3±9.6	22.3±3.4
15	26	158.0±6.7	55.5±6.6	18.8±2.1	69.9±5.3	83.0±5.2	22.3±8.4	22.0±2.2
16	3	170.3±4.2	73.7±6.1	22.0±3.5	81.7±11.7	83.8±11.8	13.4±3.0	25.48±3.2

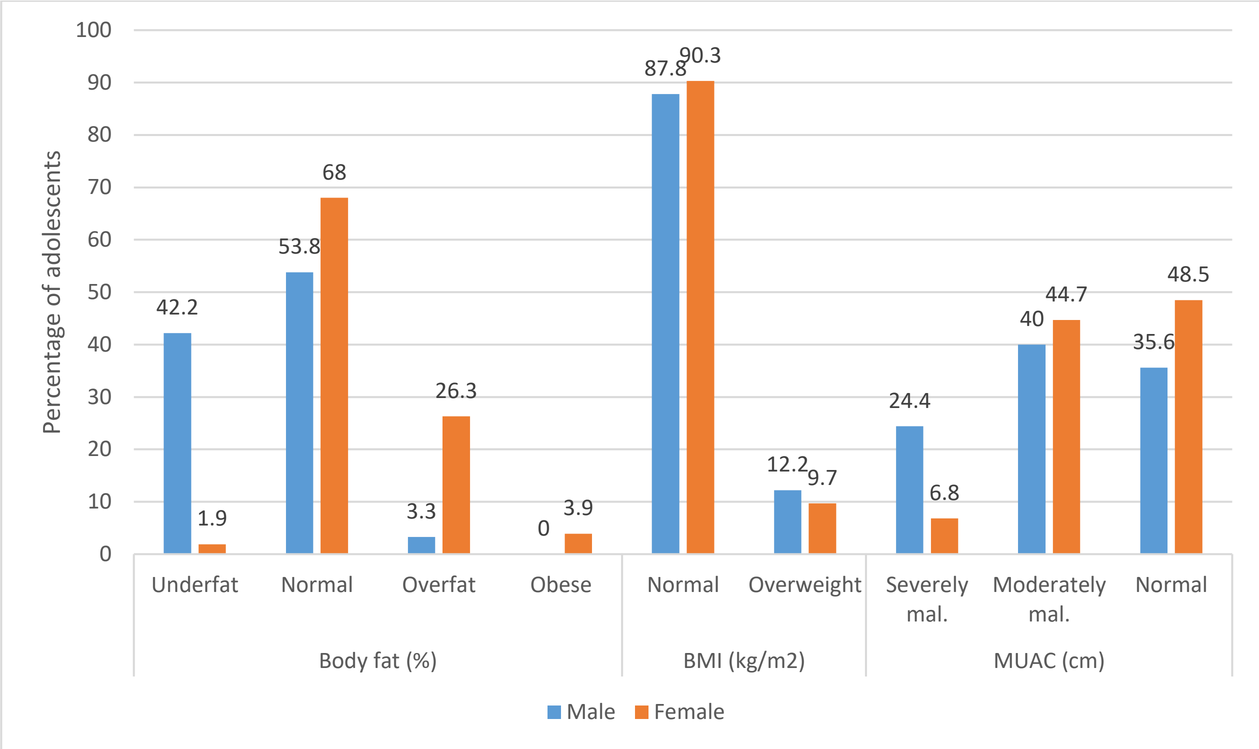

Fig.1: Distribution of BF%, BMI and MUAC by sex.

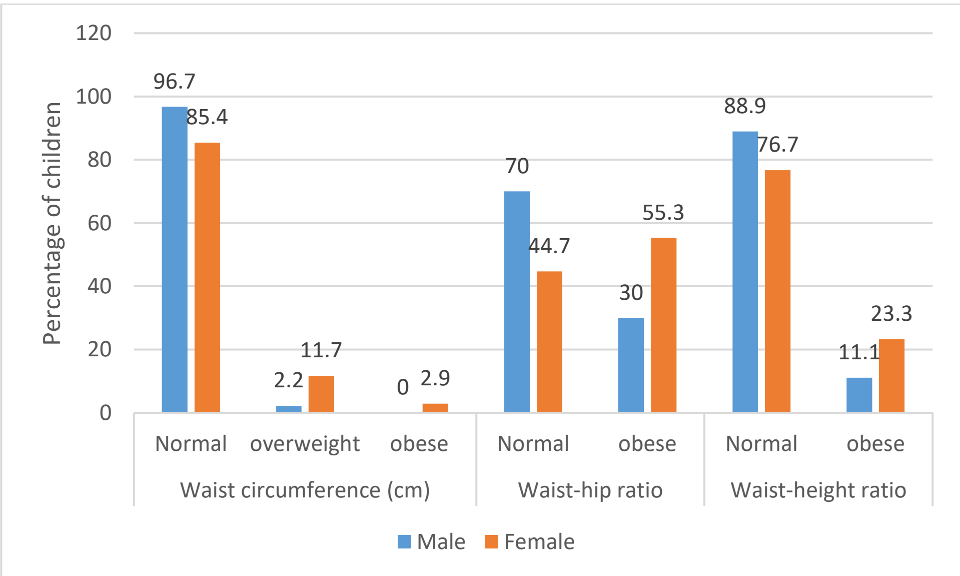

Fig.2: Distribution of WC, WHR and WHTr by sex.

8.1 Discussion of specific results

This thesis provides new and valuable insights into sustainable food systems and sustainable diets in Kiribati and some of its findings could be applied to other Small Island Developing States.

8.1.1 Sustainable food systems harmonized indicators

A key original contribution to the literature was a review of indicators for assessing sustainable food systems to facilitate any future work towards development of a harmonized model.

In March 2015, the United Nations Statistical Commission inaugurated an Inter-Agency Expert Group (IAEG) on Sustainable Development Goal (SDG) Indicators whose aim was to be in charge of monitoring harmonized and agreed indicator definitions as well as of reviewing the methodological process (UNSC, 2015). Indicators serve as the backbone for development of implementation strategies and allocation of resources accordingly. Likewise, sustainable food systems and diets serve as the backbone of many SDG goals and targets.

Harmonization can be viewed at two different levels. The first is achieving consistency in the makeup of individual indicators of a similar type, in the face of variability that can occur across studies and between countries. The second is achieving agreement and multilateral consensus on the suite of indicators that should be used to capture the essential elements of a particular topic.

In this thesis, the harmonized indicators for assessing sustainable food systems were categorized into nutrition and health indicators, environment indicators and socio-economic indicators. The nutrition and health indicators were diet-related morbidity/mortality; dietary diversity/nutrient adequacy ratios; nutritional anthropometry/body composition; physical activity/inactivity prevalence; and nutrient and non-nutrient assessment of some commonly consumed foods. Environment indicators were ecological footprint, carbon footprint, water footprint, ratio of local/regional foods and seasonality, environment management system performance, fruit and vegetable biodiversity, and land use. The income, wealth and equity indicator represent the socio-economic indicators. This is a composite indicator which measures several variables including manufacturing sector profitability, industry structure, average net farm income, employment in food system industries and quality of life (in economic terms).

8.1.1.1 Utility of a harmonized indicator model in the context of Kiribati food system

As outlined in Section 1.4.2, the Kiribati food system is characterized by a high reliance on imports, but with considerable variation in the amount and types of locally sourced food between urban and rural areas, and vulnerability to new influences such as climate-induced shocks and transitions. In the context of this food system, use of a harmonized model has the advantage of looking beyond variability in food origin, to assess overall diet composition and quality at a given point of time. If consistently applied, such a system should provide a reliable index for both changes in dietary sustainability over time.

Selection of a consistent set of harmonized baseline indicators will also be necessary to map any progress against Sustainable Development Goals, or to compare progress between countries, against the same benchmarks. This will guarantee that the interconnected issues represented by various targets are bridged as well as that the total number of indicators required for making a ‘fit-for-purpose’ monitoring indicator framework for measuring sustainable food systems is decreased. A definitive set of markers would need to be capable of capturing, highlighting and stimulating progress in the sustainability of Kiribati food systems, recognizing specific regional needs and where activity is required, illuminating multi-sectoral policy development to contribute to accomplishment of a wider cross-section of the SDGs. An evaluation and examination of the sustainability of food production and dietary patterns in various islands of Kiribati could be facilitated by the widespread utilization of a single harmonized framework as a standardised set of core indicators. This could be important in two ways: either reflectively for a review and intercomparison of existing studies or tentatively as the reason for new research. In both cases, the use of a harmonized framework offers an answer to the issue of bridging methods and tools from research undertaken in varying settings (Eme et al., 2018). The field-testing of the framework is prescribed to distinguish any noteworthy oversights or shortcomings.

There is evidence that micronutrient deficiencies and dietary sustainability remain generally poor, as they were found in previous studies (section 1.4.1)

8.1.1.2 Commentary on the viability of 'one-size-fits-all' harmonized indicators

In the last decade, there has been a proliferation of methods to assess the sustainability of food systems and diets using various categories and banks of indicators. While being locally and contextually relevant, many such systems are complex, resource-intensive, and difficult to implement or use to make comparisons across multiple settings. Use of a minimum harmonised of indicators as a one-size-fits-all approach provides several advantages, and some limitations. Benefits include reducing cost, improving usability and adoption, and allowing high-level comparisons to be made across disparate areas. The proposed harmonized indicators could be applied across settings as diverse as settings an urban community in an industrialised area where NCDs are a primary issue, a rural village in a subsistence economy where undernutrition in children is significant, and Kiribati with its high reliance on imports and a mix of under and over nutrition. The one-size-all approach is known to foster better regulation and easier budgetary plans; more knowledge inflow and sustainable growth; and creates an opportunity for comparison and strengthening of the indicators across various settings. For example, the harmonization of gender indicators in Kyrgzstan strengthened the gender monitoring of the Millennium Development Goals (MDGs) in their different regions (UNIFEM, 2006).

The main limitations come down to potential for oversimplification, and the continued need to interpret or adapt some indicators into their local settings. In the first area, inflexibility may lead to important contributory factors being overlooked in some peculiar/different settings. In the second area, it should be noted that harmonisation of indicator variables themselves does not mean that some interpretation may not be needed to apply them to a local context, or that international consensus may needed to achieve standardisation of the indicator methodology. Both areas are well known limitations of indicator models, which are recognised as being approximate representations of reality. Nevertheless, indicator models that fill the role of translating empirical observational data to accurate representative overviews are regarded as essential for key areas of public policy, and harmonisation of approaches is especially desirable when comparing between countries and mapping overall progress, most notably in the SDGs. Thus, the SDGs have seen a drive toward agreed sets of standardised and harmonised indicators (Kim, 2020).

Some of the lessons learned from my study for others undertaking research on sustainability of food systems and diets include that in a place where there are no baseline data underpinned by clear methodology and findings, there is need to develop this information from first principles in order to characterise the situation for other researchers. Recruitment of the enumerators and participants may be becoming more difficult; my perception based on feedback was that some people are getting tired of participating in various research initiatives being directed at them, as a result of a range of research organizations and projects converging on the same small populations, often with little or no obvious changes or benefit. Researchers should also be aware of an attitude that foreign researchers may be inclined to impose a problem and solution on the people without allowing them to become fully involved and engaged in the process. For this reason researchers should ensure that they carry out a community-directed projects. My thesis has provided the current nutrition situation in these Islands of Kiribati which serves as a major tool for addressing how sustainable their food systems and diets will be in the next years.

8.1.2 Dietary assessments of households

This dissertation also presents results and a preliminary analysis of information obtained through the Kiribati Health Champions (KHC) baseline survey on the nutrition/dietary assessments of households in South Tarawa. The KHC program is a four-year (2017-2020) New Zealand Partnerships funded initiative that is implemented by Caritas Aotearoa New Zealand with development partner organizations – Diocese of Tarawa and Nauru. The KHC program has the overall goal for I-Kiribati people to live healthy lives. The four-year activity is based on inter-connected components – sustainable diet research; nutrition leadership training; health promotion; and capability strengthening. Importantly, this study is one of the few studies in Small Island Developing States (SIDS) that reports nutritional status using dietary intakes of households.

Indigenous foods were coded to enable data entry to FoodWorks Professional nutrient analysis software. The software calculates the nutrient composition for each day’s meals (breakfast, lunch and dinner) for every individual that participated in the dietary assessment methods. Food items were coded by selecting items from drop-down lists in the software supported by the 2004 Pacific Food Composition Database. The food composition database was found to be adequate for all the indigenous foods encountered in the dietary analysis, and no substitutions needed to be made.

Low consumption of fruits and vegetables and high intake of sugar and cereals among the subjects studied reflects the inadequate components of dietary intake. According to Secretariat of the Pacific Community, fruit and vegetable consumption in the Pacific Island nations and territories is significantly lower than the daily recommended intake of five servings per person (Secretariat of the Pacific Community, 2010). Inadequate intake of fruit and vegetables is often attributed to poverty and food insecurity in developing nations (FAO, 2015). Low intake of plant-based foods, including fruits and vegetables, is linked to greater risk of various chronic non-communicable diseases such as hypertension, diabetes, obesity, stroke and cardiovascular disease (CVD) (Choi et al., 2015; Aune et al., 2017). Although this study did not measure the contribution of sugar-sweetened beverages (SSBs) to the overall high sugar intakes in Kiribati because of lack of proper nutrition labelling in many of the locally made SSBs consumed, sugar was observed to make a significant contribution because of the frequent consumption of SSBs. Findings from Snowdon (2014) revealed that the consumption of SSBs over the Pacific region, especially among adolescents, was high. Many Pacific Island nations such as Fiji, Nauru, Tonga and Cook Islands, have made some efforts to reduce the intake of SSBs by enforcing sales or excise taxes on SSBs thereby increasing the price to consumers (Snowdon, 2014). These countries endorsed school food policies with the intention to ban entry of SSBs in schools. The objective to have an oversight on promotion and patronage of SSBs has seen constrained by implementation to date in the area, even though some school food strategies do impede promoting and publicizing SSBs in schools and their environs. Kiribati proposed the year 2014 as a due date for sugary beverage duties being authorized and actualized however sadly this enactment has not come around (WCRFI, 2018). SSBs are one important source of sugar, but as part of this research it was also found that it was common to add sugar to meals. The significant use of added sugar in preparing and/or already prepared foods or at the table among the I-Kiribati subjects is of concern and needs urgent intervention. The possible adverse outcome of consuming diets rich in sugar, are basically both the negative health consequences associated with sugar itself, and harmful results linked with surplus calories from sugars, including an increase in overweight and obesity and a shift from a more nutrient-rich foods (Murphy and Johnson, 2003).

High consumption of rice and flour based dishes among the subjects in South Tarawa (ST) is also worrisome. The dominance of these dishes is a major factor behind the monotony of diets among the population studied. These foods are imported, highly processed and unfortified, and are subsidized by the government to make them available and affordable to the people, unlike their more nutritious counterparts, *i.e.*, fruit and vegetables. Despite the fact that rice and flour are imported duty-free, they have not supplanted the taste choice of I-Kiribati who select traditional foods such as taro or bananas; however they provide a low-cost option, especially for families in the urban areas with no home gardens.

Kiribati has a mandatory fortification legislation of iron (as ferrous fumarate) for wheat flour but during this work it was observed that in many supermarkets where these flours were sold, they were unfortified. Most flours imported from Fiji were fortified with iron but others imported from the Philippines and Turkey were unfortified. This indicates that there is a gap in enforcing this mandatory fortification legislation for various reasons, including the possibility of corruption among border officials (Buchanan, 2012).

The food consumption pattern of the households in ST and Butaritari (BT) reflected high consumption of non-traditional diets and refined foods, which manifested in multiple micronutrient malnutrition and low dietary diversity: strong risk factors for obesity and diabetes. The expansion of multi-national large companies and increased risk to international food markets in Kiribati has impelled a nutrition shift towards intake of more Westernized, refined foods and beverages, progressively displacing the indigenous diet (WHO, 2013). The low median DDS and FVS indicates overall poor dietary quality. Diverse diets provide nutrient adequacy because different foods and food groups are good sources for various macro- and micronutrients (Stacy, 2016).

In relation to protein, the majority (over 80%) of the studied populations in ST and BT consumed fish/seafoods based on the 24-hour dietary recall results. Fish contributed about one-fifth of the protein in the diets consumed in this study. Fish is an essential component of foods consumed in many Pacific Island nations and domains, and fishing activities contribute great inputs to both individual and household food and nutrition security, especially in rural areas (Charlton et al., 2016). The per capita yearly fish intake measured globally ranged from 18 to 63 kg (Charlton et al., 2016). Largely, fish contributed more than half of dietary protein from animal sources in agrarian areas across a broad territory of Pacific Small Island Developing States (PSIDS). Therefore, fish and other seafood provide a majority of high quality protein and omega-3 (n-3) fatty acid intake.

The low consumption of meats/pork, dairy products, and eggs observed especially in BT may be explained due to cost. These foods are perceived as ‘cash foods’, and then sold by the people who produce them to make income, leading to the increased intakes of cheaper foods that are dense in energy and fat. Meats/pork, eggs and dairy products are one of the best sources of high quality protein and micronutrients that are fundamental for normal development (Smith et al., 2013). Milk, meat and eggs give around 13% of the energy and 28% of the protein eaten worldwide; in low and middle income countries (LMIC) and in Kiribati, this increases to 20% and 40% for energy and protein (FAO, 2009). The increased consumption of meat and milk in developing nations is compelled by factors such as high education levels, urbanization, rising earnings and social influence (Mclntyre, 2009).

Based on average the minimum Average Macronutrient Distribution Range (AMDR) the subjects in this study met and exceeded the minima of 15%, 20% and 45% energy from protein, fat and carbohydrates, respectively. The 24-hour dietary recall showed that many subjects in ST had intakes of riboflavin, niacin, vitamin A, potassium, magnesium, calcium, iron and zinc below their recommended levels. The subjects in BT had fewer deficient nutrients compared to those in ST. Their intakes were more frequently deficient in vitamin A, magnesium, calcium, iron and zinc. Vitamin A is important for several physiological processes, together with keeping up the integrity and performance of all surface tissues (epithelia) for example the skin, the gut, the bladder, the labyrinth and the eye (Gilbert, 2013). Vitamin A deficiency is a known cause of child mortality and one of its main consequences is increased risk of severe infection (Gilbert, 2013). Magnesium is essential for several biochemical reactions to occur in the human body and this includes regulation of normal nerve and body function, keeping heartbeat steady, and helps in the control of blood glucose levels (Rosanoff, 2005). Calcium is a mineral that is necessary for the soundness of bones and teeth, and a normal heart cadence, thus its deficiency might have adverse health consequences (Pravina et al., 2013). Iron is important for several metabolic functions including oxygen and electron transport and its deficiency could lead to various forms of iron-deficiency anaemia (Abbaspour et al. 2014). Zinc is an important micro-mineral for humans and performs an essential function in the structural component of proteins and enzymes; its deficiency affects the immune and endocrine system (Sauer et al., 2016).

The basis for calculating and assessing individual-based measures such as RNI from recall of a representative householder was because the household representatives (mostly the female members of the households who were involved in cooking/purchasing of the food) maintained oversight and had a very good understanding of what the members of their households were consuming and provided their own 24-hr recall to represent their household. The weighed food record was collected for all the members of the households as they consumed. Each individual intake (from 24-hr dietary recall and weighed food record) was compared with their RNI specific for their age and sex. This is regarded as a valid approach in the context of this study because the RNI is the average intake level of a particular nutrient that is likely to meet the nutrient requirements of 97-98% of healthy individuals in a particular life stage or gender group.

The variation in the nutrient intakes between the urban (ST) and rural (BT) study locations could be linked to consumption of more local traditional foods such as breadfruits, coconut and different varieties of sea products like crab, eel fish and octopus in BT. This was supported from the results of weighed food records. For all age groups based in both locations, vitamin A and calcium intakes were inadequate; and the requirement for dietary iron intake was not met for those 10 years and over for both sexes. Inadequacies of nutrients consumed from different foods in the study locations could be mainly attributed to poorly diversified diets and insufficient nutrient-rich food intake. The Kiribati Government has built up a procedure to energize expanded local food production in the remote islands and extend trade from the northern outer islands (for example Butaritari) to South Tarawa to support the increasing urban population of South Tarawa. The legislature-sanctioned cargo endowment to traders to support marketing in South Tarawa and informal evidence showed that there are currently progressively settled markets for some homestead items (Rimon, 2011). The cargo sponsorship strategy—, which was intended to improve commercial activities in the remote islands and food production to provide the requirements of the urban centre—appears to have been ineffectual (to date). Currently, the sponsorship just covers restricted agricultural crops including green leafy vegetables, pumpkin and banana. It excludes other cash crops like local varieties of taro, coconuts and some marine items (Rimon, 2011).

8.1.3 Anthropometry and body composition

In BT, the prevalence of obesity based on BMI and BF% are 74.8% and 91.2%, respectively. In ST, the figures are 46.8% and 64.1%, respectively. The mean obesity prevalence using BMI classification was higher than the national prevalence of 38.4% reported in 2014 (WHO, 2014). This suggests that the obesity prevalence is on the rise and urgent interventions are needed to reduce this public health problem. Obesity, an important casual factor for NCDs, has seen an expanding pattern in the Pacific Island countries, and some of them have highest obesity prevalence rates on the planet (WHO, 2018). Many studies have identified the burden of obesity in this region include high hospital costs (which drain government spending plans), early death, and increased morbidity and mortality (Anderson, 2013; Cheng, 2010; Finucane et al., 2011). Nonetheless, there are many collaborating factors that shape dietary patterns. These include salaries, costs, individual tendencies and feelings, social traditions, and sociocultural components (Parry, 2010). In pushing ahead, endeavours that tackle obesity from infancy or before birth and adopt a deep-rooted strategy should be reinforced. Approaches should be all around structured and assessed to guarantee the greatest effect and drawn on worldwide and territorial recommendations. There may be benefit in consolidating efforts or fusing approaches that currently focus on different areas such as schools, food systems and obesogenic settings. For instance, a few studies have shown that food costs impact food-purchasing behaviour. A little study was carried out in a cafeteria setting and was intended to look at the impacts of accessibility and cost on the utilization of fruit and salad at the consumer's level. It was indicated that increasing variety and lessoning cost considerably tripled the consumption of both items while returning cost and accessibility to the original natural conditions took utilization back to its original levels (Chan and Woo, 2010). A larger report intended to take a gander on the impacts of health education and estimating on the utilization of candy machine snacks likewise indicated comparable outcomes, in which cost decreases on low-fat items expanded the relative acquisition of low-fat items by 9%, 39%, and 93% in the 10%, 25%, and half value decrease conditions, individually (Jerry et al., 2001). Policy areas affecting physical activity settings incorporate urban planning strategies, transport approaches and organizational strategies on the provision of facilities for physical activity (Robitaille et al., 2004; Pate et al., 2006). Living in walkable networks and having parks and other diversion offices close by were reliably connected with more significant levels of physical movement in youth, adolescents, adults and elderly. Better school plan, for example, including ball circles and having an enormous school grounds, and better building structure, for example, signs advancing stair use and more advantageous access to stairs than to lifts were related with more significant levels of physical action in youth, adolescents, adults and elderly (Sallis and Glanz, 2009).

The use of BMI to define overweight and obesity across populations has become an important issue in the debate over its appropriateness. Several studies have shown that the association between BMI and BF% differs among ethnic groups; for example, studies with Indian (Gallagher et al., 2000), Indonesian (Gallagher et al., 2000), Tongan (Craig et al., 2007), Australian (Piers et al., 2003) and Jamaican (Luke et al., 2000) populations have established that a single BMI represents different values of fat percentage due to factors such as environmental characteristics and the population ethnicity. This present study (as in Chapter 8) showed the ideal cut-off points for predicting BF% among I-Kiribati people were observed to be 24.5kg/m^2 for men and 32.9 kg/m^2 for women. These BMI values vary from the cut-off points for predicting BF% in American Caucasian and European Caucasian populations which are 30 kg/m^2 for both genders (Piers et al., 2003). Energy balance and body build could be reasons for differences in the BF/BMI relationship among the ethnic groups (Deurenberg et al., 1999). Overweight (BMI of 25 to <30 kg/m^2) and obesity (BMI of $\geq$30 kg/m^2) cut-points have a very low sensitivity in the studied Kiribati population. These standard BMI cut-points overwhelmingly utilized information from

Western European and American populaces (WHO, 1995). A couple of assessments have demonstrated that native minority populaces have a comparable degree of health risk at lower adiposity limits than white populaces (Wen et al. 2009, Misra et al., 2009 , Kumar et al., 2011). It is noteworthy that cut-off points need to be agreed and interpreted for native minority populaces since they develop greater weight-related issues at a more youthful age, prompting more terrible eventual outcomes, therefore earlier mediation might be vital in this populace.

The final data chapter of this thesis (Chapter 7) assessed the prevalence of obesity as determined by different anthropometric indices among adolescents in Butaritari Island. The purpose of this chapter was to determine when this population becomes predisposed to overweight and obesity; and to the best of my knowledge, this is the first prevalence obesity study on adolescents in Kiribati. The results showed that female subjects were significantly bigger and had higher mean values of WC, BMI and BF% compared to their male counterparts. This finding is supported by other studies (Amuta and Houmsou, 2009; Senbanjo et al., 2009) which showed that females had higher values for obesity-related measure than males. The prevalence of obesity amongst the adolescents across different measures were 7.3% (WC), 2.1% (BF%), 10.8% (BMI), 44.3% (WHR) and 17.5% (WHTr). It was also observed in this study that mean values of WHR and WHTr were higher in females than males. This could be attributed to the fact that adolescent females generally have a gynaecoid fat distribution, *i.e.*, greater distribution of lower body fat. This result is conflicting with past studies that noted higher WHR and WHTr in males (Moleno et al., 1998; Freedman et al., 2007). A few investigations have demonstrated that the probability of an obese child turning into an obese adult increases with the age of the child independently of the length of time that the child has been obese (Deshmukh-Tasker et al., 2006, Biro and Wein, 2010). As observed from this thesis research, the adult population had triple the prevalence of obesity compared to their children. This indicates that obesity prevalence appears to heighten between adolescence and adulthood. Intervention to curb overweight and obesity targeted during the transition period between adolescence and adulthood may therefore be more impactful.

Data that enable the comparison of established risk factors in youth, such as blood pressure, blood lipids, or other blood markers, with total and regional body fatness in different age and ethnic groups would be required before adopting population-specific BMI cut-offs as a matter of policy. More information about the role of fat distribution in the risk of disease would also be valuable, given the evidence that peripheral and central adiposity have significantly different effects on health outcomes. This additional biomedical information was not a focus of these surveys, and this limitation should be borne in mind.

The factor that determines the type of measure to be used depends on the objective of the study. For example because the body mass index (BMI) is a measure to characterize the degree rather than the apportioning of obesity, waist circumference (WC) as an indicator of body fat distribution is to a great extent applied to characterize correlated risk factors in obese adolescents, such as metabolic syndrome indicators (Janssen et al., 2005). The International Diabetes Federation has suggested including WC as a screening indicator of abdominal obesity in children and has described WC as one of the risk criteria for classifying metabolic disorder in children >10 years old (Zimmet et al., 2007).

The suggested cut-offs are different from the norm. The calculations have been re-checked and still show the same results. This is similar to the findings of the study by Duncan et al. (2010) where they found that the need to adjust cut-off points for overweight and obesity ranged from an average of 3.3 and 3.8kgm^{-2} lower than the standard cut-points. Although in my study, the optimal sensitivity and specificity were attained by adjusting BMI cut-off values to predict obesity based on the WHO criteria: BF% >25% in men and >35% in women, according to the receiver operating characteristic curve (ROC) analysis adjusted for age and for the whole group, it is important to state most ethnic-specific cut-offs for BMI study used a large sample size (>1000). Most of the ethnic-specific studies used BIA measurements for estimating percent fat percentages (Wollner et al., 2017; Duncan et al., 2010; Hunma et al., 2016)

8.1.4 Nutrition knowledge and attitude

The overall knowledge of good nutrition among the respondents was moderate (BT) and acceptable (ST). Surprisingly, good nutrition knowledge was higher among rural households (BT) than urban households (ST). This reflects the possibility that traditional knowledge that is transferred from generation to generation could lead to good nutrition knowledge. Another attributable factor could be that more developmental health programmes are targeted more to rural settings like BT and may have a positive effect on these households. Kuhnlein (2015) identified the importance of all-encompassing information of and beliefs about food, wellbeing and health guarded by Indigenous Peoples and their connections to nutrition and health. It was suggested that it is fundamental to build community support and activity for manageability and self-assurance to establish wellness and nobility to local methods for recognizing what an important and healthy life is. Qualitative results obtained in this work also showed some of the respondents had some level of good knowledge on how to prevent non-communicable diseases. As an example; a 32 year old female cleaner from South Tarawa reported, "A sick person who has diabetes should be given foods which are balanced, that contains no fat, no starch such as breadfruit, cassava, sea foods and cabbage leaves". Another female respondent from Butaritari stated, "A sick person who has diabetes should be given foods, drink plenty of water in a day, eat little amount of rice and do exercise everyday". It is essential to state that knowledge is an essential component, but even good knowledge is no help if other factors are driving poor nutrition choices. Therefore, educational initiatives in Kiribati may not be effective unless they are linked to sustainable initiatives that drive nutritional outcomes. Preparing instructions for proper nutrition, as an effective factor to social, economic and cultural characteristics, can also play critical role in nutritional knowledge of people.

8.1.5 Policy Implications

A series of global statements and meetings have advanced sustainable food systems (SFS), and focused on their significance in relation to guaranteeing food security and nutrition. The Secretary General of the United Nations (during the Conference on Sustainable Development, Rio + 20, the Zero Hunger Challenge), underscored the central role of food security and nutrition (FSN) for sustainable development (Meybeck and Gitz, 2015). In 2014, members of the FAO and WHO embraced the Rome Declaration on Nutrition (FAO/WHO, 2015) that shows a comprehensive methodology, perceiving 'that the underlying drivers of and components prompting unhealthiness are unpredictable and multidimensional', focusing on the need to 'improve SFS by creating sound open approaches from generation to utilization.' The Decade of Action for Nutrition rose up out of the ICN2 and its related Framework for Action. Regional initiatives incorporate the UN Conference for Small Island Developing States and its SIDS Accelerated Modalities of Action (SAMOA) Pathway, and the Convention for Biological Diversity's Cross-cutting Initiative on Biodiversity for Food and Nutrition (Meybeck and Gitz, 2015). Despite these declarations and initiatives globally and in SIDS, it is unclear why the nutrition situation in Kiribati is worsening for there have been no improvements since the results of the 1985 National Nutrition Survey and the National Demographic Survey in 2009 compared to the findings of my thesis. This signals a need for a review of the nutrition commitments and scale up of nutrition-sensitive programmes in the Island of Kiribati.

8.1.6 Assessing evidence for change

The general state of understanding relating to nutrition in Kiribati prior to this study is outlined in Section 1.4.1. Among other factors a key limitation has been lack of systematic baseline data of the type collected in this work. However overall previous work had indicated poor nutritional health statistics over the last 3-4 decades including selected micronutrient deficiencies and increasing adult obesity.

Unfortunately for Kiribati, this work provides no evidence that the situation has become any better. Instead, the results of this work serve to reiterate the problem and extend the range of likely micronutrient deficiencies. Results are consistent with the idea that poor nutrition in Kiribati is either continuing at much the same level or becoming gradually worse.

Previous work established that there was high prevalence of vitamin A deficiency and anemia which were determined clinically (Ministry of Health and Family Planning, 1985). Although this study used dietary assessment methods to estimate nutrient intakes, its results indicate that 30 years after the previous (clinical) study, the populations studied still showed substantial deficiencies in their dietary intakes of vitamin A and iron. Similarly, the 2015/2016 STEPS survey conducted among adults (25-64 years) established that the mean number of servings of fruits and vegetables consumed per week was below 1. Although this study did not use the same methodology, results were consistent as there were about 10% or fewer of the study populations (on both islands) that had consumed fruits and vegetables over the previous day in the 24-hour dietary recall. Looking at the percentage of overweight and obesity, the 2015/2016 STEPS survey reported national levels as

81.4% for overweight, and 46.4% for obesity. In this work the average obesity prevalence for the subjects from the two islands was 60.8%. The two studies are not *directly* comparable, because the STEPS work was on a national scale whereas this study was regional. However, the results of this work do not provide any evidence for any improvement. Rather, they are consistent with the likelihood that the situation has worsened. It seems likely that reliance on poor diets has become entrenched and now extends across decades and generations. There remains a need for a community-directed intervention approach to be used to improve the nutritional status of the Kiribati people.

8.2 Limitations

This thesis has several limitations. One of the impediments was that a portion of the harmonized markers have not been field-tried and that the audit was restricted to just investigations of recognized pointers that were explicitly proposed or utilized. This portion includes some of the nutrition and health indicators (diet-related morbidity/mortality; and nutrient and non-nutrient assessment of some commonly consumed foods), all the environmental indicators and the socio-economic indicators.

Critical limitations in previous studies may have added to the irregularity crosswise over earlier findings. Dietary diversity scores may be influenced by the number of foods and food categories used in the assessment. Whereas some studies focus on five traditional food groups (fruits, vegetables, meat or protein sources, dairy, and grains) others extend the scope to a more extensive range, for example: desserts, snacks, and caloric drinks (Azadbakht and Esmailzadeh, 2011; Keim et al., 2014). In this work the approach was to select a range that reflected the traditional food groupings while also incorporating salt and sugar as important added components of the Kiribati diet. Although no system will be perfect, this approach was considered to be an optimum mix of providing consistent information for indicator use, reflecting key differences between the two study sites (*e.g.* higher fish consumption in one area shows up as more protein), and including additives that are associated with recognised health problems (sugar and salt).

One weakness the 24-hour recall methodology it that applied to any individual, it does not provide food consumption frequency estimates. However, because different households are unlikely to all eat the same mix of foods over one 24-hr period, the method is adequate for assessing intake in a large population. In this study, the collection of data using the three-day food record was really cumbersome because it exerts a lot of burden for the subjects during the measurements of their foods before and after their intake, however, the subjects were very motivated and consistent. Foods eaten not more than one occasion per week may not be captured in the weighed food recall and also the individual may modify his/her diet to make it simpler to record, or to hide poor dietary pattern.

Evaluation of optional salt (including salt used in cooking or at the table) is especially tricky in dietary surveying. For weighed food records, very precise scales were used, because salt added to food is used in gram and sub-gram amounts that may not register on generally-utilized scales. For 24-hour recall, the amount of salt added to cooked meals will be variable and rely on specific cooking strategies, and some may be added but not consumed where liquid components are left over. For certain populations, uncertainties in estimating optional salt may not significantly alter estimates but for other populations, that amount of salt included during cooking could be a significant and variable source of their sodium consumption. There are (obviously) some uncertainties around salt and consequently sodium.

The major constraint of the nutrition KAP study in this population was the trouble of getting a standard reference to characterize the respondents' knowledge, attitude and practice levels and establishing cut-off points.

Other limitations for the obesity prevalence study among Junior Secondary School (JSS) students was that it was carried out in a junior secondary school of Butaritari (students' age range 12 to 16 years), and although its results are indicative they should not be generalized to the school adolescent population in Kiribati. The study sample size was small which could be attributed to the small number of students attending the Junior Secondary School (JSS) in the Island at the time of the research. The school studied was the only JSS in the Island.

8.3 Recommendations

A key finding of this work is that nutrition situation in Kiribati has not improved. Instead, based on the study populations, micronutrient deficiencies are likely to extend beyond Vitamin A and iron, and the prevalence of overweight and obesity may be worsening. In addition, results of the KAP study undertaken as part of this work suggest that poor knowledge and attitudes to nutrition are not a primary cause of the underlying problems.

These results suggest an urgent need for the Kiribati Government and its health agencies to:

1. Undertake a review of current nutrition-related policies and interventions to establish whether there are any key points of failure that could be addressed, or successes that could be built upon. One example area and policy (outside the direct scope of this thesis) may be nutritional costs and benefits associated with the government subsidy on imported rice (Section 8.1.2).

2. Commission an assessment of options of positive policy initiatives and interventions that could be implemented to encourage Kiribati food production and its diversification. Although educational initiatives may have a place, results of this work suggest that more fundamental structural changes are needed to improve dietary diversity and decrease reliance on poorer quality and imported foods.

In terms of future research, this work has provided the first systematic baseline based on 24-hour dietary recall, weighed food records and dietary diversity in two areas of Kiribati, which is also aligned with approaches to international indicators. Data of this type is essential for measuring progress towards goals both within Kiribati and when reporting internationally. It is therefore recommended that the Kiribati Government undertake to work with outside partner agencies to implement an ongoing programme of dietary assessment at periodic (e.g. five-yearly) intervals, using the same methodologies as applied in this thesis.

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APPENDICES

Appendices that follow comprise:

Appendix 1: Population-based food consumption survey forms including interviewer observation form

Appendix 2: KAP questionnaire towards nutrition

Appendix 3: Food use questionnaire

Appendix 4: Ethics approval letters

Appendix 5: Statements of contribution

Population-based Food Consumption Survey of the People of Kiribaiti 2017 &2018

DAY ONE INTAKE QUESTIONNAIRE

Sample Person ID: __ __ __ __

Interviewer ID: __ __

__ __ : __ __ (am / pm)
Time Started

Date of Interview: __ __ - __ __ -20 __ __
D M Y

__ __ : __ __ (am / pm)
Time Ended

Date of Intake: __ __ - __ __ -20 __ __
D M Y

Day: Mon / Tue / Wed / Thu / Fri / Sat / Sun

Interview conducted at:
(1) Respondent's Home
(2) Survey Interview Centre
(3) Other location ____________

Are you the person most responsible for planning or preparing the meals in your household?
(0) No (1) Yes (9) Refused (8) Don't know/Not sure

How best can you describe your physical activity level?

(a) Extremely inactive (b) Sedentary (c) Moderately active (d) Vigorously active

(e) Extremely active

General Introduction

Hello! I am__________ and I am an interviewer of the Caritas, New Zealand. We would like to ask about your food consumption, your second interview. It will take about 40-45 minutes. Do you have any questions?

24-hour Dietary Intake Questionnaire

<u>Introduction:</u>

This part of the interview is to enable us to find out what you have eaten the previous day. All that you have eaten including drinks, snacks, sauces, spices, and salad dressings will need to be recalled.

There is no right or wrong answer in this interview, you only need to tell me what you have actually eaten. Do you have any questions? If not, let's start.

<u>Interview steps:</u>

1. Quick List of Food Items

   [Quickly record all food and drink items consumed in the previous day in the "Quick List of Food Items"]

   Please tell me everything you ate or drank all day yesterday, from 6 o'clock yesterday morning until 6 o'clock this morning. Include all you ate and drank at home and away—even snacks. [Do not interrupt unnecessarily.]

   [When respondent stops, ask:] ***Anything else?***

   Now, I'm going to ask you more details about the foods and beverages you just listed. I want you tell me "when", "which occasion", "what", "how much" and "where" you ate all your foods yesterday.

   When I ask about amounts, you can use these measuring guides and food pictures for the size or weight of foods. (If at respondent's home) Please use any of your own cups, mugs, or bowls to estimate the amount of food you ate or drank at home yesterday, or check any package labels that may be helpful.

   When you remember anything else you ate or drank as we go along, please tell me.

2. a. Column 1A ***About what time did you (eat/drink) the food?***

   b. Column 1B ***What would you call this occasion?***

3. Query about the food eaten: [GO TO FIB Q.2]

   a. Column 2A Transfer the Quick List Food to Column 2A, cross out the food in Quick List.

   b. Column 2B Ask about the ingredients and details.

What was the (food) you (ate/drank) made of?

What food ingredients were in the (meal or dish)?

Did it have any other ingredients? [If yes] ***What were they?***

[Request food labels if possible when respondent cannot answer the ingredients]

4. Column 3 Ask about amounts: ***How much did you eat (each of them) ?*** [GO TO FIB Q.3]

5. Column 4 Ask about the food source: ***Where did you obtain the (food)?***

6. Go to the next food item on the Quick List. [Skip this step and go to step 7 when all foods in the Quick List have been asked]

   Did you have (next Quick List Item) at (Time) with your (Occasion) or was it another time?

   [If SAME OCCASION Go to step 3; If DIFFERENT OCCASION Go to Step 2] Go through all items on the Quick List.

7. Food break and review: ***Now let's see what you ate between occasions and if I have everything***:

a. ***What was the first food or drink you had after waking up yesterday? (Time?) (First occasion?)***

   b. ***Now at (Time) for (This occasion) you had (Foods), did you have anything else?***

   c. ***Did you have anything to eat or drink between your (Time) (This occasion) and (Time) when you had (Next occasion)? Such as snacks, deserts, fruits or drinks?***

Repeat 7b and 7c for each occasion except last occasion.

For last occasion, go to 7d

d. ***Now at (Time) for (Last occasion) you had (Foods), did you have anything else?***

   e. ***Did you have anything to eat or drink after your (Time) (Last occasion) but before 6am this morning?***

   f. ***Did you have anything to eat or drink between midnight last night and waking up today?***

I'd like you to try to remember anything else you ate or drank yesterday, that you haven't already told me about, including anything you ate or drank while preparing a meal or while waiting to eat.

[When respondent says no, or when respondent stops, show hand card 1]

Did you eat these foods?

[If yes, ask for the details;   If no, continue on step 8]

Individual Intake Form

Quick List of Food Items	Column 1		Column 2		Column 3	Column 4	Coder use only	
	A. Time	B. Occasion	A. Food/Drink and Additions	B. Description of Food/Drink and Ingredient	How much of this (FOOD) did you actually eat/drink)?	Where did you obtain the (FOOD)?	Food code	Amount

Occasion: 1. Breakfast 2. Brunch 3. Lunch 4. Dinner 5. Late night meal 6. Fruit
7. Food and/or beverage break, snack, alcohol beverage or other beverage 8. Other (specify):__________________________

Source of food: 1. Homemade 2. Restaurant/cafeteria/fast food shop/deli 3. Food stall/hawker 4. Supermarket/Food store 5. Workplace tuck shop
6. Day care 7. Friend/relative's home 8. Party/BBQ/banquet/special event 9. Other (specify):________

8. Was the amount of food that you ate yesterday about usual, less than usual, or more than usual?

(1) Usual (Go to 9) (2) Less than usual (Go to 8a) (3) More than usual (Go to 8b)

8a. What is the main reason the amount you ate yesterday was less than usual?

(1) Sickness

(2) Short of money

(3) Traveling

(4) At a social function, special meal or on a special day

(5) On vacation

(6) Too busy

(7) Not hungry

(8) Dieting

(9) Fasting

(10) Bored

(11) Stressed

(12) Other reason:______________________

8b. What is the main reason the amount you ate yesterday was more than usual?

(1) Traveling

(2) At a social function, special meal, or on a special day

(3) On vacation or day off

(4) Very hungry

(5) Bored or stressed

(6) Some other reason: ________________________

9. How could you describe your current dietary habit? [Show card]

(1) No special diet, I eat almost everything

(2) Vegetarian

(3) Special diet:___________________________

Thank you for your cooperation!

Time ended: |__ __ : __ __ (am / pm)

Interviewer Observation Form

[Do not read these questions to the respondent.]

A. Who else helped in responding for this interview? (Circle all that apply)

(0) No one
(1) Sample person
(2) Mother of sample person
(3) Father of sample person
(4) Wife of sample person
(5) Husband of sample person
(6) Daughter(s) of sample person
(7) Son(s) of sample person
(8) Sister(s) of sample person
(9) Brother(s) of sample person
(10) Grandparent(s) of sample person
(11) Aunt(s) of sample person
(12) Uncle(s) of sample person
(13) Maid(s) of sample person
(14) Someone else (specify) – other than interviewer ________________________

B. Did you or the respondent have difficulty with this intake interview?

(0) No

(1) Yes

C. What was the reason for this difficulty?

____

____

____

____

For office use only					
Date received:			Data entry:	Yes	No
Complete Questionnaire:	Yes	No	Entered by:		
Missing data make up:	Yes	No	Re-entry:	Yes	No
Verified by:			Entered by:		

KNOWLEDGE, ATTITUDE AND PRACTICE TOWARDS NUTRITION QUESTIONNAIRE

Section A: Socio-demographic information of the respondents

1. Name and code	What is your name?	
	Insert respondent code	_ _ _ _
2. Sex	*Insert the sex of the respondent*	Male ☐ Female ☐
3. Age	When is your birthday? *Probe if necessary*: On what day and in which month and year were you born?	_ _ / _ _ /_ _ _ _ day month year
	How old are you? *Probe if necessary*: What was your age at your last birthday? *If the information conflicts with the previous question, determine which one is more accurate*	Age in completed years _ _
4. Geographical characteristics	Where do you live? *Adapt to the local geographical characteristics: district, city, village, section, tribe, etc.*	☐District ____________________ ☐City ____________________ ☐Village ____________________ ☐Section ____________________ ☐Other ____________________
5. Educational level	Have you ever attended school? *If yes, continue asking*: What is the highest level of school you attended? What is the highest grade/form/year you completed at that level?	None ☐ Primary school ☐ Secondary school ☐ Higher ☐ Grade _ _

Section B: Knowledge, Attitude and Practice of mothers and youths towards nutrition

1. How important is it to you to eat healthy?

A. Very important [ ] B. Somewhat important [ ] C. Not that important [ ]

D. Not at all important [ ]

2. What does 'eating healthy' mean to you? (Check all that apply).

A. Low calorie (energy) foods [ ] B. Low carbs [ ] C. Low fat [ ]

D. Low sodium [ ] E. Low sugar [ ] F. Eating fresh [ ]

G. Organic foods [ ] H. Natural foods [ ] I. Whole grains

J. Others (please specify) ________________________

3. What forms of fruits and vegetables do you use? (Check all that apply)

A. Tinned [ ] B. Frozen [ ] C. Dried [ ] D. Fresh [ ] E. 100% Juice [ ]

F. Others (please specify) ________________________________

4. How easy/difficult is it for you to get your 5 daily servings of fruits and vegetables (WHO recommendation)?

A. Easy [ ] B. Fairly easy [ ] C. Somewhat difficult [ ] D. Very difficult [ ]

5. Where do you usually consume fruits and/or vegetables?

A. Always at home [ ] B. Mostly at home [ ] C. About equally, home and at work [ ]

D. Mostly at home, some dining out [ ] E. About equally, home and when dining out [ ]

F. Mostly when dining out [ ] G. Others (please specify)______________________

6. How easy/difficult is it to get your children to eat their vegetables?

A. Easy [ ] B. Somewhat easy [ ] C. Somewhat difficult [ ]

D. Very difficult E. N/A (don't have children at home)

F. Others (please specify)______________________

7. Do you read the Nutrition facts label on grocery items?

A. Almost always [ ] B. Usually [ ] C. Sometimes [ ] D. Rarely [ ]

E. Never [ ] F. Others (please specify)______________________

8. In a typical week, how often do you eat the following meals with one or more members of your households?

	0-1 day/ week	2-3 days/week	4-5 days/week	6-7 days/week
Breakfast				
Lunch				
Dinner				

9. On the average, how many drinks with sugar do you take per day?

A. 0 [ ] B. 1 [ ] C. 2 [ ] D. 3+ [ ]

10. If you were to buy a drink from the shop when you are thirsty, which of these would you choose?

A. Coconut water [ ] B. toddy [ ] C. Water with sugar [ ] D. Water [ ]

E. Tea [ ] F. Coffee [ ] G. Others (please specify) ______________.

11. Do you take alcoholic drink? A. Yes [ ] B. No [ ]

12. Have you had a drink containing alcohol in the last 7 days? A. Yes [ ] B. No [ ]

13. On a night out, which of these drinks would you choose to drink?

A. Beer [ ] B. Kava [ ] C. Home-brew [ ] D. Toddy [ ]

E. Others (please specify) ______________.

14. If you were to have a snack, which of the following would you choose?

A. Nuts [ ] B. Donuts [ ] C. Fruit/vegetables [ ]

D. Cake/Biscuits [ ] E. fried bread [ ]

15. How many times do you take snacks on average a day? ______________

16. Do you smoke cigarettes? A. Yes [ ] B. No [ ]

17. On average, how many cigarettes do you smoke a day? ___________________

18. Tick √ (only one option) where appropriate in the following table

Variables	Always	Frequency	Occasionally	Rarely	Never
1. I choose foods low in sugar					
2. I eat snacks, especially after dinner					
3. When choosing the food I eat, consider its health benefit					
4. I add at least 2 spoons of sugar into coffee or tea					
5. I add sugar to food while cooking and/or after it is served					
6. I drink at least 1.5 litres of plain water daily					
7. I wash my fruit (s) each time I want to eat them					
8. I prefer quality to quantity in selection of meals					

19. Main source of water for drinking, cooking and hand washing (select all that applies by ticking √)

Source of water	Drinking	Cooking	Hand washing
Piped water			
Tube well/borehole			
Dug well			
Water from spring			
Rainwater collection			
Cart with small tank/drum			
Surface water (river, stream, lake, pond)			
Bottled water			

CALCULATION OF INDIVIDUAL INTAKE OF EACH INGREDIENT IN A RECIPE FORM

1. Code No ☐ 2. A ☐ 3. ☐ 4. Weig ☐ (g)

Meal: Breakfast (B) / Lunch (L) / Supper (S)/ Snacks (Sn) Day: M/ T/ W/ Th / F/ S / Su

Ingredient/recipe	(a) Amount in recipe (g)	(b) Total cooked wt. of recipe (g)	(c) Amount of recipe consumed (g)	(d) Conversion factor (a/b)	(e) Amount of ingredient consumed (g) (c/b x a)
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					

Meal: Breakfast (B) / Lunch (L) / Supper (S)/ Snacks (Sn) Day: M/ T/ W/ Th / F/ S / Su

1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					

Meal: Breakfast (B) / Lunch (L) / Supper (S)/ Snacks (Sn) Day: M/ T/ W/ Th / F/ S / Su

1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					

Traditional Food Use Questionnaire

1. How do you get your foods?

   i. Purchase/ Produce/ Partly purchase and Produce

   ii. Super markets/ local markets/ Pick up fruits and vegetables around the place

   iii. fishing

2. What are the three main crops/ hunter/gathering for food – like lagoon fish, seafood, shellfish, sea worms, mangrove fruits found in this community? How do you cook and preserve these foods?
3. Are there any part of a tree plant that you eat, if yes mention them? Leaves/ roots/bark etc
4. Do you consume traditional (indigenous) fruits and vegetables? What are your most commonly consumed fruits and vegetables and the forms of consumption? How do you get these fruits and vegetables? (Note you asked the respondent the ones he/she mentioned)
5. Do you have special foods- foods that are prepared or consumed during special periods such as

   i. wedding ceremony ii. First menstruation celebration iii. during pregnancy/lactation iv. Children/elderly

   v. religious/cultural periods such as Baptisms, ordinations, Easter and Christmas celebrations

6. Is/Are there any food (s) that is/are inappropriate to be eaten in the above mentioned periods?
7. What traditional food is eaten when someone is sick? All the foods mentioned will be associated with its healing properties.

8. In your opinion, what do you think is the cause of high prevalence of Non-communicable diseases- obesity, diabetes, hypertension etc in this locality? In what ways can it be reduced?

GOVERNMENT OF KIRIBATI
OFFICE OF TE BERETITENTI
P.O Box 68, Bairiki Tarawa
Tel: (686) 21183 **Fax:** (686) 21902

File Ref: OB 3/83 **Date: Wednesday 16th August 2017**

Principal Immigration Officer
Ministry of Foreign Affairs & Immigration
P.O. Box 68, Bairiki
Tarawa, KIRIBATI

FILMING and RESEARCH CLEARANCE

This is to certify that the following person(s) have applied for a Filming and Research Clearance from this office and has been duly approved effective from the registered date of this letter.

NAME	[redacted] NUMBER
PAUL EZE EME	[redacted]

The above person(s) will be required to pay in cash, a Filming and Research fee in the amount of AUD$350.00 to the Revenue Cashier at the Ministry of Finance in Bairiki. Subsequently, the receipt must be deposited at the Office of the President in Bairiki to the Registry Section.

Please kindly accord to the above captioned person(s) the necessary assistance required in processing his filming and researching at the Museum and Ministry of Internal Affairs.

Please feel free to contact the undersigned should you require further clarification or information.

Mr. Tearinibeia E. Teabo
for Secretary Office of Te Bretitenti

GOVERNMENT OF KIRIBATI
OFFICE OF TE BERETITENTI
P.O Box 68, Bairiki Tarawa
Tel: (686) 21183 **Fax:** (686) 21902

File Ref: OB 3/83 **Date: Monday 20th of July 2018**

Principal Immigration Officer
Ministry of Foreign Affairs & Immigration
P.O. Box 68, Bairiki
Tarawa, KIRIBATI

FILMING and RESEARCH CLEARANCE

This is to certify that the following person(s) have applied for a Filming and Research Clearance from this office and has been duly approved effective from the registered date of this letter.

NAME	[redacted]NUMBER
PAUL EZE EME	[redacted]

The above person(s) will be required to pay in cash, a Filming and Research fee in the amount of AUD$350.00 upon arrival, to the Revenue Cashier at the Ministry of Finance in Bairiki.
Subsequently, the receipt must be deposited at the Office of the President in Bairiki to the Registry Section. The applicant will carry out his research from 6th of August until 27th of August 2018.

Immigration Department please accord to the above captioned person(s) the necessary assistance required in processing the filming team's entry permit to enter Kiribati borders.

Please feel free to contact the undersigned should you require further clarification or information.

Mr. Tearinibeia E. Teabo
for Secretary Office of Te Bretitenti

MASSEY UNIVERSITY
GRADUATE RESEARCH SCHOOL

DRC 16

STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of candidate:	Paul Eze Eme
Name/title of Primary Supervisor:	Dr. Nick Kim
Name of Research Output and full reference:	
Eme, P. E., Douwes, J., Kim, N., Foliaki, S., & Burlingame, B. (2019). Review of Methodologies for Assessing Sustainable Diets and Potential for Development of Harmonised Indicators. *International journal of environmental research and public health*, *16*(7), 1184	
In which Chapter is the Manuscript /Published work:	Chapter 2
Please indicate:	
• The percentage of the manuscript/Published Work that was contributed by the candidate:	90%
And	
• Describe the contribution that the candidate has made to the Manuscript/Published Work:	
The candidate was actively involved in the conception, design, solely collected data, perform analysis, wrote the first draft, and revision of the paper	
For manuscripts intended for publication please indicate target journal:	
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Date:	26/08/2019
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Date:	26/08/2019

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Name/title of Primary Supervisor:	Dr. Nick Kim
Name of Research Output and full reference:	
Harriet Kuhnlein, **Paul Eme** and Yon Fernandez-Larrinoa (2018). Indigenous Food Systems: Contributions to Sustainable Food Systems and Sustainable Diets. Sustainable diets: Linking Nutrition and Food Systems, Chapter 7.Edited by Barbara Burlingame and Sandro Dernini. Published by CABI.	
In which Chapter is the Manuscript /Published work:	Between Chapter 2 and 3
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Name/title of Primary Supervisor:	Dr. Nick Kim
Name of Research Output and full reference:	
Eme, P. E., Burlingame, B., Douwes, J., Kim, N., & Foliaki, S. (2019). Quantitative estimates of dietary intake in households of South Tarawa, Kiribati. *Asia Pacific journal of clinical nutrition*, *28*(1), 131.	
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Date:	26/08/2019
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Date:	26/08/2019

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Name of Research Output and full reference:	
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And	
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Date:	26/08/2019

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We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of candidate:	Paul Eze Eme
Name/title of Primary Supervisor:	Dr. Nick Kim
Name of Research Output and full reference:	
Prevalence of obesity and the relationship between Body Mass Index and Body Fat percentage among the adult population in South Tarawa and Butaritari, Kiribati Islands**.**	
In which Chapter is the Manuscript /Published work:	Chapter 6
Please indicate:	
• The percentage of the manuscript/Published Work that was contributed by the candidate:	90%
And	
• Describe the contribution that the candidate has made to the Manuscript/Published Work:	
The candidate was actively involved in the conception, design, solely collected data, perform analysis, wrote the first draft, and revision of the paper	
For manuscripts intended for publication please indicate target journal:	
Submitted to Asia Pacific Journal of Public Health under review at the time of thesis submission	
Candidate's Signature:	[signature]
Date:	26/08/2019
Primary Supervisor's Signature:	[signature]
Date:	26/08/2019

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STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of candidate:	Paul Eze Eme
Name/title of Primary Supervisor:	Dr. Nick Kim
Name of Research Output and full reference:	
Assessment of body adiposity of secondary school students in Butaritari Island, Kiribati	
In which Chapter is the Manuscript /Published work:	Chapter 7
Please indicate:	
• The percentage of the manuscript/Published Work that was contributed by the candidate:	90%
And	
• Describe the contribution that the candidate has made to the Manuscript/Published Work:	
The candidate was actively involved in the conception, design, solely collected data, perform analysis, wrote the first draft, and revision of the paper	
For manuscripts intended for publication please indicate target journal:	
Prepared to be submitted to Pacific Health Dialog at the time of thesis submission	
Candidate's Signature:	[signature]
Date:	26/08/2019
Primary Supervisor's Signature:	[signature]
Date:	26/08/2019