`ATIAH MUNIRAH BINTI MELI MASTER OF SCIENCE 2023

ASSOCIATION OF DIETARY INTAKES, NUTRITIONAL STATUS AND PHYSICAL ACTIVITY ON COGNITIVE PERFORMANCES AMONG FISHERMEN'S CHILDREN IN TERENGGANU

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MASTER OF SCIENCE
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Thesis Submitted in Fulfilment of the Requirements for the Degree of Master of Science in the Faculty of Fisheries and Food Science Universiti Malaysia Terengganu

2023

DEDICATION

Dedicated this thesis to:

Ummi, Abah, and supervisors who always encourage and support me throughout this journey.

Thank you so much.

Abstract of thesis presented to the Senate of Universiti Malaysia Terengganu in fulfilment of the requirements for the degree of Master of Science

ASSOCIATION OF DIETARY INTAKES, NUTRITIONAL STATUS AND PHYSICAL ACTIVITY ON COGNITIVE PERFORMANCES AMONG FISHERMEN'S CHILDREN IN TERENGGANU

`ATIAH MUNIRAH BINTI MELI

2023

Main Supervisor	**:**	**Asma' binti Ali, PhD**
Co-Supervisor	**:**	**Associate Professor Hayati binti Mohd Yusof, PhD**
Faculty	**:**	**Faculty of Fisheries and Food Science**

Low cognitive performance is a primary concern among fishermen's children in Terengganu. Thus, this study evaluated the risk of dietary intake, nutritional status, physical activity, and associated factors on cognitive performance among fishermen's children aged 7 to 11 in Kuala Terengganu and Kuala Nerus. A questionnaire was used to retrieve the participants' sociodemographic data. Subsequently, a 24-hour dietary recall was conducted over two days (one weekday and one weekend) to ascertain their dietary intake and adequacy. The participants' anthropometric measurements were obtained by determining their height-for-age and body mass index (BMI)-for-age, and median urinary iodine was also performed. The Physical Activity Questionnaire for Children (PAQ-C) was used to measure the participants' physical activity and divided them into three categories: low, moderate, and high. The Raven's Coloured Progressive Matrices score classified their cognitive performance as follows: intellectually superior, above average, average, below average, or intellectually impaired. The findings indicated that the participants had adequate intake of all necessary nutrients except for fat, dietary fibre, thiamine, folate, vitamin C, vitamin E, calcium, zinc, and potassium. Majority have normal height-for-age (Mean = -1.01±1.03) and BMI-for-age [Median = -0.86 (2.11)], but 56.4% were iodine deficient [Median = 83.9 (102)]. Furthermore, 75.5% of the participants engaged in moderate physical activity (Mean

= 2.84±0.577), while their cognitive performance was below average [Median = 80.0 (21.0)]. Moreover, there was a significant relationship between cognitive performance and the mother's education level ($\chi^2(2, N=94) = 0.050$, $p = 0.037$), BMI-for-age ($\chi^2(2, N=94) = 6.271$, $p = 0.012$), protein ($\chi^2(2, N=94) = 5.407$, $p = 0.020$), and niacin ($\chi^2(2, N=94) = 4.608$, $p = 0.032$). Out of the four variables, BMI-for-age (OR = 0.290, 95% Cl [0.91,0.920], $p = 0.036$) and fourth quartiles of protein intake (≥52.69g) (dummy variable for *'protein'*) (OR = 7.565, 95%Cl [1.470,38.926], $p = 0.015$) were identified as major risk factors for low cognitive performance among the participants. In summary, a balanced diet and healthy lifestyles are crucial for a child's growth and development, particularly their cognitive development. Thus, interventions emphasising the promotion of healthy lifestyles, particularly focusing on BMI-for-age and protein intake, are advised.

Abstrak tesis yang dikemukakan kepada Senat Universiti Malaysia Terengganu sebagai memenuhi keperluan untuk Ijazah Sarjana Sains

HUBUNGKAIT ANTARA PENGAMBILAN PEMAKANAN, STATUS PEMAKANAN DAN AKTIVITI FIZIKAL TERHADAP PRESTASI KOGNITIF DALAM KALANGAN ANAK-ANAK NELAYAN DI TERENGGANU

`ATIAH MUNIRAH BINTI MELI

2023

Penyelia : **Asma' binti Ali, PhD**

Penyelia Bersama : **Associate Professor Hayati binti Mohd Yusof, PhD**

Fakulti : **Fakulti Perikanan dan Sains Makanan**

Prestasi kognitif yang rendah merupakan kebimbangan utama dalam kalangan anak-anak nelayan di Malaysia. Oleh itu, kajian ini menilai risiko pengambilan diet, status pemakanan, aktiviti fizikal, dan faktor-faktor yang berkaitan dengan prestasi kognitif dalam kalangan anak-anak nelayan berumur tujuh hingga 11 tahun di Kuala Terengganu dan Kuala Nerus. Soal selidik telah digunakan untuk mendapatkan data sosiodemografik peserta. Pengingatan kembali diet 24 jam telah dijalankan selama dua hari (satu hari dalam hari bekerja dan satu hari pada hujung minggu) untuk memastikan pengambilan dan kecukupan diet. Ukuran antropometrik peserta diperoleh dengan menentukan ketinggian-untuk-umur dan indeks jisim tubuh (BMI)-untuk-umur, serta ujian median air kencing iodin. Soal Selidik Aktiviti Fizikal untuk Kanak-kanak (PAQ-C) digunakan untuk mengukur aktiviti fizikal yang dibahagikan kepada tiga kategori: rendah, sederhana dan tinggi. Matriks Progresif Berwarna Raven digunakan untuk mengukur keupayaan kognitif para peserta seperti berikut: melebihi purata, purata, di bawah purata atau cacat intelektual. Penemuan menunjukkan bahawa para peserta mempunyai pengambilan nutrien yang mencukupi kecuali lemak, serat makanan, tiamin, folat, vitamin C, vitamin E, kalsium, zink dan kalium. Kebanyakan peserta mempunyai ketinggian normal mengikut umur (Min = 1.01±1.03) dan BMI-untuk-umur (Median = -0.86 (2.11)], tetapi 56.4% kekurangan iodin [Median = 83.9 (102)]. Tambahan pula, 75.5% para peserta terlibat dalam aktiviti fizikal sederhana (Min = 2.84±0.577), manakala prestasi kognitif mereka diklasifikasikan di bawah purata [Median = 80.0 (21.0)]. Selain itu, terdapat perhubungan yang nyata antara prestasi kognitif dan tahap pendidikan ibu (χ^2(2, N=94) = 0.050, p = 0.037), BMI-untuk-umur (χ^2(2, N=94) = 6.271, p=0.012), protein (χ^2(2, N=94) = 5.407, p = 0.020), dan niasin (χ^2(2, N=94) = 4.608, p = 0.032). Antara empat pembolehubah tersebut, BMI-untuk-umur (OR = 0.290, 95%Cl [0.91,0.920], p = 0.036) dan kuartil keempat pengambilan protein (≥52.69g) (pembolehubah dummy untuk 'protein') (OR = 7.565, 95%Cl [1.470,38.926], p = 0.015) dikenal pasti sebagai faktor risiko utama yang menyumbang kepada prestasi kognitif rendah dalam kalangan peserta. Secara tuntasnya, diet seimbang dan gaya hidup sihat adalah penting untuk pertumbuhan dan perkembangan kanak-kanak, terutamanya perkembangan kognitif mereka. Oleh itu, intervensi yang menekankan promosi gaya hidup sihat, terutamanya memberi tumpuan kepada BMI-untuk-umur dan pengambilan protein, adalah dinasihatkan.

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Furthermore, special thanks to my friends and new friends who helped and supported me throughout this study. May Allah’s blessings always with them all. Thank you so much for everything.

~ 파이팅 해야지 ~

APPROVALS

I certify that an Examination Committee has met on 22nd March 2023 to conduct the final examination of `Atiah Munirah binti Meli, on her Master of Science thesis entitled **"Association of dietary intakes, nutritional status and physical activity on cognitive performances among fishermen's children in Terengganu"** in accordance with the regulations approved by the Senate of Universiti Malaysia Terengganu. The Committee recommends that the candidate be awarded the relevant degree. The members of the Examination Committee are as follows:

Assoc. Prof. Ts. Dr. Amir Izzwan bin Zamri, Ph.D
Associate Professor,
Faculty of Fisheries and Food Science,
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PROF, DR. MOHD EFFENDY BIN ABD. WAHID, Ph.D
Dean of Faculty of Fisheries and Food Science
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Date:

This thesis has been accepted by the Senate of Universiti Malaysia Terengganu in fulfilment of the requirement for the degree of Master of Science.

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PROF, DR. MOHD EFFENDY BIN ABD. WAHID, Ph.D
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Date:

DECRALATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UMT or other institutions.

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`ATIAH MUNIRAH BIINTI MELI

Date:

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LIST OF ABBREVIATIONS

BMI	Body Mass Index
EAR	Estimated Average Requirement
FAO	Food and Agriculture Organization
NPANM	National Plan of Action for Nutrition of Malaysia
NRP	Nutrition Research Priority
PAC-Q	Physical Activity Questionnaire for Children
RCPM	Raven’s Coloured Progressive Matrices
RNI	Recommended Nutrient Intake
SEANUTS	South East Asia Nutrition Survey
USDA	United States Department of Agriculture
WHO	World Health Organization

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CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Children's brains grow and develop at the fastest rate during their first years of life (McAfee et al., 2012). At this stage of development, adequate food intake, as well as physical exercise, are critical for the children's brain development (Gomes da Silva & Arida, 2015). Many studies have indicated that adequate dietary intake, good nutritional status, and better physical activity play an important role in brain development and improving cognitive performance (Bidzan-Bluma & Lipowska, 2018; Bryan et al., 2004; Macpherson et al., 2017; Nurliyana et al., 2020; Timmons, 2007; Gomes da Silva & Arida, 2015).

Diet adequacy refers to a comparison of an individual's or population's dietary intake to a set of dietary requirements (Castro-Quezada et al., 2014; Itandehui et al., 2010; Román-Viñas et al., 2009). According to Malaysian Recommended Nutrient Intake (RNI) (2017), children aged 7 to 9 years old have an energy requirement of 1750 kcal for boys and 1610 kcal for girls, while boys and girls aged 10 to 12 have an energy requirement of 1930 kcal and 1710 kcal, respectively. According to several studies, Malaysian children's daily total calorie intake ranged between 1600 to 1900 kcal (Karim & Abdul Razak, 2019; Henry et al., 2019; Yang et al., 2017; Woon et al., 2014). Additionally, Woon et al. (2014) discovered that there are 75% of 293 children did not meet the RNI for energy, indicating that generally, there is low food intake. Besides that, according to a study on dietary intake by the 3rd National Plan of Action for Nutrition of Malaysia (NPANM III) (2016), it is discovered that adolescents eat fewer than three servings per day of vegetables, less than two servings per day of fruits, and less than one to three servings per day of milk and dairy products. Moreover, there are 93.7% of adolescents eat fewer items that are beneficial for cognitive development (NPANM III, 2016). Some recent studies have demonstrated a strong connection between several nutrient intakes and cognitive performance (Fortune et al., 2019; Kim & Kang, 2017; Spencer et al., 2017; Wang et al., 2021). Moreover, nutrients such as iodine (Cusick & Georgieff, 2017; Georgieff et al., 2019; Nyaradi et al., 2013), iron (Cusick & Georgieff, 2017; Georgieff et al., 2019; Nyaradi et al., 2013), folate (Bryan et al. 2004; Georgieff et al., 2019; Nyaradi et al., 2013), vitamin B12 (Georgieff et al., 2019; Nyaradi et al., 2013) and zinc (Cusick & Georgieff, 2017; Georgieff et al., 2019; Nyaradi et al., 2013) are important for brain development thus, cognitive performance. This shows how important to have an adequate dietary intake of this selected nutrient intake, especially iodine, iron, folate, vitamin B12, and zinc, toward growth development, specifically brain development.

Besides dietary intake and adequacy, nutritional status also uses to measure if one's having sufficient food consumption for healthy development, notably cognitive development. Nutritional status is a marker of malnutrition, including underweight, wasting, and stunting, which may be used to measure undernutrition, whereas overweight and obesity are indicators of excessive food consumption (World Health Organization (WHO, 2010). Globally, 40 million children under five are overweight, and the number of overweight and obese children is growing, especially in lower-income nations, putting about 200 million children under five at risk for stunting, wasting, or both (United Nations Children's Fund (UNICEF, 2019). In Malaysia, school-aged children have significant issues of thinness, stunting, overweight, and obesity (NPANM III, 2016). The high prevalence of both overnutrition and undernutrition is referred to as a "double burden" problem. In Terengganu, the case of thinness among children rose from 6.7% in 2011 to 8.4% in 2015 (Ahmad et al., 2017). This demonstrates that malnutrition is a severe problem not just globally but also in Malaysia. Additionally, it has been discovered that children's poor cognitive development is a result of malnutrition problems (Nyaradi et al., 2013; Prado & Dewey, 2014). Haile et al. (2016) discovered that improving height-for-age results in higher cognitive test scores. This can be supported by Nurliyana et al. (2020), where a study mentioned that stunting could affect cognitive performance where there will be delayed motor developments which particularly inhibit their exploration and learning process from their surroundings, which leads to poor cognitive performance. This shows that nutritional status does have an influence on children’s cognitive performances.

Aside from diet-related, physical activity is also important for one’s development. Physical activity is defined as "any bodily movement produced by skeletal muscles that require energy expenditure" (WHO, 2020). According to the Centers for Disease Control and Prevention (CDC) (2019), children and adolescents between the ages of 6 and 17 must engage in 60 minutes of aerobic, muscle-strengthening, and bone-strengthening physical exercise each day. Globally, only 23.8% of boys and 15.4% of girls worldwide who took part in the Global School-based Student Health Survey (GSHS) met the criterion to be physically active for at least 60 minutes per day (Guthold et al., 2010; Wong et al., 2016). The same GSHS data from Malaysia reveals a troubling trend, with just 15.3% of girls and 30.2% of boys between the ages of 13 and 17 meeting physical activity guidelines while more than 48.5% of girls and 46.4% of boys reported engaging in sedentary activities for more than 3 hours per day (Lau et al., 2013; Wong et al., 2016). This shows physical inactivity is a pervasive problem among schoolchildren. In children, physical activity is important to enhance cognitive development and academic achievement (Bidzan-Bluma & Lipowska, 2018; Eime et al., 2013; Janssen & Leblanc, 2010; Macpherson et al., 2017; Wong et al.; 2016). It has been suggested that physical activity has positive benefits on children's and adolescents' cognitive development, including attention, working memory, classroom conduct, and academic success. (Zeng, 2017). Another study has shown that by doing physical exercise or any physical activity, the cognitive function of the children improved compared to those with less physical activity (Mandolesi et al., 2018). Thus, this shows that physical activity is an aspect that is prominent in child development.

As mentioned before, dietary intake, nutritional status, and physical activity play an important role in improving cognitive performance. The “cognitive performance” refers to the capacity to locate logic, solve problems, schedule, make nonfigurative judgments, grasp many ideas, and learn from experience, all of which are components of general mental competence that are measured by intelligence quotient (IQ) (Al-Mekhlafi et al., 2011; Dan & Walter, 2015). Cognitive abilities are important predictors of academic and occupational success (Duckworth et al., 2019; Shi & Qu, 2021; Stadler et al., 2016). They also play a role in the ability to maintain social relationships, engage in recreational activities, and age successfully (Bidzan-Bluma & Lipowska, 2018; Murman, 2015; Wascher et al., 2018). It is estimated that more than 200 million children under the age of five fail to develop cognitively to their full potential worldwide because of poverty, inadequate health and nutrition, and inadequate care. (Grantham-Mcgregor et al., 2007; Engle et al., 2009; WHO, 2012). According to data from 2406 Malaysian children aged 5 to 12 who took part in the South East Asian Nutrition Surveys (SEANUTS), it was shown that 35.0% of Malaysian children had non-verbal IQ scores above average, although 12.2% were classified as having low/borderline IQ (Poh et al., 2019). Low or borderline intelligence is the term used to describe a group of people who fall somewhere between normal intellectual functioning and intellectual disability and have an IQ between 70 and 85 (Wieland & Zitman, 2016). Furthermore, two studies conducted in Terengganu found that there are more than half are categorized as intellectually impaired cognitive performance among fishermen’s children (Ali et al., 2020; Tai & Ali, 2018). This demonstrates that the fishermen’s children are at risk of having low cognitive performance.

Fishermen’s household refers to the family who has the breadwinner of the family who works as a fisherman, be it a coastal or deep-sea fisherman (Budiarto et al., 2020; Kusnadi, 2006). Their community is considered one of the vulnerable groups in Malaysia (Solaymani & Kari, 2014). They are prone to food insecurity, have a low level of education (Zain et al., 2018), and have low socioeconomic status (Fahmi et al., 2013). According to a study by Ramli et al. (2019), it is no longer unexpected that fishermen are associated with poverty, given that most earn half as much as *Pendapatan Garis Kemiskinan* (PGK). Moreover, overall extreme and normal poverty among Malaysian fishermen were found to be 28.10% and 81.57%, respectively (Roumah, 2016). This shows that the fishermen's community is synonymous with scarcity and a low standard of living. Lacking a healthy lifestyle exposes not only the family, particularly the children, to outdated technology and development but also creates nutritional deficiencies in the children. A study conducted by Oladimeji et al. (2015) proves that the fishermen's community suffered from protein inadequacy due to their desperate move to sell catches in order to gain money, neglecting their healthy diet. Despite these concerns, there is still a scarcity of published studies on this fishing community, particularly on their children. Thus, this present study assessed the fishermen's children's dietary intakes, nutritional status, and physical activity toward cognitive performance in Terengganu. Furthermore, if there is an association between dietary intake, nutritional status, physical activity, and cognitive performance, a risk assessment will take place to identify risk factors of cognitive performance among the fishermen’s children.

Thus, how it is needed, risk assessment offers the science-based information required by risk regulators, who utilise that information, together with other data, to make choices about risk-management activities, where risk refers to the likelihood that a hazard may result in an adverse health occurrence (Hughes & Margetts, 2011; Taylor & Yetley, 2008). Example of a previous study that involves risk assessment including a study by Aiga et al. (2019) entitled risk factors for malnutrition among school-aged children: a cross-sectional study in rural Madagascar. Another study is organophosphate exposure, associated risk factors, and exposure risk assessment among vegetable farmers in Sabah, Malaysia, by Bottigo et al. (2021). However, there is not yet any risk assessment study regarding cognitive performance. Thus, this study explored the risk assessment of poor cognitive performance among the fishermen’s children in Terengganu. All in all, this study will determine the assessment of dietary intakes, nutritional status, physical activity, and cognitive performances among fishermen’s children in Terengganu.

1.2 Problem Statement

Children's growth and cognitive development are greatly influenced by healthy lifestyle choices and optimal dietary intakes (Benton, 2010; Nyaradi et al., 2013; Tandon et al., 2016). In recent years, there has been a surge of interest in determining the association between dietary intake, nutritional status, physical activity, and cognitive performance in children of all ages. Moreover, much prior research has demonstrated an association between nutrient intake, physical activity, and cognitive performance (Bidzan-Bluma & Lipowska, 2018; Naveed et al., 2020; Sawe et al., 2020; Tandon et al., 2016; Wang et al., 2021). However, to date, there is still a lack of research on cognitive performance among children in Malaysia generally, moreover, if association with nutrient intake and physical activity. Investigating cognitive performance is critical because it covers how a child learns to think, reason, and use language, all of which are important to the child's overall growth and development (Dick & Riddell, 2010; Haddad et al., 2019).

There are few studies carried out to examine cognitive performance among children in Malaysia. However, those studies focusing on different populations, such as Orang Asli and homeless children (Chin et al., 2020; Murtaza, 2017; Teh et al., 2020) and different age groups, such as preschool children aged 5 to 6 (Hutagalung & Isa, 2017; Hutagalung et al., 2022). There are only two studies that focus on cognitive performance among fishermen's children, particularly in Terengganu (Ali et al., 2020; Tai & Ali, 2018). Tai and Ali (2018) reported that there is 94% had a level of cognitive performance below average. The study was conducted among 100 fishermen's children aged 7 to 12 years old in Terengganu. Another study conducted by Ali et al. (2020) shows the level of cognitive performance is below average, with most of the students (66.3%, n = 95) categorized into Grade V (intellectually impaired). However, both studies only focused on the relationship between diet intake and cognitive performance. Nonetheless, the percentages of children of fishermen with low cognitive performance were quite high. As a result, research into the variables that contribute to the cognitive performance of fishermen's children, especially dietary intake, nutritional status, and physical activity, is required in order to improve their cognitive performance.

Malnutrition is one factor that may impair cognitive performance among fishermen's children. Previous studies prove that deficiency of certain nutrients such as iodine, iron, folate, vitamin B12, and zinc shows a negative effect on cognitive performance among children (Black, 2011; Bryan et al., 2004; Cusick & Georgieff, 2017; Georgieff et al., 2019; Khor & Misra, 2012; Nyaradi et al., 2013). On the contrary, research conducted by Tai and Asma' (2018) in Terengganu exclusively for fishermen's children aged 7 to 12 shows poor micronutrient intake among fishermen's children, but there is no association with cognitive performance. However, the previous study only focused on the respondents' breakfast meals which could affect the reliability of the diet recall process. Thus, this study was anticipating an average full-day dietary intake instead of just breakfast. Besides that, Ali et al. (2020) also shows no association between diet quality and cognitive performance. The study was conducted among fishermen’s children aged 7 to 11 years old in Terengganu. Although the research's targeted respondents fit the present study's criteria, the prior study focused on diet quality using the Healthy Eating Index (HEI). Thus, a more extensive examination of each macro- and micronutrient was seen in this investigation among this population.

Besides nutrient deficiency, BMI-for-age and height-for-age have also been proven to associate with cognitive performance in previous studies (Kar et al., 2008; Li et al., 2018; Nyaradi et al., 2013; Poh et al., 2019; Prado & Dewey; 2014; Veldwijk et al., 2011). In Malaysia, Poh et al. (2019) found that among the 2,406 Malaysian children aged 5 to 12 who took part in SEANUTS, those with significant obesity are more likely to have low non-verbal IQ. Aside from that, another study conducted among 1,933 pre-schoolers aged 4–6 years in Peninsular Malaysia discovered that height-for-age was found to contribute significantly towards cognitive performance (Mohd Nasir et al., 2012). Similarly, Teh et al. (2020) also found that height-for-age was significantly associated with cognitive function among 167 Orang Asli children aged 7 to 11. However, those three studies focused on different populations from the targeted population of this study, where Poh et al. (2019) and Mohd Nasir et al. (2012) focused on Malaysian children generally, and Teh et al. (2020) focused on Orang Asli children. This shows that there is still lacking studies regarding the association between BMI-for-age and height-for-age with cognitive performance among fishermen’s children. There are few studies regarding BMI-for-age and height-for-age among fishermen’s children (Bahtiar et al., 2021; Hashim et al., 2021; Zakaria et al., 2022). However, those studies focused on different areas, such as food insecurity (Hashim et al., 2021), mothers' child feeding knowledge, attitude, and practices (Zakaria et al., 2022), and child development (Bahtiar et al., 2021). Thus, one of the purposes of this study was to see if there was an association between BMI-for-age and height-for-age and cognitive performance in fishermen's children.

Other than that, physical activity may also be another factor that could influence the cognitive performance among fishermen’s children in Terengganu.

Physical activity has been shown to be good for children's health and also improve their cognitive performance (Bidzan-Bluma & Lipowska, 2018; Gao et al., 2018; Janssen & LeBlanc, 2010). With this, physical activity has been proven to associate with cognitive performance among children in previous studies (Alesi et al., 2015; Chen et al., 2014; Kamijo et al., 2011; Kubesh et al., 2009; Verburgh et al., 2016). However, no study has been conducted in Malaysia on the relationship between children's cognitive performance and physical activity, particularly among fishermen's children in Terengganu. Nevertheless, there is low physical activity among Malaysian children generally, which could influence their cognitive performance. Chin and Zakaria (2015) discovered that Malaysian children by the age of 7-12 years old had a low physical activity level while their sedentary behavior was classified as high. Another study by Lee et al. (2015) reported that children engage in sedentary lifestyle activities for an average of 6.7 hours per day, with just 15% of children reaching the recommended pedometer step count of 13,000 steps per day for boys and 11,000 steps per day for girls. Thus, the result of the study proved that the children were physically inactive (Lee et al., 2015). Moreover, according to the Malaysia School-Based Nutrition Survey 2012, 57.3% of adolescents aged 10 to 17 were found to be inactive (Baharudin et al., 2014). This shows that Malaysian children generally were physically inactive, but there is still a lack of data regarding the level of physical activity among fishermen’s children, particularly in Terengganu. With this, this study explored not just the relationship between physical activity and cognitive performance among fishermen’s children in Terengganu but also explored their physical activity level.

In conclusion, although earlier research identified a number of variables, particularly dietary intake, nutritional status, and physical activity, that are associated with children's cognitive performance, their influence on the children of fisherman have not yet been investigated. It is important to investigate this population as they are considered a vulnerable group that faces food insecurity, low education, and low socio-economic status (Ali et al., 2019; Apine et al., 2018; Hussin et al., 2015). Thus, in order to offer a better knowledge of the causes and risks that may be connected to cognitive performance among fishermen's children, this is an essential area that has to be further investigated. Apart from that, this study is also relatively related to the 12th Nutrition Research Priority (NRP) 2021-2025, where it is regarded as similarly significant in terms of satisfying the nation's demands for additional knowledge and data necessary to improve the population's health and nutritional wellbeing. The life course approach to food intake and dietary practises, which is research priority area 3, is relevant to this study. The primary goals of the study were to identify the health impacts of dietary practises and food intake in different age groups and to investigate how these factors affected people's physical, mental, and social well-being, particularly in relation to cognitive function. In addition, this study was in line with research priority area 4, which deals with dietary excesses and deficiencies. Here, the major goal was to ascertain how macronutrient and micronutrient status related to health outcomes, particularly cognitive function.

1.3 Significant of the study

To date, only few studies has been undertaken in Malaysia to directly investigate fishermen's children's cognitive performance and the factors that may be associated with it. Due to the lack of baseline data, this study gave a valuable opportunity to measure cognitive performance and factors associated with it among Terengganu fishermen's children. If there is a large percentage of low cognitive performance and it has a significant association with any factors, the study would continue to look at the risk assessment of low cognitive performance among Terengganu fishermen's children. With the identification of risk in the target group, nutrition education and intervention, such as promoting healthy eating or improving parenting skills, may help improve the health and education of fishermen's children. Thus, this research might have an influence on society, the economy, and the nation.

One of the societal effects is that it will improve the life course of fishermen's children, which is consistent with the 11th Malaysia Plan Strategic Thrust 3 of "Accelerating Human Capital Development for an Advanced Nation.". Lowering the risk of having low cognitive performance through appropriate intervention will increase the capacities of the fishermen's children as well as their school's academic success. As a result, they will have a better life.

Improving their cognitive performance and academic performance in school may have an indirect impact on the economy. This is because the improved cognitive ability is associated with higher wages and more job opportunities (Ozawa et al., 2022). As a result, children who have healthy cognitive development are more likely to succeed in developing their human capital through education and more productive in their adult careers.

In terms of the nation's impact, the implementation of nutrition education and intervention, such as promoting healthy eating or improving parenting skills, maybe a forerunner of a new generation of fishermen with high capabilities in work productivity aligned with their improved cognitive performance. According to Nandi et al. (2017), early health and nutritional interventions, such as those that boost the health and nutritional status of future mothers and expectant moms as well as those that treat young children directly, have a major influence on productivity across the lifespan in low- and middle-income nations.

1.4 Research objectives

1.4.1 General objectives

The general objective of this study is to assess dietary intake, nutritional status, physical activity, and their associated factors toward cognitive performances among fishermen’s children aged 7 to 11 years old in Terengganu and its risk toward low cognitive performance.

1.4.2 Specific objectives

The specific research objectives of this study are:

1. To determine socio-demographic profile, dietary intake, nutritional status, physical activity, and cognitive performance among fishermen’s children in Terengganu.

2. To determine the relationship between factors (dietary intake, nutritional status, physical activity, and socio-demographic profile) and cognitive performance among fishermen's children in Terengganu.
3. To determine risk assessment towards cognitive performance and identify the most risk factor that influences cognitive performance via logistic regression among fishermen's children in Terengganu through children's anthropometry, biomedical assessment, dietary assessment, physical activity, and the fishermen's socio-demographic profile.

1.5 Research questions

Based on the problem statement and objectives, this research aims at answering the following research question:

1. What is the possible factor that contributes to cognitive performance among fishermen's children in Terengganu?
2. What is the level of cognitive performance among fishermen's children in Terengganu?
3. What is the relationship between the factors and cognitive performance among fishermen's children in Terengganu?
4. What is the risk assessment of poor cognitive performance among fishermen's children in Terengganu?
5. What is the biggest risk factor that influences low cognitive performance among fishermen's children in Terengganu?

1.6 Research hypothesis

1. There is a significant relationship between dietary intake, nutritional status, physical activity, and socio-demographic profile with cognitive performance among fishermen's children.
2. Dietary intake, nutritional status, physical activity, and socio-demographic profile are risk factors for low cognitive performance among fishermen's children.

1.7 Conceptual framework

Figure 1.1 shows sociodemographic profile, dietary intake, nutritional status, and physical activity all act as independent factors that may predict cognitive performance in children of fishermen aged 7 to 11 years old. The sociodemographic profile included information on the gender and age of the child, monthly household income, number of household members, and the mother's education level and employment Several studies found that gender, age, monthly household income, number of household members, mother’s education level and occupation were associated with cognitive performance among children (Al-Mekhlafi et al., 2011; Bogale et al., 2013; Haile et al., 2016; Hamid et al., 2011; Poh et al., 2019).

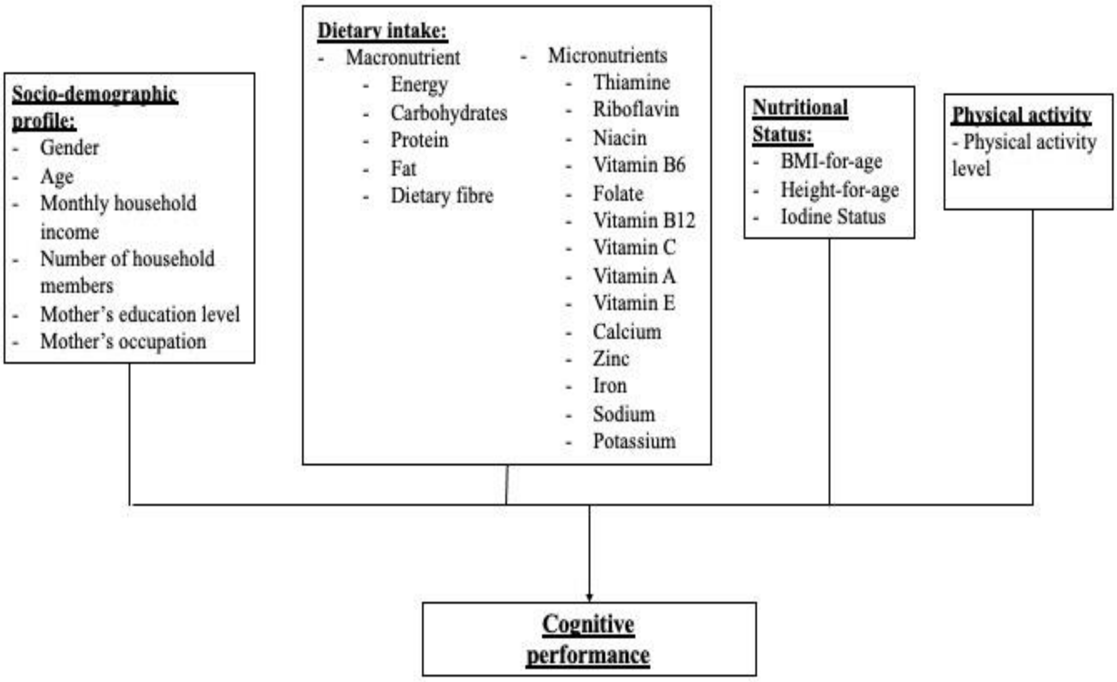

Figure 1.1: Conceptual framework

Children’s dietary intakes comprised macronutrient (energy, carbohydrates, protein, fat and dietary fibre) and micronutrient (thiamine, riboflavin, niacin, vitamin B6, folate, vitamin B12, vitamin C, vitamin A, vitamin E, calcium, zinc, iron, sodium and potassium). Previous studies have reported that nutrient influences cognitive performances among children especially iron, folate, vitamin B12, and zinc (Bhatnagar & Taneja, 2001; Chin et al., 2020; Constant et al., 2001; Hamid et al., 2011; Nyaradi et al., 2013; Swaminathan et al., 2013; Todorich et al., 2009; Youdim & Yehuda, 2000)

On the other hand, nutritional status comprised BMI-for-age, height-for-age and iodine status. Previous studies showed that thinness, obesity, stunting and iodine deficiency could lead to having poor cognitive performance among children (Meo et al., 2019; Melse-Boonstra and Jaiswal, 2010; Nurliyana et al., 2020; Poh et al., 2019; Qian et al., 2005; Sandjaja et al., 2013; Woldehanna et al., 2018; Zimmermann et al., 2006). Finally, physical activity was also included as previous studies have reported that physical activity level influences cognitive performance among children (Bai et al., 2021; Fels et al., 2015; Garcia-Hermoso et al., 2019; Mandolesi, et al., 2018; Mavilidi et al., 2019; Schmidt et al. 2015; Tee et al., 2018).

CHAPTER 2

LITERATURE REVIEW

2.1 Socioeconomic background of fishermen

Fishermen can be divided into two groups: coastal and deep-sea fishermen (Zain et al., 2018). Coastal fishermen, also known as small-scale fishermen, operate within 30 nautical miles of the coast, whereas deep sea fishermen frequently fish beyond the Exclusive Economic Zone (EEZ), which extends beyond 30 nautical miles (Mohd Khatib, 2015; Zain et al., 2018). In contrast to deep-sea fishermen who engage in large-scale operations, coastal fishermen are often the group most affected by poverty (Ghani et al., 2017). When selling fish, this group struggles with the low prices provided by vendors, resulting in a loss, especially with a lack of catches (Zain et al., 2018).

Fishing is one of the important global industries; however, it is also one of the sectors with the highest incidence of poverty (Stanford et al., 2013), especially among coastal fishermen (Raumah, 2016; Zain et al., 2018). Based on previous studies conducted in several regions, including Malaysia, had characterized fishermen as having low socioeconomic status (Ujjania & Patel, 2011; Solaymani & Kari, 2014, Yaakob & Hwee Shan, 2005) and poor standard of living (Sivanesan, 2014). Most of the fishermen's household solely depended on natural sea resources for living and was found to have higher vulnerability towards food insecurity. Since fishing operations are susceptible to uncertainties related to climate variability and environmental changes, it subsequently causes a decrease in the income of fishermen (Nath et al., 2016; Johnson & Welch, 2010).

Based on Table 2.1, there are a few issues faced by the fishermen living in Malaysia, which are poverty, marine and coastal resources, and seasonality (Ali et al., 2017; Johnson & Welch, 2010; Raumah, 2016; Solaymani & Kari, 2014; Yaakob & Chau, 2005; Zain et al., 2018; Zainuddin et al., 2019). As per mentioned before, poverty has been a huge issue among the fishermen. Based on a study by Raumah (2016), the overall extreme and normal poverty among Malaysian fishermen were found to be 28.10% and 81.57%, respectively (n=662). A majority of 47.2% of fishermen's households in Kuala Marang earned an income between RM1,160 to RM2,320, while 37% in Seberang Takir earned between RM2,320 to RM3,480 household income per month which they did not pass the National median household income, which was RM6,060 in 2016 (Zainuddin et al., 2019). Aside from income, Malaysian fisherman are impoverished in other areas, including health, insurance, and education, with around 57.4% lacking health insurance (Solaymani & Kari, 2014). This demonstrates that poverty cannot just be determined by income. Family health, insurance, sanitation, availability of power, and good roads was also considered for determining poverty levels.

Besides that, marine and coastal resources are also one of the issues faced by the fishermen. This is due to fishing activities being susceptible to environmental changes, such as the rise of sea levels, increased temperature on the sea surface, and increased acidification of the ocean (Johnson & Welch, 2010). Thus, marine resources are threatened due to the invasion of coral reefs, overfishing, and extinction of fish species (Ali et al., 2017). Plus, this is also a threat to the ecosystem and fishermen's income. If there are no more fish, the fishermen's livelihood is threatened, and they must seek employment in other fields to maintain their livelihood. Next is seasonality, where the monsoon season in Terengganu and the East Coast of Peninsular Malaysia is usually from October to March (Zain et al., 2018). During this season, the average revenue of fisherman on Peninsular Malaysia's East Coast would fall by 9 to 32% compared to the usual time (Yaakob & Chau, 2005). It is due to changes in the fisher's activity. They are limited to continuing fishing due to safety reasons, as the wave height and wind speed can rise to almost double their calm season value.

The cumulative effects of these pressures brought on by the community's difficulties might have a substantial impact on family food security and the vulnerability of the fishermen's families. However, previous studies have not dealt with the association between the socioeconomic of fishermen and nutrition problems, moreover, its association with cognitive performance.

Table 2.1: Selected studies on the socioeconomic background of fishermen

Study	Location	Subjects	Findings
Zainuddin et al. (2019)	Terengganu	10,497 fishermen	For fishermen's household income, a majority of 47.2% of fishermen's households in Kuala Marang earned an income between RM1,160 to RM2,320, while 37% in Seberang Takir earned between RM2,320 to RM3,480 household income per month.
Nursyazwin and Zein (2019)	Marang, Terengganu	50 fishermen	The average monthly income of the fishermen was MYR1,853.49 for those using hooks and lines, MYR2,105.09 for gillnets, and MYR2,595.39 for purse seines. Generally, the revenue was variable because it was based on the catch for each fishing trip, which was also influenced by the season.
Zain et al. (2018)	Kuala Terengganu	-	Fishermen are divided into coastal fishermen and deep-sea fishermen. Coastal fishermen are more affected due to the cheap price offered by fishers when selling fish. Monsoon season in Terengganu and the East Coast of Peninsular Malaysia is from October to March.
Ghani et al. (2017)	Selangor, Perak, Kedah and Johor.	306 fishermen	Various subsidies have been provided to the fishing communities, including subsistence allowance, home repair subsidies, subsidized petrol, 1 Malaysia Aid, and fishing equipment such as boats, engines, and fishing nets.

Ali et al. (2017)	Kedah, Perak, and Terengganu	246 fishermen	Massive subsidies like fuel subsidies, living allowance, catch incentives, infrastructure development, and other support programs. Marine resources such as fish, sea cucumbers, seaweed, and many others are a source of protein. However, these marine resources are threatened due to the invasion of coral reefs, overfishing, and extinction of fish species. This is also a threat to the ecosystem and fishermen's income.
Raumah (2016)	Terengganu and Kelantan	315 from Terengganu and 347 from Kelantan.	Overall extreme and normal poverty among Malaysian fishermen was found at 28.10% and 81.57%, respectively. The socioeconomic factors of households, such as age, household size, and marital status, as well as management attributes, such as education and experience, are included in the determined poverty. Aside from age and prior experience with extreme poverty, all factors were determined to be significant.
Solaymani and Kari (2014)	Rural areas in all 13 states of Malaysia.	2816 fishermen households	It is discovered that every single fisherman lacks in at least one of the eight dimensions (monthly income, education level, family health, insurance, sanitation, access to piped water, electricity & good roads). 57.4% of people live without health insurance, 9% of people lack access to piped water, and 50.1% make less than the poverty level in Malaysia on a monthly average.
Ujjania and Patel (2011)	Danti village in Valsad district (Gujarat), India	300 fishermen aged 18-72 years old	10% of fishermen were illiterate, and 90% had primary-level education. 95.7 % takes financial support from the non-reliable source.

Jonhson and Welch (2010)	-	-	Fishing operations are susceptible to uncertainties related to climate variability and environmental changes. For example, the rise of sea level increased temperature on the sea surface and increased acidification of the ocean
Yaakob and Chau (2005)	Peninsular Malaysia	-	When compared to the typical season, the average revenue of fisherman on Peninsular Malaysia's east coast decreased by from 9 to 32%.

2.2 Dietary intake, nutritional status, and cognitive performance among fishermen's children: a review[1]

This paper highlights the dietary intake of fishermen's children, their nutritional status, and their cognitive performance. It will help to have a reasonable perspective of their dietary intake and their relationship with nutritional status and how it inevitably influences cognitive performance. The objective of this study is to review previous studies on the nutritional status and dietary intake of the fishermen's children. Besides that, this study also reviewed the relationship between nutritional status, dietary intake, and cognitive development among the fishermen's children. The outcome of this study will help to provide a better understanding of the nutritional status of the fishermen's children and identify gaps and deficiencies in previous work.

2.2.1 Identifying studies and study selection

Studies published from 1997 to 2020 were searched from electronic databases such as Science Direct, Taylor and Francis, Springer Link, PubMed, and Elsevier and open databases such as Google Scholar. The key terms "nutritional status",

[1]This part has been published in Malaysian Journal of Public Health Medicine, 21(1): 148-159 (2021)-SCOPUS (SJR Q3) – (Appendix F)

“malnutrition”, “undernutrition”, “overnutrition”, “dietary intake”, “nutrient intake”, “food intake” and “diet” combined with the terms “fishermen’s children” and “fishing community” and "cognitive performance" and “cognitive function" in duplicates were used during the search. The references from the retrieved journals were also searched for additional related studies. The searches were restricted to academic journals published in English languages. All types of research studies were included in the search except review papers and systematic reviews.

Cross-sectional studies that involved children or adolescents aged below 18 years old from fishing communities were included in this review, as well as studies that focused specifically on the mother or caregiver-child pairs. Studies on adults in fishing communities and non-healthy participants (i.e., serious illness, physical disability) were excluded from this review. The reviewed studies were carefully selected if the studies provided information about the nutritional status and dietary or nutrient intake of the children from fishing communities, and since few studies found cognitive performance among such groups, similar studies on children were considered to show an association of the nutritional status with cognitive performance. As a result, 20 studies are selected for this review.

2.2.2 Charting data

Studies are grouped into two categories according to the type of investigation undertaken. Ten of the retrieved studies examined the dietary intake and nutritional status in fishermen’s children, while ten studies examined the cognitive performance in children and adolescents and the factors contributing to it. The study location(s), author(s), year of publication, objective(s) of study, number of participants, research instrument(s), and findings on the nutritional status and dietary intake of the fishermen’s children were summarized in Table 2.2 while the association of nutritional status and other factors contributing to the cognitive performance were shown in Table 2.3.

Table 2.2: Selected studies on nutritional status and dietary intake of fishermen's children.

Study	Study Location	Objective of the study	Study population	Research Instrument	Nutritional Status	Dietary Intake
Murillo-Castillo et al. (2020)	Kino Bay is a fishing community located in the Northwest of Mexico.	To determine if food insecurity was associated with lower fruit and vegetable consumption and overweight and obesity in children from Mexican fishing communities.	100 elementary-school children aged 6–12 years	Anthropometric measurements (wt and ht), Food frequency questionnaire of fruits and vegetables, The Mexican Scale of Food Security	Overweight: 25% Obese: 24% Severely obese: 8%	Lower consumption of fruits and fruits plus vegetables.
Gibson et al. (2020)	Komodo District, West Manggarai Regency, NTT.	To investigates the contribution of fish and small-scale coastal fisheries livelihood activities to food and nutrition security.	66 households participated in the study	Household survey, Focus groups discussions, Semi-structured interviews, Market survey, Anthropometric measurements (wt and ht)	Stunting: 50%	-High consumption of fish -Low consumption of vitamin A-rich fruit & vegetables -High consumption of sweet and savoury snacks
Capanzana et al. (2018)	Philippines	To analyse the nutritional status of Filipino children ages 0–60 months (0–5.0 years old) and 61–120 months (5.08–10.0 years old) in households headed by fisherfolks.	3,423 young children and 16,398 schoolchildren participants	Anthropometric measurements (wt and ht)	Underweight: 19.9% Stunting: 30.3% Wasting: 7.9% Overweight: 5%	No related finding.
Hwee Shan et al. (2018)	Terengganu	To assess diet quality and its association with nutritional status among 7 to 12 years old fishermen's	100 fishermen's children	Questionnaire, Anthropometric measurements, 24-hr recall	Severe thinness: 8% Thinness: 4% Overweight: 9% Obesity: 8%	-low intake of energy (1204.43 kcal), carbohydrates (163.76g), and fats (39.43g)

		children in Terengganu.				-High intake of protein (49g) -Low intake of calcium (300.98mg) -High intake of iron (15.44mg) -High intake of vitamins A (1085.78µg RE) and C (53.65mg)
Bandoh & Kenu (2017)	Ekumfi Narkwa, central region of Ghana	To examine the quality of food consumed in terms of nutrient adequacy of children in the fishing community.	250 children between 6 to 59 months	Dietary diversity questionnaire, Interview of caregivers	No related finding	Very low consumption of vitamin A-rich foods. High Iron consumption from fish.
Baker-French (2013)	Plurinational State of Bolivia.	To examine the prevalence and correlates of household food insecurity, childhood stunting, and maternal overweight in fisher populations in Bolivia's Northern Amazon Basin.	304 urban and 327 rural households with a head female of childbearing age (15-49 years) during the low water (October-November) and 186 urban and 297 rural households during the high water (February -March) seasons.	Anthropometric measurement (wt, ht), Household Food Insecurity Access Scale, Household Hunger Scale, Household Dietary Diversity Score	Stunted: -34% (urban) -42% (rural)	More than one-quarter of respondents did not consumed any vegetables or vitamin A-rich fruits or vegetables in the specified period.
Moshy et al. (2013)	Jibondo and Chole villages within Mafia	To determine the prevalence of underweight	104 and 52 children under five from	In-depth interviews and Focus Group Discussions	Underweight: 60%	No related finding.

	Island Marine Park in Tanzania.	among the studied children and establish descriptions of their nutrition situation and the local perceptions of possible explanations for the underweight prevalence	Jibondo and Chole Island.	(FGDs), Weight for age analysis		
Foo et al. (2006)	Tuaran District, Sabah, Malaysia.	To determine the dietary intake of male and female adolescents in a fishing community.	94 males and 105 females adolescents aged 12-19 years old.	Anthropometric measurement (wt, ht), three days food record	Thin: -25.5% (Male) -14.3% (Female) Overweight: -6.4% (Male) -2.9% (Female)	The adolescent's intake of energy (1588.95 kcal), calcium (326.8mg), iron (10.35mg), and thiamine (0.65mg) was below the RNI levels.
Hanazaki & Begossi (2003)	São Paulo Bagre and Pedrinhas, São Paulo State, Brazil.	To analyse the association between household characteristics and the diet of two Brazilian fishing communities about the consumption of animal protein, especially fish.	14 households in São Paulo Bagre and 18 in Pedrinhas.	24-hour recall	No related finding	Energy, vitamin C, and calcium intake were below daily recommendations, while protein, iron, niacin, and phosphorus were above recommended levels.
Khor & Tee (1997)	Peninsular Malaysia.	To assess the nutritional status of children from the estates and rural community groups engaged in paddy farming, rubber planting, coconut	2,364 boys and 2,415 girls aged 18 years and below from the five communities.	Anthropometric measurements (wt and ht)	Underweight: -33% (boys) -24.6% (girls)	No related finding.

		cultivation, and fishing.				

wt. = weight, ht. = height, RNI = Recommended Nutrient Intakes for Malaysia

Table 2.3: Selected studies on cognitive in children and adolescents and factors associated with the performance.

Study	**Study Location**	**Objective of the study**	**Study population**	**Research Instrument**	**Cognitive performance**	**Contributing factors**
Demetriou et al. (2020)	Major Thessaloniki area, Greece	To explore relations between academic performance, cognition, cognition self-evaluation and self-representation	408 participants from three SES groups according to parent's education	Socio-economic status, academic achievements, and Cognitive battery.	Performance varied as a function of tasks difficulty	Cognitive development positively contributes to school achievement instead
Nurliyana et al. (2020)	Seremban, Negeri Sembilan, Malaysia	To determine the influence of linear growth and home environment on cognitive development in the first year of Malaysian infants	151 infants and mothers	Sociodemographic, anthropometry (birth wt, wt, and length), home environment, Bayley-III	Mean cognitive score is 94.54 (SD=12.00)	-Stunting and poor home environment quality affect cognitive performance -The study does not discuss the relationship between SES with cognitive and home environment quality
Chin et al. (2020)	Klang Valley, Kuala Lumpur	To assess the dietary adequacy and cognitive performance of 120 homeless children aged 7-12 years living in Klang Valley.	120 homeless children aged 7-12 years	24-hour dietary recall, Raven's Coloured Progressive Matrices (CPM).	-70% had poor cognitive performance	-There were no associations found between the energy, iron, and Vitamin B12 adequacy and cognitive performance of homeless children

						except for zinc adequacy.
Poh et al. (2019)	Malaysia	To determine the association between socioeconomic and nutritional status with cognitive performance in a nationally representative sample of Malaysian children.	2406 Malaysian children aged 5 to 12 years who had participated in the Southeast Asian Nutrition Surveys (SEANUTS)	A self-administered questionnaire, Raven's Coloured Progressive Matrices (CPM), Anthropometry.	-About a third (35.0%) of the children had above-average non-verbal IQ, while only 12.2% were categorized as having low/borderline IQ.	-Children with severe obesity, children from very low household-income families, and children whose parents had only up to primary level education had the highest prevalence of low/borderline non-verbal IQ.
Sathe & Gokhale (2019)	Goa, India	To assess nutritional status and intelligence quotient of children from fisherman community.	100 fishermen's children aged 4-6 years, 53 boys and 47 girls	Anthropometry, 24-hours recall, The Draw-a-Person test.	-The mean IQ score among the children was (105.5± 11.6) under the moderate average IQ category	-Positive correlation with occupation and education of father, anthropometry of the children, height, and MUAC. -Increased consumption of soybean and fish correlated with better anthropometric measurements and higher IQ scores
Tai & Ali (2018)	Kuala Nerus & Kuala Terengganu,	To determine the relationship between breakfast	30 children	Dietary recall, Raven's Coloured Progressive Matrices (CPM).	-Grade V (intellectually impaired): 67%	-There is no correlation between breakfast consumption (energy

	Terengganu	consumption and cognitive performance among fishermen's children aged 7 to 12 years old in Terengganu, Malaysia.			-Grade IV (below average): 27%	intake, selected macro-, and micronutrients) and cognitive performance.
Kim & Kang (2017)	Seoul, Korea	To explore dietary intake and cognitive function in healthy Korean children and adolescents	317 healthy children and adolescents	Anthropometry, food frequency questionnaire, cognitive function tests; CNSVS and vCPT	-Cognitive functions are closely related to healthy food consumption	-Vitamins b1, b6, and c, rice with mixed grains, and mushrooms are positively correlated with better cognitive function in contrast to processed carbohydrates (white rice, noodles, fast foods) and coca cola
Haile et al. (2016)	Goba Town, Ethiopia	To ascertain the relationship between students' academic achievement and their nutritional state and cognitive functioning in Goba Town, southeast Ethiopia.	131 school-age students from primary schools	Sociodemographic, anthropometry, 24h dietary recall, Kaufman assessment battery for children, Raven's Coloured Progressive Matrices.	-No value for the cognitive score was provided	-Weight for age z-score is positively associated with cognitive and school performance -All cognitive scores positively correlated with the mathematic score
Asawa et al. (2014)	Kutch, Gujarat, India	To assess the intelligence quotient of fisherman schoolchildren of Kutch,	304 fishermen's schoolchildren	Sociodemographic, anthropometry, Seguin form board, SFB	-Evident indicates low IQ among schoolchildren in fishermen	-Low SES -Low education level of parents -High body mass index

		Gujarat, India			community in Kutch	
Nasir et al. (2012)	Peninsular Malaysia	To ascertain the association between pre-schoolers in peninsular Malaysia aged 4-6 years old's cognitive performance and child feeding practises, food habits, and anthropometric indicators	1933 pre-schoolers aged 4-6 years old in peninsular Malaysia based on the department of statistics Malaysia, 2000	Sociodemographic, anthropometry, parent's nutrition knowledge, child feeding practices, food habits, Raven's Coloured Progressive Matrices (CPM).	-Mean cognitive score is 103.5 (SD=14.4), which is average. -Height-for-age and consumption of dinner were found to contribute significantly toward cognitive performance	-Ht for age, consumption of diners, and both short- and long-term nutritional status contribute positively to the performance

wt. = weight, ht. = height, SES = socioeconomic status, MUAC = Mid-Upper Arm Circumference

2.2.3 Dietary intakes

Proper nutrition is essential for children to enhance their growth and development in terms of physical, cognitive, and psychosocial. Childhood malnutrition can negatively affect physical and mental health development, and these impacts may last until adolescence or adulthood if no nutritional intervention is taken. Due to the low-income level of fishermen and the seasonality of fishing activities, fishermen's children are considered a vulnerable group that has high susceptibility towards food insecurity and malnutrition. The results were focused on the dietary intake and nutritional status among the targeted population, the relationship between dietary intake and socioeconomic status, the relationship between dietary intake and nutritional status, as well as the relationship between dietary intake, nutritional status, and cognitive development.

Dietary intakes of the fishermen's children have been investigated in this review. There are a total of six reviewed articles that mention dietary intake. The dietary intakes were documented into three different categories, which are energy, macronutrient, and micronutrient intakes. Micronutrients that are included in this review are calcium, niacin, iron, vitamin A, and vitamin C.

The energy intake of fishermen's children was examined in three studies (Hwee Shan et al., 2018; Foo et al., 2006; Hanazaki & Begossi, 2003). From those studies, it is demonstrated that the energy intake of these children was significantly lower than the recommended levels. The reduced total energy intake of the fishermen's children could be due to poor access to food. A study by Baker-French (2013) reported a high rate of household food insecurity among fishing communities in Bolivia's Northern Amazon, which was highly correlated with the socio-economic status of the fishermen's households. The amount of money spent to purchase food is dependent on the amount of the fishermen's household income (Moshy et al., 2013). Low-income level of fishermen constrained their purchasing power and decreased their household accessibility to healthy and nutritious food, which eventually resulted in inadequate energy intake among their children. Additionally, some households reduce the amount of food cooked for meals and cook whatever food is available at home as a coping strategy in the food insecurity situation (Nik Mohd Sanusi et al., 2018).

Three studies recorded a low level of carbohydrate consumption among the fishermen's children (Hwee Shan et al., 2018; Foo et al., 2006; Hanazaki & Begossi, 2003). Two studies reported that fat intake among fishermen children was lower than the recommendation (Foo et al., 2006; Shan et al., 2018). Unlike the other macronutrients, the protein intake of the fishermen's children was found to be significantly higher than the recommended levels in three reviewed studies (Hwee Shan et al., 2018; Foo et al., 2006; Hanazaki & Begossi, 2003). This is due to the high consumption of fish and seafood that are more accessible among the fishing community compared to other high protein sources such as milk products and red meat (Foo et al., 2006). This was further supported by the sufficient intake of niacin among the children, as niacin is a micronutrient that is found abundantly in fish and shellfish (Hanazaki & Begossi, 2003). Besides that, Bandoh and Kenu (2017) mention in their study that the children in Ghana have their protein requirement met by their diet, which consists mainly of fish. Additionally, a study by Gibson et al. (2020) recorded high consumption of fish, especially among children. This shows that protein intake among the fishermen's children is highly adequate.

Six reviewed articles mention various micronutrient intake, which included calcium, niacin, iron, vitamin A, and vitamin C. Three reviewed articles mention that the calcium intake among fishermen’s children was found to be lower than the recommended level (Hwee Shan et al., 2018; Foo et al., 2006; Hanazaki & Begossi, 2003). Calcium is one of the major minerals in the human body, which is responsible for proper bone mineralization, which includes the formation and maintenance of the body's skeleton structure and rigidity. A study by Foo et al. (2006) mentions that only a few people prefer or can afford to take milk or other dairy products, which have high calcium content. This can be supported by a study by Hwee Shan et al. (2018), where they stated that the low accessibility of milk products among the poor might be the cause of low milk and dairy product intake among the fishermen’s children. Moreover, the rise in the price of food and non-alcoholic beverages over the past several years has denied access of low-income groups to milk and dairy products and subsequently deprived poor children of the essential nutrients in milk (Hwee Shan et al., 2018). Two reviewed studies show that there is a high-level intake of niacin intake among fishermen’s children (Foo et al., 2006; Hanazaki & Begossi, 2003). Niacin intake is closely related to the consumption of fish and seafood. Foo et al. (2006) mention that fishing communities are more accessible to fish and seafood. Furthermore, Hanazaki and Begossi (2003) stated in their study that niacin is a micronutrient that is found abundantly in fish and shellfish.

Next, there are three reviewed studies examining the intake of iron in fishermen’s children (Hwee Shan et al., 2018; Foo et al., 2006; Hanazaki & Begossi, 2003). Foo et al. (2006) found a significantly low level of iron intake compared to the recommended daily dietary iron intake among adolescents in a fishing community. However, two studies by Hanazaki & Begossi (2003) and Hwee Shan et al. (2018) reported a high iron intake among fishermen households. This claim can be supported by a study by Bandoh and Kenu (2017), where they mention that seafood is a good source of iron; a high percentage of children in Ghana consuming flesh food, especially fish and other kinds of seafood, are likely to increase their stores of iron. Different locations and ethnicity in these studies may influence the level of iron that is needed in their daily life.

There are six reviewed studies mentioning the intake of vitamin A (Badoh & Kenu, 2017; Baker-French, 2013; Hwee Shan et al., 2018; Foo et al., 2006; Gibson et al., 2020; Hanazaki & Begossi, 2003). Four of the reviewed studies reported that there is low vitamin A intake (Badoh & Kenu, 2017; Baker-French, 2013; Gibson et al., 2020; Hanazaki & Begossi, 2003). However, two studies by Foo et al. (2006) and Hwee Shan et al. (2018). found a significantly higher vitamin A intake among adolescents in the fishing community compared to the recommendation. Based on a study by Hwee Shan et al. (2018), some of the sources of vitamin A are carrots, chicken eggs, chicken, sweet potatoes, and Indian Mackerel (Ikan Kembung). Foo et al. (2006) reported that the year-round consumption of raw local fruits and vegetables and tuber products might contribute to the high-level intake of vitamin A among adolescents in a fishing community in Malaysia. In contrast, Baker-French (2013) mentions that more than one-quarter of respondents did not consume any vegetables or vitamin A-rich fruits or vegetables in the specified period. It is also supported by Bandoh and Kenu (2017), which mention that the daily consumption of Vitamin A rich foods from both plant and animal sources daily was very low (10%) among children, whereas the daily consumption of fruits and vegetables was generally low; vitamin A rich fruits and vegetables - 11% (27 of 250), other fruits and vegetables- 31% (79 of 250), respectively. In addition to that, Gibson et al.23 found that there is low consumption of vitamin A-rich fruit and vegetables.

Vitamin C intake among the fishermen's children was examined in three studies (Hwee Shan et al., 2018; Foo et al., 2006; Hanazaki & Begossi, 2003). An older study reported low vitamin C intake among children from fishermen households in Brazil (Hanazaki & Begossi, 2003). On the other hand, Foo et al. (2006) and Hwee Shan et al. (2018) discovered that there is a higher vitamin C intake than recommended level among adolescents in the fishing community in Malaysia. Additional to that, there is an adequate intake of vitamin C, probably due to year-round consumption of raw local fruits and vegetables and tuber products (Foo et al., 2006). It can be said that different study regions, dietary patterns, and preferences of the communities could lead to differences in vitamin intake.

2.2.4 Nutritional status

Nutritional status of the fishermen's children was examined in seven studies from countries in Southeast Asia, India, South America, Mexico, and East Africa (Baker-French, 2013; Capanzana et al., 2018; Foo et al., 2006; Gibson et al., 2020; Khor & Tee, 1997; Moshy et al., 2013; Murillo-Castillo et al., 2020). Six out of seven studies recorded underweight among the fishermen's children ranged from 14.35% to 60% (Baker-French, 2013; Capanzana et al., 2018; Foo et al., 2006; Gibson et al., 2020; Khor & Tee, 1997; Moshy et al., 2013). As mentioned in a previous study by Foo et al. (2006), the overall nutritional problem is a low dietary intake, generally leading to thinness in rapidly growing children. Morshy et al. (2013) mention that reduced fish catches, low household income, and decreased food security were among the major causes of high levels of undernutrition among the children in fishing communities. This can be supported by Khor and Tee (1997), whom they mention there is a high prevalence of poverty among the fishing communities.

A study by Foo et al. (2006) shows that there is also a prevalence of overweight among fishermen's children in Malaysia. The results of the study showed that the prevalence of overweight among children did not exceed 10%. Foo et al. (2006) mention that there is less concern for overweight as the proportion of those at risk of being overweight is still small. However, two studies found that about half of the subjects are overweight and obese (Asawa et al., 2014; Murillo-Castillo et al., 2020). Murillo-Castillo et al. (2020) mention that 81.5% of school children regularly consume sweetened beverages, 61.9% of snacks, sweets, and desserts, and 53.4% of sweet cereals, which probably contributes to being overweight and obese. This can be supported by Gibson et al. (2020), who mention that there is high consumption of sweet and savoury snacks among children. This shows that the quality of dietary intake is also important in preventing malnutrition among children.

2.2.5 Cognitive performance and factors influence.

There are three reviewed studies recorded an average cognitive score (Nasir et al., 2012; Nurliyana et al., 2020; Sathe & Gokhale, 2019), while there is one study that shows that children have above-average non-verbal IQ (Poh et al., 2019). Studies by Nasir et al. (2012) and Nurliyana et al. (2020) found that the mean cognitive score among children in Peninsular Malaysia is within average; 103.5 (SD=14.4) and 94.54 (SD=12.00), respectively. A study conducted by Sathe and Gokhale (2019) also showed an average IQ score among fishermen’s children in Goa, India, with a mean score of 105.5 (SD=11.6). Poh et al. (2019) found that 35% of the children have above-average non-verbal IQ with a score between 110-119. In contrast, there are three studies that show low cognitive performance (Asawa et al., 2014; Tai & Ali, 2018; Chin et al., 2020). A study by Asawa et al. (2014) found that there was a low IQ index among schoolchildren in the fishermen community in Kutch, India. Tai & Ali (2018) found that 67% of the respondents recorded grade V (intellectually impaired), and 27% of the respondents recorded grade IV (below average). A study by Chin et al. (2020) found that 70% had poor cognitive performance. According to Haile et al. (2016), there was a statistically significant positive correlation between cognitive scores and average academic performance, although no value for the cognitive score was provided. A broader perspective has been adopted by Demetriou et al. (2020), who argue that performance varied as a function of tasks or cognitive functions difficulty level. This varied result of cognitive performances is influenced by many factors such as dietary intake, nutritional status, socioeconomic status, and also parents’ education.

There are four studies that mentioned the relationship between dietary intake and cognitive performance (Chin et al., 2020; Kim & Kang, 2017; Sathe & Gokhale, 2019; Tai & Ali, 2018). Based on the study by Sathe and Gokhale (2019), there are positive correlations between iron, zinc, vitamin B12, and folic acid with performance. In addition to that, Kim & Kang (2017) mention that vitamins B1, B6, and C are positively correlated with better cognitive function. This can also be supported by Chin et al. (2020), whom they found that there is an association between zinc adequacy and cognitive performance. Zinc plays a role in the central nervous system as a neurosecretory and cofactor (Chin et al., 2020). Thus, it can cause a developmental and intellectual delay due to its deficiency and can have a negative effect on IQ (Sathe & Gokhale, 2019). Contrary to the finding above, there are two reviewed studies that stated there is no correlation between certain diet adequacy and cognitive performance (Chin et al., 2020; Tai & Ali, 2018). Tai and Ali (2018) stated that there is no correlation between breakfast consumption (energy intake, selected macro- and micronutrients) and cognitive performance. This can be supported by a study by Chin et al. (2020), where they found that there is no association between energy, iron, and vitamin B12 and cognitive performance. This is due to there being adequate intake of energy, iron, and vitamin B12 among the children, but most are categorized in the borderline category for their cognitive performance (Chin et al., 2020).

Seven of the reviewed studies show there are positive relationships between nutritional status and cognitive development (Asawa et al., 2014; Haile et al., 2016; Kim & Kang, 2017; Nasir et al., 2012; Nurliyana et al., 2020; Poh et al., 2019; Sathe & Gokhale, 2019). A study by Nasir et al. (2012) mentions that height-for-age and consumption of dinner were found to contribute significantly to cognitive performance. In the same study, they found that children with either underweight or overweight/obese had lower academic scores compared to children with normal weight28. This can be supported by Haile et al. (2016), who discovered that weight-for-age z-score is positively associated with cognitive and school performance, especially among stunted children who have impaired behavioural development in early life and have poorer cognitive ability than non-stunted children. Additionally, a study from Nurliyana et al. (2020) also mentions that stunting can affect cognitive performance. Their study found that stunted infants experienced delayed motor development which particularly inhibits their exploration and learning process from their surroundings which leads to poor cognitive performance (Nurliyana et al., 2020). Aside from stunting/underweight, overweight/obese can also affect cognitive development (Asawa et al., 2014; Kim & Kang, 2017; Poh et al., 2019). Asawa et al. (2014) mention in their study that an overweight or high BMI leads to low cognitive performance. In addition to that, a study by Poh et al. (2019) found that children with severe obesity are more likely to have poor non-verbal IQ. Obesity can harm the brain and compromise performance on intelligence tests (Asawa et al., 2014). Children with severe obesity may intensify the adverse effect of adiposity where higher adipose tissues can result in higher adipokines production, including leptin, thus increasing insulin resistance and therefore promotes hyperinsulinemia, dyslipidemia, inflammation, and endothelial dysfunction (Poh et al., 2019). Hypertriglyceridemia (one of the dyslipidemias) will result in elevated peripheral leptin levels, which prevent the entry of leptin to the brain, thus harming brain development and, consequently, lowering cognitive performance (Poh et al., 2019). This can be supported by a study by Kim and Kang (2017), which mentions that the consumption of fast foods may diminish cognitive performance.

Socioeconomic status (SES) is one of the concerns among the fishing community due to low and unstable income. Thus, there are six reviewed studies that show the relationship between SES, dietary intake, and children's cognitive performance (Asawa et al., 2014; Chin et al., 2020; Demetriou et al., 2020; Haile et al., 2016; Nasir et al., 2012; Poh et al., 2019). Three reviewed studies have reported that low SES can have an impact on children's cognitive development (Asawa et al., 2014; Demetriou et al., 2020; Poh et al., 2019). This can be supported by a study by Nasir et al. (2012), where they mention that socioeconomically disadvantaged children and food habits, consumption of dinner of less than five a week, influence low cognitive scores and height and weight associated with performance. Besides that, household financial constraints have been associated with such conditions as limited access to cognitively stimulating materials and limited preschool experiences for children (Poh et al., 2019). Thus, have lesser opportunities to learn and fewer chances to expose themselves to cognitively challenging tasks causing a lack of cognitive stimulation (Chin et al., 2020). Furthermore, one reviewed study found that a higher wealth index is associated with better mathematics scores in school-age children (Haile et al., 2016).

Aside from SES, parents' education also reflected the cognitive performance among the children. There are two reviewed studies that show the relationship between parents' education and cognitive performance (Sathe & Gokhale, 2019; Poh et al., 2019). A positive association was found between the education of fathers and the IQ levels of children (Sathe & Gokhale, 2019). Poh et al. (2019) mention that a higher proportion of children whose parents had tertiary education were categorized as having superior non-verbal IQ. Parents with higher education may be more willing to invest time and money in caring for their children (Dotti Sani & Treas, 2016). In addition, parents with higher education usually have higher health literacy and engage in quality interactions more frequently with their children, as compared to parents with lower education (Poh et al., 2019).

This shows the correlation between nutritional status, dietary intake, and cognitive development. Certain essential nutrients are needed to help the development of the children's cognition. Lacking a certain nutrient due to socioeconomic status may contribute to poor cognitive performance among the fishermen’s children.

2.2.6 Discussion and conclusion

Based on the work undertaken in this study, opportunities for future research should include an assessment of the nutritional status and dietary intake of fishermen children in their middle childhood. Future research should also concentrate on the investigation of the implications of the nutrients which have low levels of intake among the fishermen’s children. It is suggested to conduct a longitudinal study on the diet and lifestyles pattern of children from fishing communities to examine their nutritional status more closely. Besides, future research might study the fishermen’s children's status of more micronutrients which are crucial for growth and development during childhood, such as vitamin D, zinc, iodine, and folate. Other possible areas of future research would be to investigate the differences in diet and lifestyle of the fishermen’s children during monsoon and non-monsoon periods and its effects on their nutritional status. The effects of heavy metal pollutants and their effects on the health status and cognitive performance of the children also need to consider, as seafood is susceptible to contaminants, especially mercury. These studies can then be combined with socio-demographic data to assess the economic status and education level of the fishermen’s community in Malaysia. Further correlations between the nutritional and socio-economic status of fishermen’s community with cognitive test scores to investigate factors contributing to such resulted performance hence determining the precise intervention necessary to improve nutritional, socio-economic status, and school performance.

In conclusion, most of the studies indicated that poor socioeconomic status, nutritional status, and cognitive performance applied to children and adolescents in children in general and particularly fishing communities, even though they are in different regions. Poor socioeconomic status can lead to food insecurity which can result in certain insufficient nutrients that are needed for children’s development, specifically their cognitive development. The findings of the reviewed studies indicate the need for nutrition education and economic intervention among this vulnerable group. Government and health-related authorities should implement the action plan and perhaps invite the involvement of NGOs and other third parties to introduce various types of interventions to recommend and increase consumption of vegetables, fruit, and dairy products among children fishing communities while ensuring a method to generate income throughout the year without having to be fully dependent on sea procurements. It also suggests that public forums, nutrition education programs, and motivational programs be organized in schools as well as in the fishing community, with a view to creating awareness among fishermen's parents about the value of financial security and good quality diets for their children and their impact on the learning process of their children.

2.3 Physical activity among children and its relationship with cognitive performance

Physical activity is any movement of a body component caused by skeletal muscles that consumes energy. This includes activity or action when working, playing, doing duties around the house, travelling, and indulging in recreational activities (Global Strategy on Diet, Physical Activity and Health, 2019). Physical activity has several known advantages for overall health. Physical activity at the right intensity levels benefits the cardiovascular system and bone quality in children and adolescents, as well as helping with weight management and reducing depressive symptoms. Conversely, inactivity causes an energy imbalance that can increase the risk of becoming overweight or obese and developing risk factors for cardiovascular diseases (Kantanista et al., 2021).

According to the 2018 Japan Report Card, children and youth in Japan participate in organised sports at acceptable rates, use active transportation to get to and from school, maintain healthy weights, and spend a reasonable amount of time watching recreational screens (Tanaka et al., 2019). This shows that their children and youth are relatively active. However, it is different from South Korea. Based on South Korea's 2018 Report Card, it is reported that they have poor performance in overall physical activity and physical fitness (Oh et al., 2019). Besides that, Kantanista et al. (2021) study also reported a low level of physical activity among children. For moderate-to-vigorous physical activity, only 7.5% to 69.4% of children and adolescents met the recommendations, while only 33.6% to 64.5% met the vigorous physical activity recommendations. In Malaysia, a few studies also reported that there is low physical activity among children (Dan et al., 2011; Mohd Fakree et al., 2020; Sharif et al., 2016). According to research by Dan et al. (2011), 3.0% of children fell into the high physical activity level group, 61.5% of respondents fell into the moderate category, and 33.0% of respondents fell into the low physical activity level category. Additionally, according to Mohd Fakree et al. (2020), only 50% of preschoolers engaged in adequate amounts of physical exercise. According to Sharif et al. (2016), most Malaysian adolescents and children commute actively and engage in low levels of PA.

Based on the studies above, we can see that low physical activity among children is a big concern not just in Malaysia but other countries also. This is an exception to Japan as it is recorded that their children and youth are relatively active based on their report cards (Tanaka et al., 2019). However, there is a lack of data on overall physical activity and physical fitness. On the other side, most studies on physical activity have only been carried out among children. Previous studies have not dealt with physical activity among fishermen’s children. Thus, we can see that there is a study gap regarding this topic.

Based on Table 2.4, there are a few factors that are relatively associated with physical activity. According to a study by Pate et al. (2018), parental support for physical activity, child sport participation, parent reports of the child's physical activity level, time spent outdoors by the child, community social spaces for physical activities, and the number of physical activity facilities close to the child's home are all relatively associated with children's physical activity. The author also highlights the need of starting early in infancy to increase children's physical exercise. This is in line with Dan et al. (2011), who state that peer influence, sex, and physical activity self-efficacy are three areas that have been associated to physical activity. Furthermore, Wong et al. (2016) state that ethnicity, age group, and sex do have an impact on physical activity. Chinese children were found to be the least active of all the ethnic groups, with girls usually being less active than boys and older children being less active than their younger counterparts (Wong et al., 2016). As a result, we can see that a child's physical activity can be influenced by a variety of variables, including both the child's individual factors and environmental influences.

Table 2.4: Selected studies on physical activity and cognitive performance among children.

Study	Location	Subjects	Findings
Kantanista et al. (2021)	Czech Republic, Hungary, Poland, and Slovakia	Children and adolescents aged 5–18 years	7.5% to 69.4% met moderate-to-vigorous physical activity recommendations. 33.6% to 64.5% met vigorous physical activity recommendations. Between 11.6% and 69.0% of daily recommendations for the number of steps done were met.
Mohd Fakree et al. (2020)	Sarawak	227 children aged 4 to 6 years	Children of Malay ethnicity with unemployed moms, high safety and crime scores, and walkable environments in the surrounding areas had greater proportions of physically active kids. Only fifty percent of the pre-schoolers engaged sufficient physical activity.
Tanaka et al. (2019)	Japan	-	Japanese adolescents and children participate in organised sports at favourable rates, commute to and from school by active means, maintain healthy weights, and moderate levels of recreational screen time.
Oh et al. (2019)	South Korea	-	Poor performance on overall physical activity and physical fitness.
Pate et al. (2018)	South Carolina	1080 children (501 boys and 579 girls)	The parent's encouragement of physical activity, the parent's support of physical activity, the child's participation in sports, the parent's report of the child's level of physical activity, the child's time spent outdoors, social spaces for physical activities in the community, and the number of physical activity facilities

			close to the child's home are all domains that are relatively associated with physical activity. Increasing children's physical activity should begin early in childhood.
Wong et al. (2016)	Malaysia	1702 children aged 7 to 12 years	Malaysian primary school children's overall physical activity and domains of physical activity range significantly by gender, age group, and ethnicity. Girls were generally less active than boys, older children were less active than their younger counterparts, and Chinese children were found to be the least active.
Sharif et al. (2016)	Malaysia	Children and adolescents aged 5-7 years old	Most Malaysian children and adolescents engage in low levels of PA and active commuting, high amounts of screen time, and very little of the recommended daily consumption of fruits and vegetables.
Dan et al. (2011)	Kuantan	400 children aged 13-year-old	Only 3.0% of the adolescents fell into the high physical activity level group, with one-third of responses falling into the low category and 61.5% into the moderate category. The three main factors that contributed most to determining adolescent physical activity were self-efficacy, sex, and peer pressure.
Mandolesi, et al., (2018)	-	-	Physical activity affects brains plasticity, influencing cognition and wellbeing. Acute aerobic exercise, which is characterised as a single bout of physical activity, is associated with enhanced cognitive abilities, particularly those depending on the prefrontal cortex.
Bai et al. (2021)	Perth, Australia	56 children aged 3-5 years old	Total physical activity was positively and significantly associated with cognitive school readiness. Moderate-vigorous physical activity (MVPA) was positively and significantly

	associated with cognitive school readiness scores.

When it comes to relationships with cognitive performance, two studies have found relationships between physical activity and improved cognitive performance. According to research by Mandolesi et al. (2018), exercise changes brain plasticity, affecting cognition and wellbeing. The study also notes that acute aerobic exercise, which is defined as a single bout of exercise, is associated with enhanced cognitive functioning, particularly prefrontal cortex-dependent cognition. Total physical activity was also shown to be favourably and substantially related to cognitive school readiness, according to research by Bai et al. (2021). Aside from total physical activity, moderate-vigorous physical activity (MVPA) was also positively and strongly correlated with cognitive school readiness scores.

A possible explanation of the positive relationships between physical activity and cognitive performance is physical activity improves circulation, which improves the brain's ability to receive oxygen and nutrients (Bidzan-Bluma & Lipowska, 2018; Makarowski et al., 2009; Strzalkowska et al., 2005). All systems—the neurological, hormonal, cardiovascular, pulmonary, hormonal, and immune systems—benefit from physical activity (Bidzan-Bluma & Lipowska, 2018). As a result, it promotes the maturation of the brain's motor regions, which impacts the development of motor skills and quickens the conduction of nerve impulses (Alesi et al., 2016; Jassen & Leblanc, 2010; Van der Fels et al., 2015). Physical activity also encourages the release of more neurohormonal secretions, which have a substantial influence on the excitability of synapses-forming neurons (Bidzan-Bluma & Lipowska, 2018; Hollmann & Struder, 2000). This shows that physical activity does influence cognitive development among children.

2.4 Effects of physical activity and micronutrients on cognitive performance in children aged 6 to 11 years: a systematic review and meta-analysis of randomized controlled trials[2]

This review and meta-analysis assessed the effect of physical activity and any micronutrients, alongside the extent of their impact on cognitive performance. This review closely investigated the effects of a range of micronutrients, focusing on how they influence cognition, in addition to the specific duration and method of conducting the intervention. We envisage our findings will aid in the continuation of the studies and strengthen the evidence for the link between the two variables.

2.4.1 Eligibility criteria

The formulation of research questions for this study was based on the four main concepts of PICO, specifically Patient/Population, Intervention, Comparison/Control, and Outcome. PICO is a tool that assists authors in developing a suitable research question for review articles. Based on these concepts, the authors have included four main aspects in the meta-analysis, namely children aged 6–11 years (Population), physical activity and micronutrient intake (Intervention), placebo (Comparison), and cognitive performance (Outcome). Studies were considered eligible if they targeted children between the ages of 6 and 11 who did not have any chronic medical condition, mental illness, or disability. Participants who received any sort of micronutrient supplementation during pregnancy, infancy, or toddlerhood were excluded from this study. The authors evaluated data from randomized controlled trials (RCTs) that examined the impact of physical activity or micronutrients on cognitive performance. The primary and/or secondary results of the RCTs with reporting of at least one of the following cognitive indicators: cognitive performance, academic performance, or intelligence quotient (IQ) were selected. Other types of publications, such as review articles, books, book chapters, and conference proceedings, were eliminated due to their status as secondary sources. The language was the third factor for inclusion and exclusion. Only full-text papers published in the English language were included in

[2] This part has been published in Medicina, 58(1): 57-75 (2022)- WOS Q2 – (Appendix G)

the study. To minimize misunderstanding and difficulties during the translation process for this review, all non-English language documents were eliminated. Publication years between 2012 and 2021 were chosen to ensure sufficient articles to conduct this review, in accordance with Kraus and colleagues' definition of 'research field maturity' (Kraus et al., 2020). Additionally, this review used a ten-year time span since it yielded enough publications for consideration in the review.

2.4.2 Search strategy

The present study was drafted according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) 2020 statement (Page et al., 2021). The protocol for this systematic review and meta-analysis was registered on Open Science Framework (OSF) (registration DOI:10.17605/OSF.IO/EZ8VB). The electronic databases—PubMed (National Library of Medicine and National Institutes of Health of the United States of America) and Scopus® (Elsevier B.V.)—were searched based on the eligibility criteria set. The search strategies combined multiple keyword search terms using Boolean operators. As an illustration, the main keywords used were 'physical activity' (keyword 1), 'micronutrient' (keyword 2), 'cognitive performance' (keyword 3), and 'children' (keyword 4). The search method was divided into the following two clusters in addressing two research questions: cluster 1 contained keywords 1 AND 3 AND 4; cluster 2 contained keywords 2 AND 3 AND 4. Physical activity was the primary search phrase (keyword 1), followed by 'physical activity' OR 'exercise' OR 'sport'. The key search terms for micronutrient (keyword 2) were 'vitamin' OR 'micronutrient' OR 'trace element' OR 'minerals' OR 'iodine' OR 'zinc' OR 'iron' OR 'vitamin B12' OR 'niacin' OR 'vitamin B3' OR 'vitamin D' OR 'folic acid' OR 'folate' OR 'vitamin D' OR 'vitamin D' OR 'vitamin C' OR 'vitamin B1' OR 'vitamin B6' OR 'thiamine' OR 'vitamin B9'. The key search terms for cognitive performance (keyword 3) were 'cognitive performance' OR 'intelligence quotient' OR 'academic performance' OR 'academic achievement'. 'Children' OR 'school children' OR 'school-aged children' were the primary search keywords for children (keyword 4). All article screening was conducted in- dependently by two reviewers—A.M.M and A.A. The authors of the publications included in this systematic review were contacted for any missing data. If no response was received, these studies were excluded because they could not be fully assessed for eligibility.

2.4.3 Data management and extraction

Mendeley Desktop v1.19.8 (Elsevier, London, UK) was used to import all studies, and duplicates were eliminated using the ‘remove duplicate’ feature. The remaining publications’ titles and abstracts were filtered using the eligibility criteria. The full-text articles were assessed for eligibility, irrelevant publications were eliminated, and quantitative analyses were conducted on studies that fulfilled the inclusion criteria. The characteristics of interventions were extracted, including study overview, location of the study, participant, study design, duration of the study, type of intervention, types of micronutrients, and cognitive performance score (attention, Mathematics, English, Geography, Science and Arts).

2.4.4 Data quality and analysis

The Jadad Score for RCTs was used to assess the risk of bias and quality in each study. The score was calculated based on randomization, double-blinding, dropout, and withdrawals from trials (Jadad et al., 1996). The maximum possible score was five, which implies a minimal likelihood of reporting bias, whereas a score of under three was considered a high risk of bias.

The meta-analysis was conducted using random-, fixed- or pooled-effects models with 95% confidence intervals (95% CI). For each kind of cognitive performance, mean intergroup differences were determined by comparing intervention group values to baseline values. Because there were several measurements for evaluating cognitive performance, the most used measurement in the selected studies was chosen. Hence, attention performance and academic subject scores (for Mathematics, English, Geography, Science, and Arts) were chosen to measure the children’s cognitive performance. The same concept applies to the type of micronutrients. Only micronutrients with sufficient data were chosen from the selected studies. As a result, this review article focused on vitamin B12, zinc, and iron. Other micronutrients such as iodine, folate, niacin, and thiamine were not included in the present meta-analysis owing to a lack of evidence, i.e., results from the RCT trials.

The effect size (Cohen's d) was calculated using an online calculator based on the mean differences and standard deviation (SD) for each cognitive performance (intervention and control groups). The effect size between groups was considered small (0.2), medium (0.5), and large (0.8). The standard error of the mean (SE) was computed for each outcome measure using the formula SE = es/(es*n), where 'es' denotes the effect size. Cochran's Q and I^2 were computed automatically using Microsoft Excel spreadsheets (Neyeloff et al., 2012), which were modified by Ramli et al. after the effect size and SE was inserted (Ramli et al., 2021). Cochran's Q was used to validate the existence of heterogeneity in the data, and the I^2 statistic was used to quantify the amount of heterogeneity. A negative I^2 value was regarded as comparable to zero (i.e., data were homogeneous), but I^2 values of 25%, 50%, or 75% were considered to have low, medium, or high heterogeneity, respectively (Borenstein et al., 2009). The fixed-effects model was chosen for I^2 values less than 50%, whereas the random-effects model was selected for I^2 values higher than 50%. The mean effect size data were statistically pooled and shown in a forest plot for the meta-analysis.

2.4.5 Study selection

Figure 2.1 shows the PRISMA flowchart for the study selection process. Our search strategy identified a total of 7,467 relevant studies. Seven hundred and fifty-seven duplicate articles were removed, resulting in 6,710 unique publications. The titles and abstracts of these 6,710 publications were screened according to our eligibility criteria, resulting in the retention of 64 articles. The full text of these 64 articles was retrieved and assessed, resulting in 46 publications being excluded. Nine articles met our selection criteria and were included in our meta-analysis.

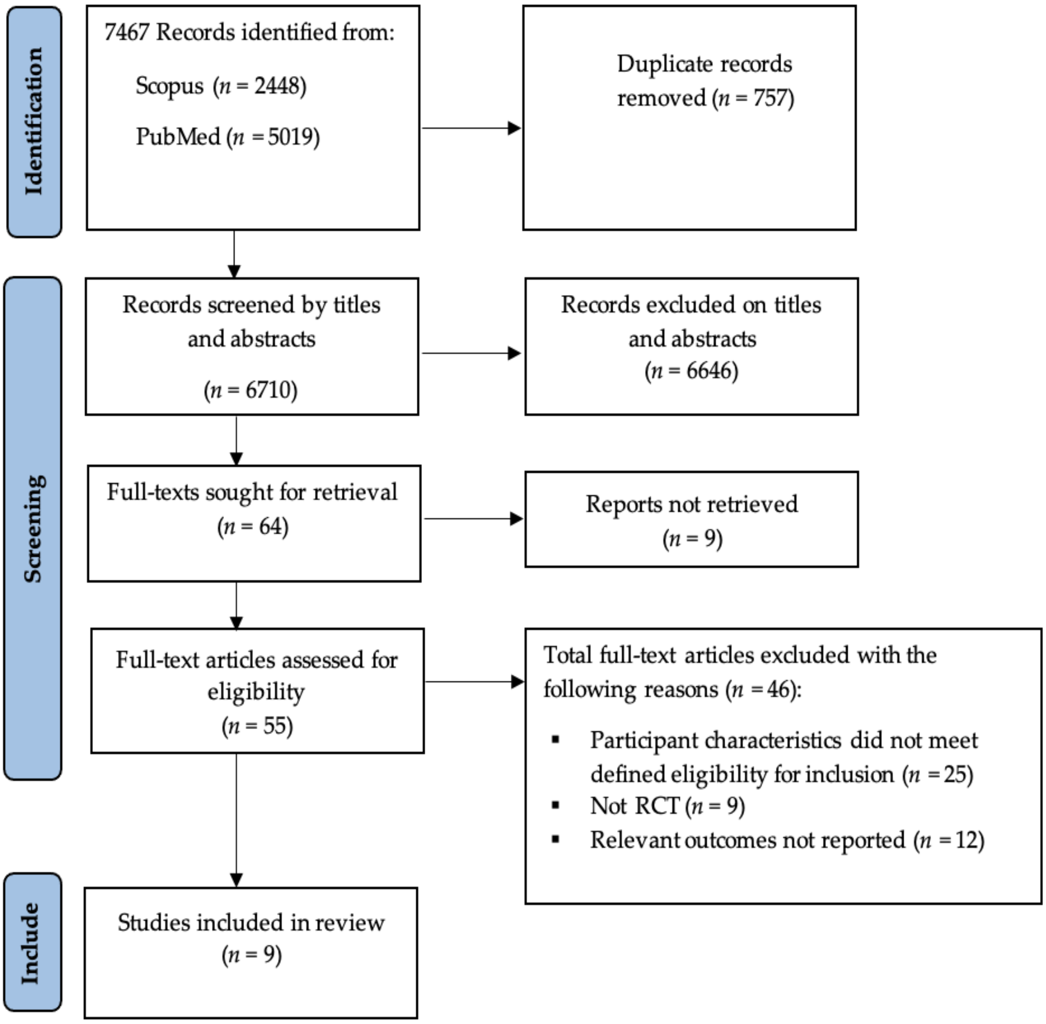

Figure 2.1: PRISMA flowchart of study selection.

2.4.6 Risk of bias based on Jadad's score.

Table 2.5 demonstrates the risks of bias in studies based on randomization, double-blinding, and dropouts in the RCTs (Jadad et al., 1996). All studies showed a low risk of bias, with a score of three or more.

Table 2.5: Summary of assessment of the risk of bias (n = 9).

Studies	Randomization (yes/no)	Appropriateness of Randomization (Detail)	Blinding (yes/no) *	Appropriateness of Blinding	An account of all Participants or Description of Withdrawal or Dropouts	Total Score
Garcia-Hermoso et al. (2019)	1	1	N/A	N/A	1	3
Mavilidi et al. (2019)	1	1	N/A	N/A	1	3
Berg et al. (2019)	1	1	N/A	N/A	1	3
Have et al. (2018)	1	1	0.5	1	1	4.5
Lind et al. (2018)	1	1	N/A	N/A	1	3
Kuriyan et al. (2016)	1	1	1	1	1	5
Janssen et al. (2014)	1	1	N/A	N/A	1	3
Hulett et al. (2014)	1	1	N/A	N/A	1	3
Ebenezer et al. (2013)	1	1	1	1	1	5

2.4.7 Study characteristics

Table 2.6 shows the selected 9 RCTs (6 articles) for the relationship between physical activity and cognitive performance. The number of participants in each trial (sample size, n) ranged from 87 to 931 participants, giving a total study population of 2139 participants included in the meta-analysis. There were two types of cognitive performance commonly measured in the RCTs—attention and Mathematics. The duration of the interventions ranged from 4 weeks to 9 months. In the present review, interventions were mostly performed within Europe, including the Netherlands, Denmark, and Amsterdam. One study was performed in Chile, and another one in Australia.

Table 2.7 shows the findings of five RCTs from three articles regarding the effectiveness of micronutrients on cognitive performance. The number of participants in each trial ranged from 227 to 1190 participants, with a total study participant of 1777. There were six types of cognitive performance commonly measured in the selected RCTs, namely attention, Mathematics, English, Geography, Science, and

Arts. The types of micronutrients included in the studies were iron, zinc, and vitamin B12.

Table 2.6: Summary of randomized controlled trials for the effectiveness of physical activity (PA) on cognitive performance.

Study	**Participant**	**Location**	**Study Design**	**Staff Implementing Intervention and Measurements (HQ or LQ)**	**Type of PA Intervention**	**Cognitive Performance***	
						Attention	**Mathematics**
Garcia-Hermoso et al. (2019)	70 children (8–10 years old)	Chile	Randomized, non-blinded, parallel design. IG: 100 CG: 70 Duration: 8 weeks	Graduates in Sport Sciences (HQ)	The Active-Start program (i.e., a program of cooperative physical games) was structured to make group cooperation essential to game success and to encourage pro-social skills.	IG = 62.48 ± 6.58 CG = 60.15 ± 7.66 *p*-value = 0.124 (effect size = 0.331)	IG = 0.02 ± 0.1 CG = 0.48 ± 0.16 $p < 0.001$ (effect size = 3.903)
Mavilidi et al. (2019)	87 children (9–10 years old)	Australia	Randomized, non-blinded, parallel design. IG_1: 29 IG_2: 29 CG: 29 Duration: 4 weeks	Classroom teacher (LQ)	IG_1: The activity breaks condition—is divided into two minutes of activity break at the beginning of the lesson and three minutes in the middle of the lesson.	N/A	IG_1 = 0.19 ± 2.55 CG = 2.14 ± 2.57 p = 0.045 (effect size = 0.762)

					IG_2: Activity breaks and Mathematics combined condition—Students performed the PA shown in the video while they answered the mathematical questions.	N/A	IG_2 = 3.11 ± 2.55 CG = 2.14 ± 2.57 *p* = 0.185 (effect size = 0.379)
Berg et al. (2019)	323 children (10–11 years old)	Netherlands	Cluster-randomized controlled trial, non-blinded, parallel design IG: 170 CG: 153 Duration: 5 weeks	Classroom teacher (LQ)	Juggling exercises—weeks 1 and 2, two balls in weeks 3 and 4, and ending with using three balls in week 5 of the program.	N/A	IG = 25.9 ± 4.8 CG = 23.3 ± 7.1 (effect size = 0.433)
Have et al. (2018)	505 children (7–8 years old)	Denmark	Cluster-Randomized, single-blinded, parallel design IG: 294 CG: 211 Duration: 9 months	Classroom teacher (LQ)	15–20 min of PA spread over an average of 6 mathematics lessons of 45 min per week	N/A	IG_1 = 1.2 ± 6.56 CG = 0 (effect size = 0.240)
Lind et al. (2018)	931 children (11 years old)	Denmark	Cluster-randomized, non-blinded, parallel design IG: 93 CG: 838 Duration: 11 weeks	Staff from the University of Southern Denmark and football coaches from the Danish Football Association (HQ)	FIFA 11 for Health for Europe—consisted of two 45-min football sessions, totaling 990 min over the 11 weeks	IG = 598.54 ± 5.54 CG = 618.19 ± 13.85 (effect size = 1.482)	N/A

Janssen et al. (2014)	123 children (10–11 years old)	Amsterdam	Randomized, non-blinded, parallel design IG_1: 108 IG_2: 111 IG_3: 89 CG: 112	Researchers (HQ)	IG_1: Passive break	IG_1 = 2.5 ± 0.71 CG = 2.9 ± 0.78 (effect size = 0.536)	N/A
					IG_2: Moderate intensity PA break	IG_2 = 2.1 ± 5.8 CG = 2.9 ± 0.78 (effect size = 0.194)	N/A
					IG_3: Vigorous-intensity PA break	IG_3 = 2.4 ± 0.62 CG = 2.9 ± 0.78 (effect size = 0.701)	N/A

* Values are the mean ± SD. Abbreviations: IG, intervention group; CG, control group; PA, physical activity; FIFA, Federation Internationale de Football Association; HQ, staff with higher professional qualifications; LQ, staff with lower professional qualifications; N/A, not available.

Table 2.7: Summary of the effectiveness of randomized controlled trials (RCTs) for micronutrients on cognitive performance.

Study	**Study Overview**	**Study Design**	**Type of Micronutrients and Doses**	**Cognitive Performance ***					
				Mathematics	**English**	**Geography**	**Science**	**Arts**	**Attention**
Hulett et al. (2014)	Subject: 360 children (7–8 years old) Country: Kenya	Cluster-randomized, non-blinded, controlled feeding intervention trial, parallel design Treatment: (1) Plain Githeri (*n* = 99) (2) Githeri + Milk (*n* = 105) (3) Githeri + Meat (*n* = 67) (4) Control (*n* = 89) Duration: two years	(1) Plain Githeri Iron = 3.93 mg Zinc = 1.68 mg	IG = 2.48 ± 1.81 CG = 3.2 ± 2.0 (effect size = 0.378)	IG = −7.51 ± 2.36 CG = −9.32 ± 2.36 (effect size = 0.765)	IG = −1.52 ± 2.36 CG = −3.88 ± 1.63 (effect size = 1.153)	IG = −6.96 ± 1.82 CG = −6.78 ± 1.82 (effect size = 0.099)	IG = 4.29 ± 1.27 CG = 3.56 ± 1.46 (effect size = 0.536)	N/A
			(2) Githeri + Milk Iron = 1.57 mg Zinc = 1.66 mg vitamin B12 = 1.04 µg	IG = 5.92 ± 1.46 CG = 3.2 ± 2.0 (effect size = 1.574)	IG = −0.97 ± 1.82 CG = −9.32 ± 2.36 (effect size = 4.005)	IG = 6.29 ± 1.27 CG = −3.88 ± 1.63 (effect size = 7.032)	IG = -0.61 ± 1.45 CG = −6.78 ± 1.82 (effect size = 3.785)	IG = 6.83 ± 1.09 CG = 3.56 ± 1.46 (effect size =	N/A

								2.569)	
			(3) Githeri + Meat Iron = 2.94 mg Zin = 2.89 mg vitamin B12 = 1.17 µg	IG = 9.37 ± 1.82 CG = 3.2 ± 2.0 (effect size = 3.205)	IG = 5.74 ± 2.18 CG = −9.32 ± 2.36 (effect size = 6.592)	IG = 6.11 ± 1.63 CG = −3.88 ± 1.63 (effect size = 6.129)	IG = −1.34 ± 1.81 CG = −6.78 ± 1.82 (effect size = 2.996)	IG = 9.19 ± 1.27 CG = 3.56 ± 1.46 (effect size = 4.074)	N/A
Kuriyan et al. (2016)	Subject: 227 children (7–10 years old) Country: India	Randomized, double-blind, placebo-controlled study, parallel design Treatment: (1) Fortified Milk (*n* = 111) (2) Control (*n* = 114) Duration: 5 months	(1) Iron = 18 mg/2 serving (2) Zinc = 1.8 mg/2 serving (3) Vitamin B12 = 1.08 mcg/2 serving	N/A	N/A	N/A	N/A	N/A	IG = 2.0 ± 0.57 CG = 1.9 ± 0.4 (effect size = 0.204)
Ebenezer et al. (2013)	Subject: 1190 (8–10 years old) Country: Sri Lanka	Prospective, placebo-controlled randomized, parallel design Treatment: (1) Iron Supplement (*n* = 615) (2) Control (*n* = 575) Duration: 6 months	Iron = 60 mg	IG = 13.9 ± 17.4 CG = 12.2 ± 16.1 (effect size = 0.101)	N/A	N/A	N/A	N/A	IG = 3.4 ± 6.1 CG = 3.0 ± 6.3 (effect size = 0.065)

*Values are the mean ± SD; Abbreviations: IG, intervention group; CG, control group; N/A, not available

2.4.8 Summary of meta-analysis

The outcomes evaluated in this meta-analysis were attention, Mathematics, English, Geography, Science, and Arts. Nine RCTs with 2139 participants were included in the meta-analysis for the effect of physical activity on cognitive performance, whereas five RCTs with 1777 participants were included in the meta-analysis for the effect of micronutrients on cognitive performance. Two studies investigated three interventions each and were considered separately in the analyses (Hullet et al., 2014; Jassen et al., 2014). Mavilidi et al. investigated two types of physical activity intervention, and data from the two groups were treated as findings from two different studies (Mavilidi et al., 2019).

2.4.9 Effect of physical activity and micronutrients on cognitive performance

Two different types of cognitive performance were measured in this analysis—Mathematics, and attention. Figure 2.2 shows the meta-analysis of the effect of physical activity on Mathematics in four studies with five trials. All five interventions showed positive effects on Mathematics (the treatment group favoured). The study by Garcia-Hermoso et al. demonstrated the largest effect size (d = 3.9, 95% CI: 3.61, 4.2), followed by Mavilidi et al. (Activity break) (d = 0.76, 95% CI: 0.54, 0.99), Berg et al. (d = 0.43, 95% CI: 0.36,0.51), Mavilidi et al. (Activity break and Mathematics) (d = 0.38, 95% CI: 0.22, 0.54) and Have et al. (d = 0.24, 95% CI: 0.2, 0.28). The data showed a high level of heterogeneity with I^2 = 99.3% and, hence, were subjected to random-effects analysis. Physical activity exhibited a large pooled-effect size on Mathematics, with d = 1.12 (95% CI: 0.56, 1.67).

Figure 2.3 shows the meta-analysis of the three studies with five trials that aimed to improve cognitive performance via physical activity interventions that were included. All five interventions exhibited positive effects on attention (treatment group favoured). Lind and co-workers' study showed the highest effect size (d = 1.48, 95% CI: 1.4, 1.56), followed by Janssen et al. (vigorous intensity PA break) (d = 0.7, 95% CI: 0.54, 0.82), Janssen et al. (passive break) (d = 0.54, 95% CI: 0.44,0.63), Garcia-Hermoso et al. (d = 0.33, 95% CI: 0.24) and Janssen et al. (moderate intensity PA break) (d = 0.19, 95% CI: 0.14, 0.25). The data showed a high level of heterogeneity with I^2 = 99.5% and, hence, were subjected to random-effects analysis. The physical activity demonstrated a medium pooled-effect size on attention, with a d value of 0.65 (95% CI: 0.15, 1.14).

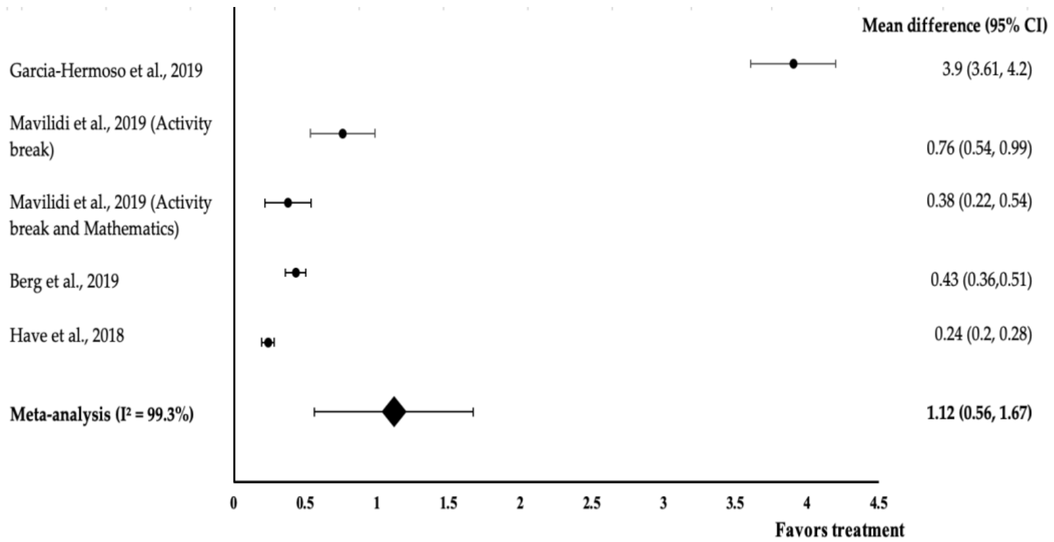

Figure 2.2: Forest plot showing the effect of physical activity on Mathematics, expressed as mean differences between the values obtained in the intervention and control groups. A positive effect size indicated that physical activity increased Mathematics performance. Horizontal lines represent 95% of CIs. Diamonds indicate the pooled-effect size from the random-effects analysis. The values ±0.2, ±0.5, and ±0.8 signify small, medium, and large effect sizes, respectively.

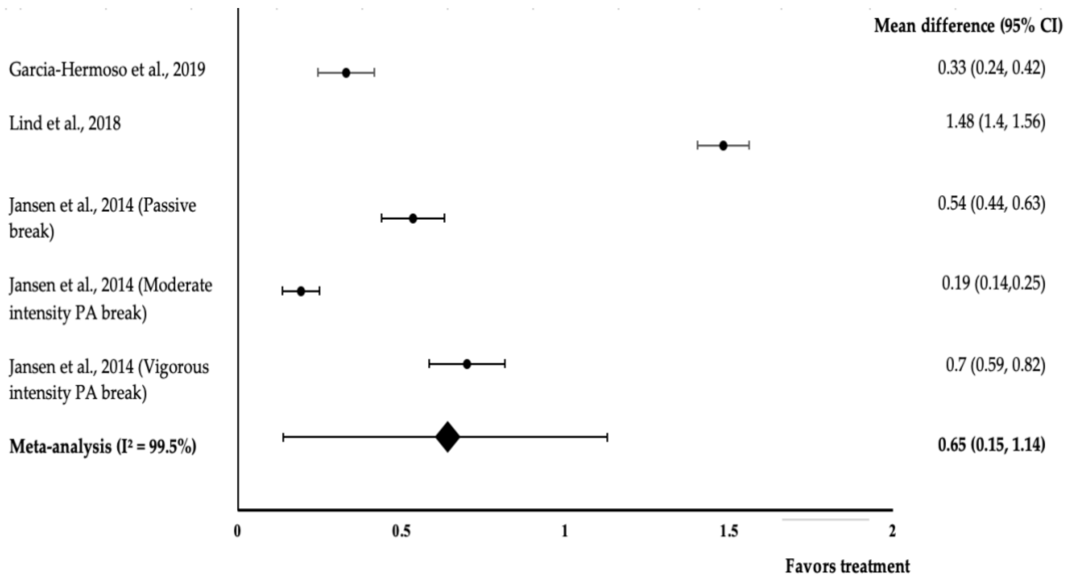

Figure 2.3: Forest plot showing the effect of physical activity on attention, expressed as mean differences between the values obtained in the intervention and control groups. A positive effect size indicated that physical activity increased attention. Horizontal lines represent 95% of CIs. Diamonds indicate the pooled-effect size from the random-effects analysis. The values ±0.2, ±0.5, and ±0.8 are illustrative of the small, medium, and large effect sizes, respectively.

Six different types of cognitive performance were measured in this analysis – Mathematics, English, Geography, Science, Arts, and attention. Three types of micronutrients were measured in the meta-analysis, namely vitamin B12, iron, and zinc. Figure 2.4 shows the meta-analysis of the impact of micronutrients on Mathematics. Two studies with four trials were included in the meta-analysis. For vitamin B12, both interventions showed a positive effect on Mathematics (the treatment group favoured). The study by Hullet et al. showed that 1.17 µg of B12 in meat Githeri had the largest effect size (d = 3.21, 95% CI: 2.92, 3.49), followed by 1.04 µg of B12 in milk Githeri (d = 1.57, 95% CI: 1.4, 1.75). The data showed a high level of heterogeneity with I^2 = 98.9% and, hence, were subjected to random-effects analysis. Vitamin B12 demonstrated a large pooled-effect size on Mathematics, with a d value of 2.39 (95% CI: 0.79, 3.98). With zinc, all three interventions showed positive effects on Mathematics (the treatment group favoured). 2.89 mg of zinc in meat Githeri provided the highest effect size (d = 3.21, 95% CI: 2.92, 3.49), followed by 1.66 mg of zinc in milk Githeri (d = 1.57, 95% CI: 1.4, 1.75) and 1.68 mg of zinc in plain Githeri (d = 0.38, 95% CI: 0.29, 0.47). The data showed a high level of heterogeneity with I^2 = 99.6% and, therefore, were subjected to random-effects analysis. Zinc showed a large pooled-effect size on Mathematics, with d = 1.17 (95% CI: −0.9, 1.99). As for iron, all four interventions exhibited a positive effect on Mathematics (the treatment group favoured). 2.94 mg of iron in meat Githeri provided the highest effect size (d = 3.21, 95% CI: 2.92, 3.49), followed by 1.57 mg of iron in milk Githeri (d = 1.57, 95% CI: 1.4, 1.75), 3.93 mg of iron in plain Githeri (d = 0.38, 95% CI: 0.29, 0.47) and Ebenezer et al. with 60 mg of iron (d = 0.1, 95% CI: 0.08, 0.12). The data showed a high level of heterogeneity with I2 = 99.6%; hence, these data were subjected to random-effects analysis. Iron demonstrated a large pooled-effect size on mathematics, with d = 1.29 (95% CI: 0.54, 2.06).

Figure 2.5 shows the meta-analysis of the effect of micronutrients on English. One study with three trials was included in the meta-analysis. As for the effect of vitamin B12, both interventions were associated with a positive effect on English (treatment group favoured). The work of Hullet et al. with 1.17 µg of B12 in meat Githeri demonstrated the highest effect size (d = 6.56, 95% CI: 6.19, 6.99), followed by 1.04 µg of B12 in milk Githeri (d = 4.0, 95% CI: 3.72, 4.29), respectively. The data showed a high level of heterogeneity with I2 = 99.1% and were, therefore, subjected to random-effects analysis. Vitamin B12 showed a large pooled-effect size on English, with d = 5.29 (95% CI: 2.76, 7.83). As for the effect of zinc, all three interventions displayed a positive effect on English (the treatment group favoured). Zinc (2.89 mg) in meat Githeri showed the highest effect size (d = 6.59, 95% CI: 6.19, 6.55), followed by 1.66 mg of zinc in milk Githeri (d = 4.0, 95% CI: 3.72, 4.29) and 1.68 mg of zinc in plain Githeri (d = 0.77, 95% CI: 0.64, 0.89). The data demonstrated a high level of heterogeneity with I^2 = 99.8%; thus, these data were subjected to random-effects analysis. Zinc was associated with large pooled-effect size on English, with d = 3.78 (95% CI: 0.44, 7.13). Regarding the effect of iron, all three interventions produced a positive effect on English (the treatment group favoured). Iron (2.94 mg) in meat Githeri showed the highest effect size (d = 6.59, 95% CI: 6.19, 6.55), followed by 1.57 mg of iron in milk Githeri (d = 4.0, 95% CI: 3.72, 4.29) and 3.93 mg of iron in plain Githeri (d = 0.77, 95% CI: 0.64, 0.89). The data demonstrated a high level of heterogeneity with I^2 = 99.6% and, therefore, were subjected to random-effects analysis. Iron showed a large pooled-effect size on English, with d = 1.29 (95% CI: 0.44, 7.13).

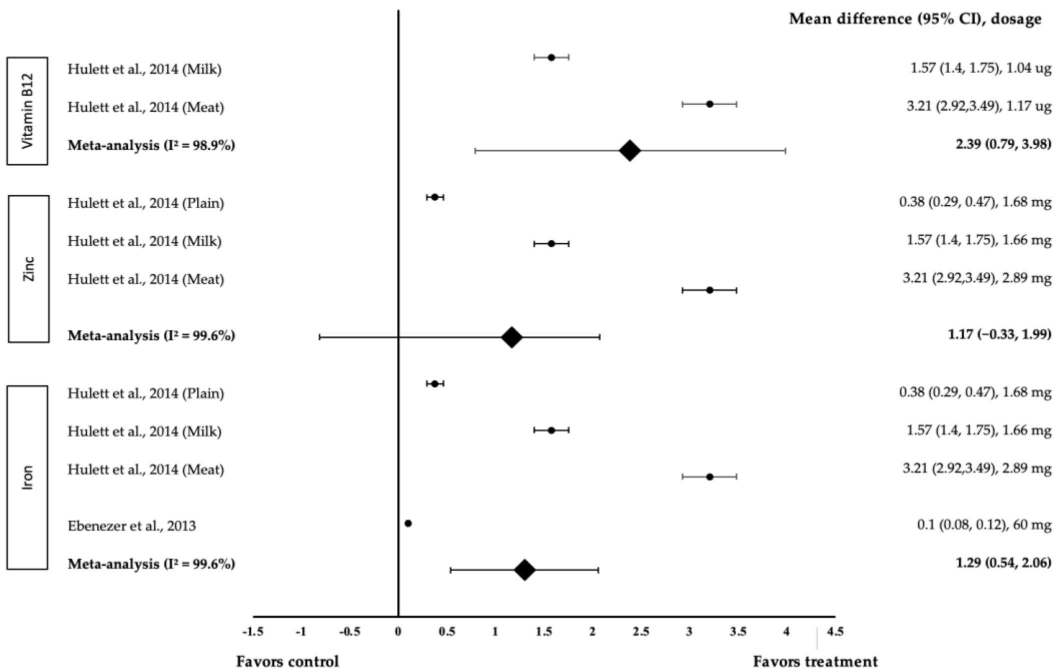

Figure 2.4: Forest plot showing the effect of vitamin B12, zinc, and iron on Mathematics, expressed as mean differences between the values obtained in the intervention and control groups. A positive effect size indicated that vitamin B12, zinc, and iron increased Mathematics skills. Horizontal lines represent 95% of CIs. Diamonds indicate the pooled-effect size from the random-effects analysis. The values ±0.2, ±0.5, and ±0.8 represent small, medium, and large effect sizes, respectively.

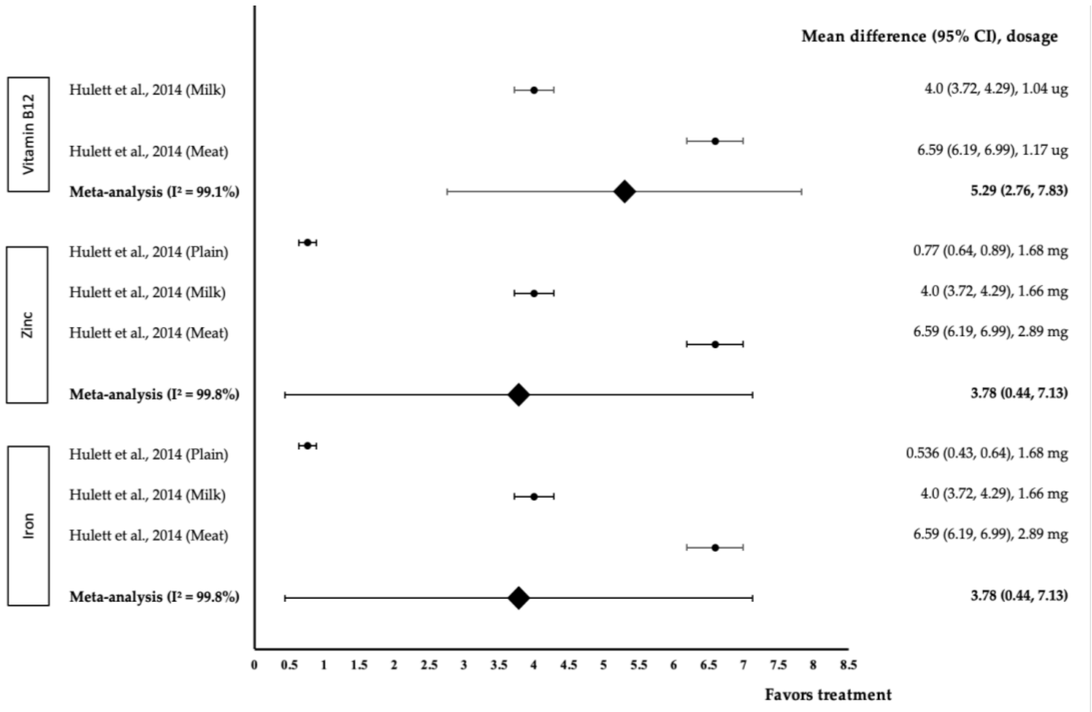

Figure 2.5: Forest plot illustrating the effect of vitamin B12, zinc, and iron on English, expressed as mean differences between the values obtained in the intervention and control groups. A positive effect size indicated that vitamin B12, zinc, and iron increased English skills. Horizontal lines represent 95% of CIs. Diamonds are indicative of the pooled-effect size from the random-effects analysis. The values ±0.2, ±0.5, and ±0.8 represent small, medium, and large effect sizes, respectively.

Figure 2.6 shows the meta-analysis of the effect of micronutrients on Geography. One study with three trials was included in the meta-analysis. As for the effect of vitamin B12, both interventions showed a positive effect on Geography (treatment group favoured). Hullet and colleagues' study with 1.04 µg of B12 in milk Githeri provided the highest effect size (d = 7.03, 95% CI: 6.66, 7.4), followed by 1.17 µg of B12 in meat Githeri (d = 6.13, 95% CI: 5.74, 6.51). The data showed a high level of heterogeneity with I^2 = 99.1% and, hence, were subjected to random-effects analysis. Vitamin B12 demonstrated a large pooled-effect size on Geography, with d = 5.29 (95% CI: 2.76, 7.83). Regarding zinc's effect, all three interventions were found to positively affect Geography (treatment group favoured). 1.66 mg of zinc in milk Githeri provided the highest effect size (d = 7.03, 95% CI: 6.66, 7.4), followed by 2.89 mg of zinc in meat Githeri (d = 6.13, 95% CI: 5.74, 6.51) and 1.68 mg of zinc in plain Githeri (d = 1.15, 95% CI: 1.0, 1.31). The data showed a high level of heterogeneity with I^2 = 99.8%, and hence, were subjected to random-effects analysis. Zinc was associated with large pooled-effect size on Geography, with d = 4.77 (95% CI: 0.56, 8.98). In terms of the effect of iron, all three interventions positively affected Geography (treatment group favoured). Iron (1.57 mg) in milk Githeri produced the highest effect size (d = 7.03, 95% CI: 6.66, 7.4), followed by 2.94 mg of iron in meat Githeri (d = 6.13, 95% CI: 5.74, 6.51) and 3.93 mg of iron in plain Githeri (d = 1.15, 95% CI: 1.0, 1.31). The data showed a high level of heterogeneity with I2 = 99.8%; therefore, these data were subjected to random-effects analysis. Iron showed a large pooled-effect size on geography, with d = 4.77 (95% CI: 0.56, 8.98).

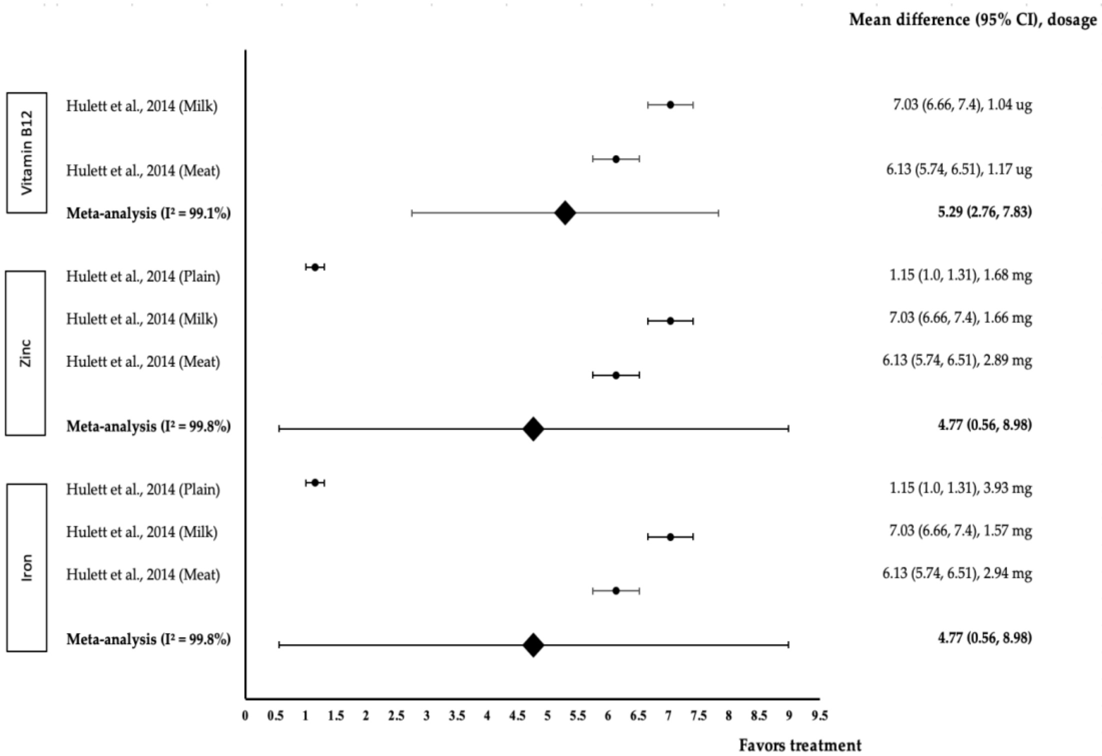

Figure 2.6: Forest plot showing the effect of vitamin B12, zinc, and iron on Geography, expressed as mean differences between the values obtained in the intervention and control groups. A positive effect size indicated that vitamin B12, zinc, and iron increased Geography skills. Horizontal lines represent 95% of CIs. Diamonds indicate the pooled-effect size from the random-effects analysis. The values ±0.2, ±0.5, and ±0.8 represent small, medium, and large effect sizes, respectively.

Figure 2.7 shows the meta-analysis of the effect of micronutrients on Science. One study with three trials was included in the meta-analysis. As for the effect of vitamin B12, both interventions showed a positive effect on Science (the treatment group favoured). Hullet and co-workers' research with 1.04 µg of B12 in milk Githeri demonstrated the highest effect size (*d* = 3.79, 95% CI: 3.51, 4.05), followed by 1.17 µg of B12 in meat Githeri (*d* = 3.0, 95% CI: 3.51, 4.05). The data were associated with a high level of heterogeneity with I^2 = 93.7% and were, therefore, subjected to random-effects analysis. Vitamin B12 showed a large pooled-effect size on Science, with *d* = 3.39 (95% CI: 2.62, 4.16). As for the effect of zinc, all three interventions showed a positive effect on Science (the treatment group favoured). Zinc (1.66 mg) in milk Githeri demonstrated the highest effect size *d* = 3.79, 95% CI: 3.51, 4.05, followed by 2.89 mg of zinc in meat Githeri (*d* = 3.0, 95% CI: 3.51, 4.05) and 1.68 mg of zinc in plain Githeri (*d* = 0.1, 95% CI: 0.05, 0.14). The data showed a high level of heterogeneity with I^2 = 99.8% and, hence, were subjected to random-effects analysis. Zinc exhibited a large pooled-effect size on Science, with *d* = 2.29 (95% CI: −0.34, 4.93). Regarding iron's effect, all three interventions were associated with a positive effect on Science (the treatment group favoured). Iron (1.57 mg) in milk Githeri provided the highest effect size (*d* = 3.79, 95% CI: 3.51, 4.05), followed by 2.94 mg of iron in meat Githeri (*d* = 3.0, 95% CI: 3.51, 4.05) and 3.93 mg of iron in plain Githeri (*d* = 0.1, 95% CI: 0.05, 0.14). The data showed a high level of heterogeneity with I^2 = 99.8%; these data were, therefore, subjected to random-effects analysis. Iron demonstrated a large pooled-effect size on science, with *d* = 2.29 (95% CI: −0.34, 4.93).

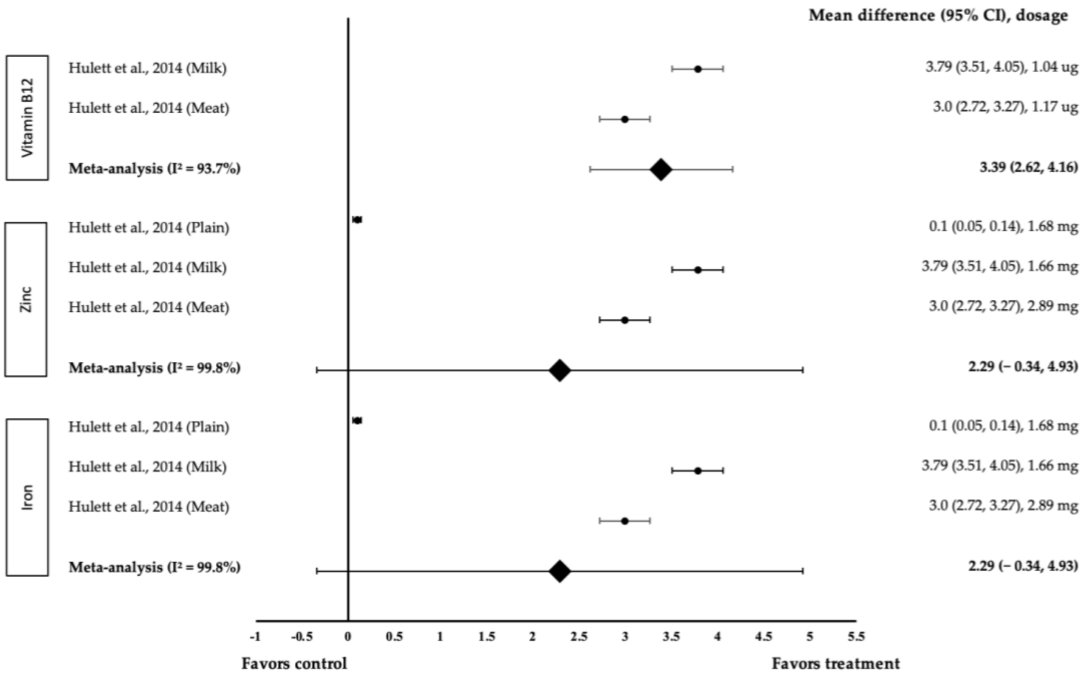

Figure 2.7: Forest plot showing the effect of vitamin B12, zinc, and iron on Science, expressed as mean differences between the values obtained in the intervention and control groups. A positive effect size indicated that vitamin B12, zinc, and iron increased Science skills. Horizontal lines represent 95% of CIs. Diamonds indicate the pooled-effect size from the random-effects analysis. The values ±0.2, ±0.5, and ±0.8 represent small, medium, and large effect sizes, respectively.

Figure 2.8 shows the meta-analysis of the effect of micronutrients on Arts. One study with three trials was included in the meta-analysis. As for the effect of vitamin B12, both interventions showed a positive effect on Arts (treatment group favoured). The study by Hullet et al. with 1.17 µg of B12 in meat Githeri demonstrated the highest effect size (d = 4.07, 95% CI: 3.76, 4.39), followed by 1.04 µg of B12 in milk Githeri (d = 2.57, 95% CI: 2.34, 2.79). The data showed a high level of heterogeneity with I^2 = 99.1% and, hence, were subjected to random-effects analysis. Vitamin B12 showed a large pooled-effect size on Arts, with d = 3.32 (95% CI: 1.84, 4.79). In terms of the effect of zinc, all three interventions positively affected Arts (treatment group favoured). Zinc (2.89 mg) in meat Githeri showed the highest effect size (d = 4.07, 95% CI: 3.76, 4.39), followed by 1.66 mg of zinc in milk Githeri (d = 2.57, 95% CI: 2.34, 2.79) and 1.68 mg of zinc in plain Githeri (d = 0.54, 95% CI: 0.43, 0.64). The data showed a high level of heterogeneity with I^2 = 99.8%; thus, they were subjected to random-effects analysis. Zinc showed a large pooled-effect size on Arts, with d = 2.39 (95% CI: 0.33, 4.45). As for the effect of iron, all three interventions produced a positive effect on Arts (treatment group favoured). Iron (2.94 mg) in meat Githeri provided the highest effect size (d = 4.07, 95% CI: 3.76, 4.39), followed by 1.57 mg of iron in milk Githeri (d = 2.57, 95% CI: 2.34, 2.79) and 3.93 mg of iron in plain Githeri (d = 0.54, 95% CI: 0.43, 0.64). Therefore, the data showed a high level of heterogeneity with I^2 = 99.8% and were subjected to random-effects analysis. Iron provided a large pooled-effect size on arts, with d = 2.39 (95% CI: 0.33, 4.45).

Figure 2.9 indicates the meta-analysis of the effect of iron on attention, which included two studies with two trials. Both interventions were shown to positively affect attention (treatment group favoured). Kuriyan and colleagues' study with 9 mg of iron was associated with the highest effect size (d = 0.204, 95% CI: 0.15, 0.26), followed by Ebenezer et al. with 60 mg of iron (d = 0.07, 95% CI: 0.05, 0.79). Because the data demonstrated a high level of heterogeneity with I^2 = 90.2%, they were subjected to random-effects analysis. Iron displayed a small pooled-effect size on attention, with a d value of 0.13 (95% CI: −0.001, 0.26).

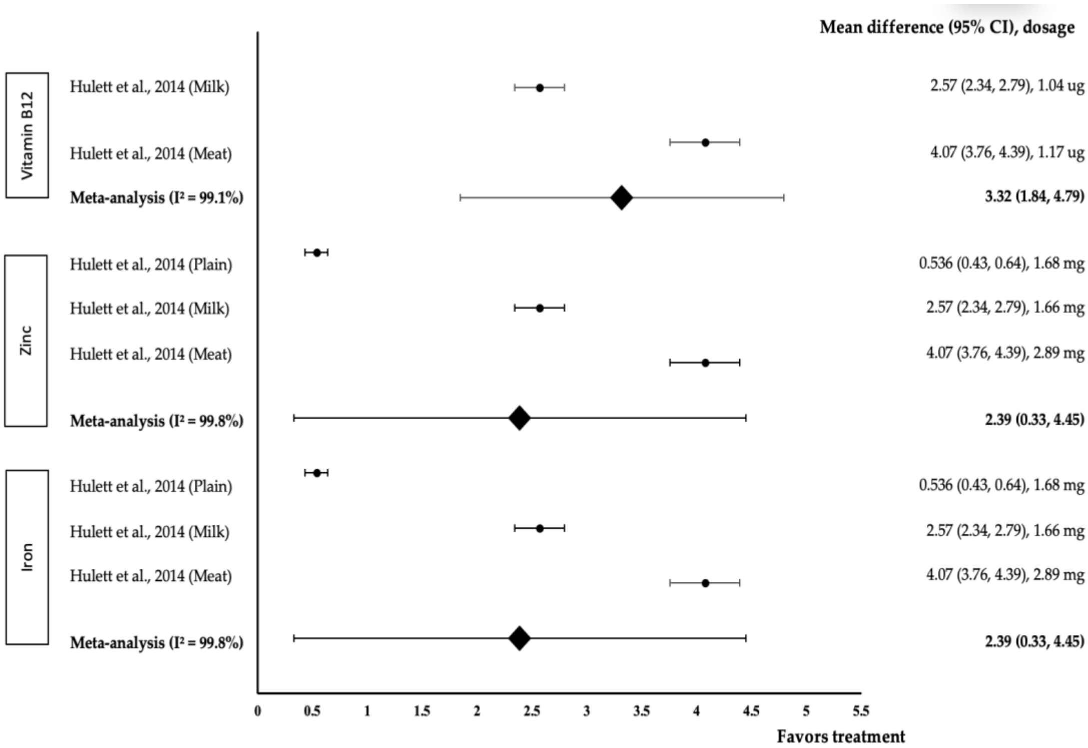

Figure 2.8: Forest plot showing the effect of vitamin B12, zinc, and iron on Arts, expressed as mean differences between the values obtained in the intervention and control groups. A positive effect size indicated that vitamin B12, zinc, and iron increased Arts capabilities. Horizontal lines represent 95% of CIs. Diamonds indicate the pooled-effect size from the random-effects analysis. The values ±0.2, ±0.5, and ±0.8 represent small, medium, and large effect sizes, respectively.

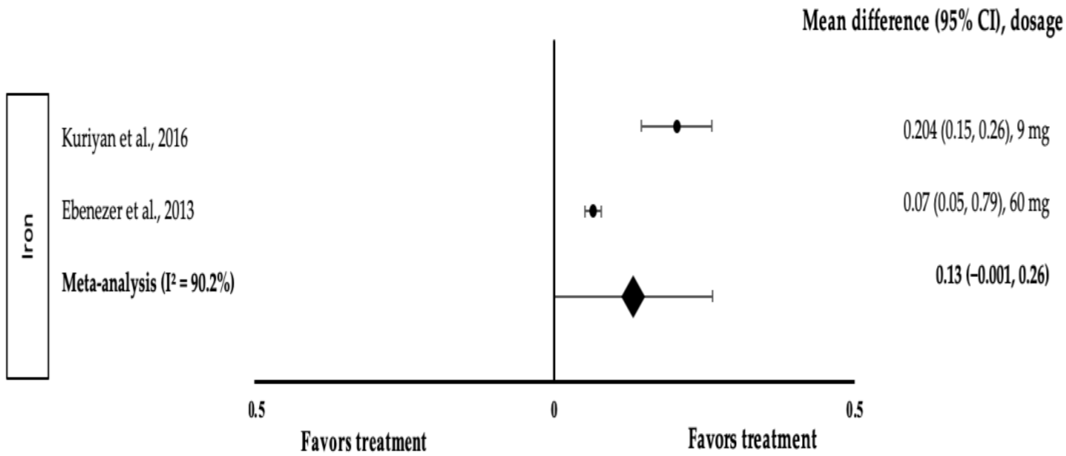

Figure 2.9: Forest plot showing the effect of iron on attention, expressed as mean differences between the values obtained in the intervention and control groups. A positive effect size indicated that iron increased attention. Horizontal lines represent 95% of CIs. Diamonds signify the pooled-effect size from the random-effects analysis. The values ±0.2, ±0.5, and ±0.8 indicate small, medium, and large effect sizes, respectively.

2.4.10 Discussion and conclusion

This systematic review with meta-analysis synthesized the evidence of the effectiveness of physical activity and micronutrients in increasing children's cognitive performance. It was evident that physical activity had a substantial impact on both Mathematics and attention. However, Mathematics showed a larger pooled effect size compared to attention. Hence, this review suggested that physical activity had a higher effect on increasing Mathematics scores compared to the level of attention. This observation might be due to the duration of the intervention; the longer the intervention, the more likely attention capacity will improve (García-Hermoso et al., 2019). According to work by Lind and colleagues, the effect of physical activity on attention had the largest effect size, and their study had the longest intervention period among all five treatments at 11 weeks (Lind et al., 2018). This result can be supported by a previous meta-analysis by de Greeff et al., where longitudinal physical activity programs positively affect cognitive functions as well as academic performance compared to physical activity break interventions (de Greeff et al., 2018). In line with our findings, their results suggested an association between the duration of the physical activity program and improved cognitive performance. Besides the length of intervention, the type of physical activity can also influence cognitive performance. Physical activity programs, such as the Active-Start program (García-Hermoso et al., 2019), can show more improvement compared to physical activity breaks, as conducted by Mavillidi et al. (2019) and Have et al. (2018) with respect to Mathematics performance. In support of these findings, a previous meta-analysis was also found to demonstrate that physically active lessons are more effective than active breaks (Watson et al., 2017).

Program design and teaching strategies can also influence the effectiveness of an intervention. Alvarez-Bueno et al. (2017) found that interventions developed by a trained specialist are associated with increased benefits. Based on our analysis of the studies, Garcia-Hermoso et al. (2019) and Lind et al. (2018) had the most effect on cognitive performance (Figure 2 and Figure 3). The intervention programs in both studies were developed and carried out by trained specialists, such as in the 'FIFA 11 for Health' for Europe program run by staff from the University of Southern Denmark and football coaches from the Danish Football Association (Lind et al., 2018). The

Active-Start intervention was designed by the research team and delivered by a graduate in Sport Sciences (García-Hermoso et al., 2019). Contrasting with the other three studies (Berg et al., 2019; Have et al., 2018; Mavillidi et al., 2019), the intervention was carried out by a classroom teacher who had a lower qualification. This teacher might not have been aware or sufficiently alert whether they made a mistake and simply followed the instructions given by the researcher during the delivery of the intervention. This finding can be further supported by Sember et al. (2020), who found that interventions performed by staff with higher qualifications are more effective compared to those administered by practitioners with lower qualifications in the field.

Based on our meta-analysis, it is evident that micronutrients had a substantial impact on several cognitive performance areas, such as Mathematics, English, Geography, and Arts. Micronutrients, such as vitamin B12, zinc, and iron, met the inclusion criteria, and hence, they were included in the analysis (Ebenezer et al., 2013; Hullet et al., 2014; Kuriyan et al., 2016). These three nutrients are essential for brain development and are postulated to influence cognitive performance. Iron is involved in oligodendrocyte development and myelin production (Todorich et al., 2009) and is a cofactor for neurotransmitter synthesis (Youdim & Yehuda, 2000). Zinc is associated with neuronal migration, synaptogenesis, and neurogenesis (Bhatnagar & Taneja, 2011). Vitamin B12 affects methylation in the central nervous system (Alpert & Fava, 1997) and maintains the integrity of the myelin sheath via vascular disease prevention (Hankey & Eikelboom, 1999). Based on our meta-analysis, iron and vitamin B12 had a substantial effect on Mathematics performance. Furthermore, vitamin B12 had the largest pooled effect size and is, therefore, more effective than zinc and iron. A larger dose of vitamin B12 has also been shown to improve Mathematics performance. Iron, on the other hand, was not as effective. According to Ebenezer et al. (2013), even though the dosage was the largest compared to the other treatments, there was no effect on cognitive performance. Aside from that, the three Hullet et al. (2014) treatments used a snack that may have included different nutrients from the supplement used in the Ebenezer et al. (2013) trial. The effect of vitamin B12, zinc, and iron on English and Arts has been studied in a comparative meta-analysis (Figures 5 and 8). However, as compared to Arts performance, English performance had a larger pooled-effect size for each of the three micronutrients. The dose of vitamin B12 and zinc may have influenced English and Arts performance because the higher the dosage, the larger the effect size. A 1.17 µg of vitamin B12 has been found to be more effective than 1.04 µg, and 2.94 mg of zinc is more effective than 1.68 mg and 1.66 mg. However, iron supplementation does not appear to influence English or Arts performance (Hullet et al., 2014). Vitamin B12, zinc, and iron have a major impact on Geography performance. Geography test results improved considerably with increased consumption of iron, calories per kg of body weight, vitamin B12, zinc, and riboflavin (Hullet et al., 2014). In terms of the link between micronutrients and Science performance, only vitamin B12 had a significant effect. The consumption of other nutrients (energy, protein, iron, zinc, folate, vitamin B6, riboflavin) was not associated with Science test scores (Hullet et al., 2014).

This study did not find a significant association between iron and attention in the meta-analysis, as the error bar was close to the centre line ($d = 0.13$, 95% CI: −0.001, 0.26). This observation is supported by Gou et al. (2015), who claimed that iron did not improve global cognitive scores. However, a contradictory result was provided by Low et al. (2013), who observed that iron could improve the global cognitive score and the measures of attention. Kuriyan et al. (2016) showed a higher effect compared to Ebenezer et al. (2013), potentially because multi-nutrient-fortified foods or drinks are more beneficial than supplements. Multiple micronutrient food supplements (MMFS) added to school meals daily for 12 months were found to significantly improve attention (Kumar & Rajagopalan, 2008). Kuriyan et al. (2016) used fortified milk as the intervention in their study, an approach that is more likely to be helpful because it may also include other nutrients that aid in cognitive growth. According to one study, 0.9 mg of zinc and 0.54 µg of vitamin B12 improved children's attention when added together in milk (Kuriyan et al., 2016). A combination of a few nutrients may be more effective in increasing cognitive development compared to a single nutrient. Hence, it is suggested that multi-nutrient intervention is likely associated with a positive effect on cognitive performance.

This review found the effects of three micronutrients (vitamin B12, iron, and zinc) on cognitive performance. Other important micronutrients, namely iodine, folate, vitamin B6, and vitamin A were not included in this review due to poor-quality data.

Further RCTs investigating the effect of these micronutrients on cognitive performance are highly encouraged, especially in children aged 6 to 11 years.

Collectively, our review and meta-analysis comprised nine articles with 14 high-quality RCTs, nine of which focused on physical activity and five on micronutrients with respect to cognitive performance. It is evident that both physical activity and micronutrients had substantial impacts on cognitive performance. The intervention duration was found to be important because longer research periods were sufficient for evaluating significant improvements in cognitive performance, particularly attention. According to the findings of our meta-analysis, physical activity influenced both Mathematics and attention performance. In terms of micronutrients, vitamin B12 had an impact on Mathematics, English, Geography, Science, and Arts. Zinc influenced English, Geography, and Arts, whereas iron affected Mathematics, English, Geography, and Arts. The study data showed a significant level of heterogeneity; hence, conclusions shall be taken with care. To further validate the findings described in this review, a more comprehensive intervention with a particular dose, degree of physical activity, a higher range of cognitive performance, and a well-planned research study design, with adjustments for dietary intake and other health outcomes, are required in the future.

2.5 Research instruments

2.5.1 Research instruments of dietary intake and adequacy

For the diet adequacy instrument, 24-hour food recall was used. The 24-hour recall is frequently used in dietary surveys and research since respondents do not need to be literate and the interview may be customised to the person's level of food knowledge, making it a relatively low-burden approach for the subject (Foster & Bradley, 2018). Aside from that, children reported more errors in ASA24™ compared to interviewer-administered 24-hour food recall (Baranowski et al., 2012), making this instrument more reliable and valid. A study by Tai & Ali (2018) used this method to collect data regarding dietary intake among fishermen children. Then, the analysis of food recall is done by using Nutritionist Pro Nutrition Analysis Software NutriPro) Version 20. Table 2.8 shows previous studies that administrated food recall questionnaires to assess diet adequacy.

Table 2.8: Selected studies on research instruments of diet adequacy

Study	Subjects	Measuring instrument	Findings
Baranowski et al. (2014)	-	Food recall; Food Intake Recording Software System, version 4 (FIRSSt4)	Children reported more errors in ASA24™ compared to an interviewer-administered 24-hour food recall.
Marianne et al. (2017)	Children 9 to 24 months	Food recall	Local fieldworkers were trained by experts to assist with dietary recall tasks.
Tai & Ali (2018)	30 children	Food recall	Analysis of a food recall is done by using Nutritionist Pro Nutrition Analysis Software NutriPro) Version 20.
Foster & Bradley (2018)	-	Food recall	The 24-hour recall is frequently used in dietary surveys and research since respondents do not need to be literate and the interview may be customised to the person's level of food knowledge, making it a relatively low-burden approach for the subject.

2.5.2 Research instruments of nutritional status

Based on Table 2.9, there are three studies that used the z-score to record the nutritional status of children (Oui et al., 2016: Ahmad et al., 2017: Azli et al., 2019). The body weight of samples will be measured with an electronic weighing scale; meanwhile, the body height of samples will be measured with a SECA stadiometer. The measurement will be taken twice, and the average reading will be taken and applied in WHO Anthro (version 3.2.2) calculator and recorded. The Body Mass Index (BMI) of the children will be calculated through the formula. Then, it will be plotted on the WHO Growth Chart (2006) for BMI-for-age z-scores to determine if the child is overweight, obese, or wasting. The same goes for Height-for-age; the height of the children will be plotted on the WHO Growth Chart (2006) and z-scores to determine if the child is undergoing stunting as stunting is an indicator of malnutrition among children in the fishermen community. Both BMI and height-for-age will also be calculated based on the WHO Anthro (version 3.2.2) calculator.

Table 2.9: Selected studies on research instruments of nutritional status

Study	Subjects	Measuring instrument	Findings
Oui et al. (2016)	Pre-schoolers aged 1 to 6 years old	WHO anthropometric measurement	Weight-for-age and height-for-age of the subjects were computed to Z-score by using WHO Anthro software version 3.2.2.
Ahmad et al. (2017)	School adolescents	WHO anthropometric measurement	BMI-for-age z-score is computed using WHO AnthroPlus software.
Azli et al. (2019)	Respondents aged 15-49 years old	WHO anthropometric measurement	Identify underweight, stunting, and wasting by using weight-for-age, height-for-age, and weight-for-height, respectively.

2.5.3 Research instrument of physical activity

As for physical activity assessment, the Physical Activity Questionnaire for Children (PAQ-C) is chosen for this research. Table 2.10 shows previous studies that administered the PAQ-C questionnaire to assess physical activity. PAQ-C is a self-administered, seven-day recall questionnaire that measures engagement in various physical activities, such as those that take place during physical education, lunch, recess, after school in the evenings, and on weekends, and it is also recommended for individuals between the ages of 8 and 14 (Kowalski et al., 2004). This questionnaire is also cost-effective and easy to use. Besides that, this instrument also has been widely tested and validated. According to Voss et al., 2017, for children with congenital heart disease, the PAQ-C still can provide a valid estimation of general levels of physical activity. This shows that PAQ-C is valid enough to use in this research.

Table 2.10: Selected studies on research instruments of physical activity.

Study	Measuring instrument	Findings
Kowalski et al. (2004)	Physical Activity Questionnaire for Children (PAQ- C)	PAQ-C is a self-administered, 7-day recall questionnaire that assesses participation in different physical activities, including the activity during physical education, lunch break, recess, and after school in the evening and at weekends. Recommended for individuals aged 8 -14 years old. This instrument has been widely tested and validated.
Voss et al. (2017)	Physical Activity Questionnaire for Children (PAQ- C)	For children with congenital heart disease, the PAQ-C provides a valid estimation of general levels of physical activity. A self-administered questionnaire, cost-effective and easy to use.

2.5.4 Research instruments of cognitive performance

Raven Coloured Progressive Matrices (RCPM) were used to measure the cognitive performance among fishermen’s children in this research. This test consists of 36 questions divided into three sets/scales (A, AB, and B) with 12 items each. The components, which include drawing with the missing piece, are arranged in escalating order of complexity. The person must finish the challenge by selecting one of six possible answers. Each accurate response will receive one mark, while each incorrect response will receive 0 points. Zero is the least and 36 is the maximum score (Raven, 2004). The main objective of RCPM is to assess a person's potential for learning, which is comparable to fluid intelligence as it is described in the most recent version of the psychometric theory of intelligence, the Cattell-Horn-Carroll Theory of Cognitive Abilities (Schneider & McGrew, 2012). Besides that, this test does not assess one’s verbal language capacity or acquired cultural knowledge, which is important as the primary language of this population is Malay instead of English. Compared to another cognitive test, specifically Wechsler Intelligence Scale for Children Fifth Edition (WISC-V), it is a western-based cognitive function test, and Full-Scale Intelligence Quotient (FSIQ) cannot be used as only certain tests are appropriate for children with limited educational opportunities and non-verbal tests. Thus, the RCPM test is more appropriate to use in this population. Table 2.11 shows previous studies regarding RCPM as a research instrument for cognitive performance. According to research by Ghazali et al. (2018), the RCPM is a valid and reliable tool for assessing children's intelligence in Malaysia. The Cronbach's alpha values for the subgroup scores and the total score for the RCPM were between 0.70 and 0.87, which is regarded typical for strong instrument internal consistency (Hamid, 2011). This demonstrates that the RCPM is a reliable, valid, and a consistent tool for assessing children's intelligence in Malaysia. Besides that, a study by Tai & Ali (2018) used this method among fishermen's children for cognitive performance, which is the same target as this research.

Table 2.11: Selected studies on research instruments of cognitive performance.

Study	Subjects	Measuring instrument	Findings
Raven (2004)		RCPM	Consisting of 36 questions. Composed of three sets/ scales (A, AB, and B) with 12 items each. The items are organized in ascending order of difficulty, which consists of drawing with the missing part. The individual needs to complete the task by choosing one among six alternative responses. Every correct response will get one mark, and zero marks for each wrong response. The minimum score is zero, and the maximum is 36.
Hamid (2011)		RCPM	The Cronbach's alpha values for the subset scores and the overall score for the RCPM were between 0.70 and 0.87. A value of Cronbach's alpha of 0.70 or higher is considered standard for good internal consistency of the instrument.

Schneider & McGrew (2012)		RCPM	The main purpose of Raven's Matrices, as well as that of CPM, is to measure one's capacity for education, which is similar to fluid intelligence proposed in the most current model of the psychometric theory of intelligence, Cattell- Horn-Carroll Theory of Cognitive Abilities.
Ghazali (2018)		RCPM	RCPM are reliable and valid instruments to test intelligence among Malaysian children.
Tai & Asma' (2018)	7-12 years old children in Terengganu	RCPM	It consists of 36 questions, and each question has one missing part at the bottom of the right side.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The study design and protocol were reported according to standard protocol items of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) (Cuschieri, 2019; Vandenbroucke et al., 2014; von Elm et al., 2014).

This project was funded under the Fundamental Research Grant Scheme for Research Acculturation of Early Career Researchers (FRGS–RACER): RACER/1/2019/SKK06/UMT//1. In this research project, an extensive secondary analysis was conducted on the data collected from a prior study titled 'Profiling of Nutritional Status of Mothers and Fishermen's Children in Terengganu.' This previous study was conducted by a team of seven undergraduate students who were instrumental in gathering the necessary data. As a result, the present thesis builds upon and extends the original research by re-analysing and reinterpreting the existing dataset. The secondary analysis approach was chosen for several reasons. Firstly, it allows for the efficient use of previously collected data, maximizing the value of the original study while minimizing the time and resources required for new data collection. Additionally, secondary analysis can provide new insights and perspectives, potentially leading to novel findings and a deeper understanding of the research topic. It is also worth noting that the researcher made considerable efforts to expand the scope of the study by reaching out to the leader of the fishermen community in Setiu (refer to Appendix D for the letter of invitation to conduct research in Setiu, and to Appendix E for photographs documenting the meeting with the leader of the fishermen community in Setiu.). Having secured their approval to conduct research in the area, the researcher was well-prepared to gather additional data that would have enriched the findings of this study. Regrettably, due to the sudden implementation of a COVID-19 lockdown the very next day, the researcher was unable to proceed with the planned data collection. In addition to the secondary analysis, the researcher also conducted a meta-analysis of relevant review papers, which necessitated advanced knowledge and a high level of analytical skill. This meta-analysis served to strengthen the study's foundation by incorporating a broader context and synthesizing findings from multiple sources, thereby providing a more comprehensive understanding of the research topic.

In this chapter, the study procedure, as well as the study’s design and sampling, were further detailed. This chapter also included the research instruments that were used, as well as the data collection process. The pilot research has been completed, and this chapter will go through it in more detail. Finally, this chapter will go into the data analysis that was done and the ethical approvals that were received.

3.2 Study design

This is a cross-sectional study conducted to assess dietary intakes, nutritional status, physical activity, and cognitive performances among 94 fishermen’s children aged 7-11 years old in Terengganu through purposive and snowball sampling. A validated questionnaire was employed through a researcher-administered approach involving parents/caregiver and their children to obtain the household socioeconomic status and children’s comprehensive dietary intake. Throughout the study, the fishermen's children also had an anthropometric assessment (BMI for age and height for age), a biochemical assessment (including urine iodine analysis), and physical activity. Raven’s Coloured Progressive Matrices were performed for their cognitive assessments. The main objective of this study is to assess dietary intake, nutritional status, physical activity, and associated factors toward cognitive performances among fishermen’s children aged 7 to 11 years old in Terengganu and its risk toward poor cognitive performance among them.

3.3 Study location

The study was carried out in Terengganu, Malaysia. Terengganu is situated on the Malaysia Peninsula's east coast, facing the South China Sea. Terengganu's coastline environment is characterized by large stretches of sandy beach with just a few rocky or coral reefs (Matsunuma et al., 2011). Geographical factors prompted coastal residents to enter the fishery industry (Sulaiman & Saat, 2017). Thus, the states of Terengganu are very synonyms for fisheries activity (Kuala Terengganu Municipal Council, 2016; Sulaiman & Saat, 2017).

There are a total of eight districts in Terengganu, which are Besut, Kuala Nerus, Dungun, Kuala Terengganu, Hulu Terengganu, Marang, Kemaman, and Setiu (Terengganu State Government, 2021). For this study, two districts were selected: Kuala Terengganu and Kuala Nerus. The districts were located near the sea and heavily populated by fishermen households (Data Asas Negeri Terengganu, 2020). The research covered several villages from Batu Rakit to Kuala Terengganu, with Batu Rakit, Gong Badak, Seberang Takir, and Kuala Terengganu being the zones involved. Kuala Terengganu recorded 1,179 fishermen, while Kuala Nerus recorded 515 fishermen (Data Asas Negeri Terengganu, 2020).

3.4 Sampling framework

In this cross-sectional study, convenience sampling was used to select districts in Terengganu, and two sampling methods were used in the surveying process which is purposive sampling and snowball sampling were used as shown in Figure 3.1. Convenience sampling was chosen because it was the most accessible method for the researcher, as well as the simplest, cheapest, and least time-consuming method for data collecting (Etikan et al., 2016; Jager et al., 2017). Thus, Kuala Nerus and Kuala ˆTerengganu were selected.

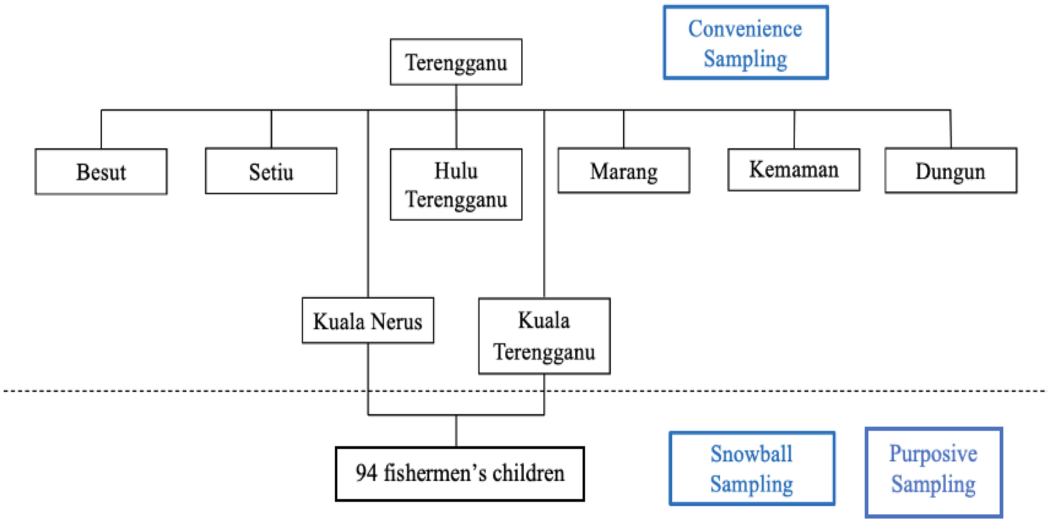

Figure 3.1: Sampling Framework

Purposive sampling was conducted during initial visits to the targeted households before conducting the study. This method involves identification, selection of a group of individuals, and the willingness to participate in the study. Screening questions were used by asking a few questions to the members of the household. The first inquiry was, "Does either parent work as a fisherman?" This is to meet the children's background criterion, which requires replies to come from a family of fishermen. The age of their children was the next question that was asked. Children between the ages of 7 and 11 had to be included in the household. This is to ensure it fulfils the sampling subject requirement. Then, to achieve 94 of the responders, snowball sampling was utilized as there is a rarity of respondents that fits the criteria, which were healthy 7 to 11 years old children from the fishermen community. This is because most fishermen mentioned that the fishermen nowadays are veterans that bear no children between the age range required; however, they managed to give us names and phone numbers for us to contact and asked for consent to visit their houses for this study. The selected respondents were also asked if they knew any eligible respondents for further data collection.

Considering that the fishermen community is a minority, a few pre-steps were made before directly approaching them. With this, to start the sampling process, contact information for respondents who live in Batu Rakit and Seberang Takir was gained from the East Coast Economic Region Development Council (ECERDC)

Terengganu through an officer named Puan Yaniza. Besides that, the leader of Persatuan Nelayan Kawasan Kuala Terengganu Utara, i.e., Encik Hafizan, was also contacted to discuss the purpose of the study and the best way how to approach respondents. Encik Hafizan suggested waiting and approaching the fishermen at the jetty directly. However, the fishermen's arrival at the jetty was uncertain. As a result, it took some time at first, but with the snowball sampling approach, there was no need to wait at the jetty. Figure 3.2 summarize on how the respondent were approach for data collection.

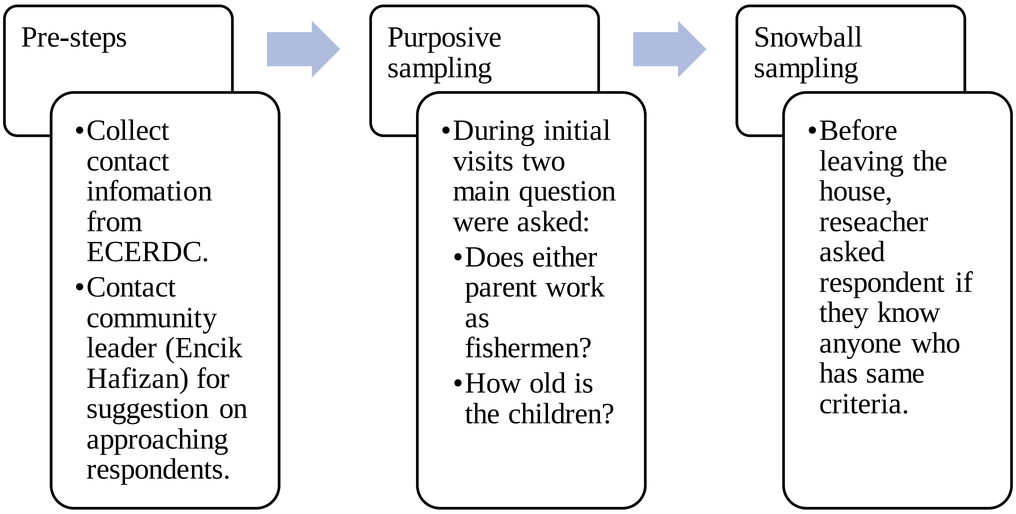

Figure 3.2: Flowchart on how respondent were approach for data collection

3.5 Sampling subject

In this study, fishermen’s children aged 7 to 11 years old were recruited in two districts in Terengganu. Mothers of the children were also recruited to help with some parts of the questionnaire regarding sociodemographic background. Only children aged 7 to 11 years old were participants due to the targeted population being primary school children. Children aged 12 years old were not included due to the RCPM test has been administered to a large group of typically developing children between 5 and 11 years of age (Raven, 2008; Smirni, 2020). Besides that, age groups for RNI (2017) have also been considered. Thus, the children were limited to primary school-aged children, which are 7-11 years old.

The inclusion criteria for participants include a father/caretaker working as a fisherman, aged between 7 to 11, who understands Bahasa Melayu and voluntary participation in which only children are approved by their parents or guardians. Meanwhile, some of the exclusion criteria are children who have a chronic disease and must not have any physical disabilities.

3.6 Sample size

For a population-based survey, the expected prevalence of a variable of interest, the degree of confidence, and the allowable margin of error all plays a significant role in determining the suitable sample size (Pourhoseingholi et al., 2013; Suresh & Chandrashekara, 2012). Therefore, this study sample size was determined based on the estimated prevalence of a nutrition-related variable, the level of confidence, and the margin of error desired. The prevalence of intellectually impaired cognitive performance of fishermen’s children was selected for the sample size calculation. The sample size required was calculated according to the following Cochran formula:

$$n=\frac{Z^2[P(1-P)]}{e^2}$$

Description:
n = Minimum sample size
P = Expected proportion in population based on the previous study
Z = Z-statistics (1.96 for 95% confidence level)
e = Margin of error

The prevalence of intellectually impaired cognitive performance of fishermen’s children in Terengganu was 67%, based on a previous study (Tai & Ali, 2018). At a 95% confidence interval and a 10% level of precision, the sample size required for the survey was calculated as follows:

$$\frac{1.96^2[0.67(1-0.67)]}{(0.1)^2} = 85$$

The considerable proportion of attrition in survey-type studies, usually 10%

85 + (85 x 10%) = 93.5~ 94

Therefore, after the 10% attrition considered, the final sample size of the study is 94.

3.7 Ethical approval

Ethical approval was obtained from the Universiti Malaysia Terengganu Human Research Ethics Committees. The No. of Human Ethics Approval was JKEPM/2019/37 with the title of Profiling of Nutritional Status of Mother and Fisherman Children in Terengganu (Appendix A) and JKEM/2021/64 with the title of Risk Assessment of Poor Cognitive Performance Among Fishermen's Children in Terengganu (Appendix B). Furthermore, all study participants were told of the study's aims and objectives, and a signed consent form was collected from each of them via the subject information sheet.

3.8 Research instrument

The research instruments for data collection were in the form of a questionnaire and nutritional assessments. The questionnaire and the interviews with respondents were conducted in Bahasa Malaysia. Furthermore, the surveys were all researcher-administered from the mother's side to the children's side, who ranged in age from 7 to 11 years old. The survey questionnaire consists of six parts, as shown in Table 3.1. Part 1 is a socio-demographic question, Part 2 is a 24-hour dietary recall that assesses the adequacy of dietary intake (RNI, 2017), Part 3 is a physical activity assessment for fishermen's children over the last 7 days, which is the Physical Activity Questionnaire for Children (PAQ-C) (Kowalski et al., 2004), Part 4 is an anthropometric measurement that aims to monitor the growth of fishermen's children (WHO, 2000), Part 5 is a urinary iodine analysis that assesses the iodine intakes of fishermen's children (Jooste & Strydom, 2010; Zimmermann, 2008), and Part 6 is the cognitive performance test with 36 matrices of diagrammatic puzzles of Raven's Coloured Progressive Matrices (RCPM) (Raven, 2008).

Table 3.1: Summary of the research instrument.

Part	Questionnaires	No. of items	Sources	Validation
1	Socio-demographic question	8	(Hwee Shan et al., 2018; Miza & Alfian; 2019; Ocke et al., 2012; Tietze et al., 2000; Zainuddin et al., 2019)	
2	24-hour dietary recall	5	(RNI, 2017)	Children reported more errors in ASA24TM compared to interviewer-administered 24-hour food recall (Baranowski et al., 2012). The 24-h dietary recall method can be used in adolescents to assess population dietary risk levels and differences between groups (Arsenault et al., 2020)
3	Physical Activity Questionnaire for Children (PAQ-C)	9	(Kowalski et al., 2004)	$\alpha = 0.75$ among 73 students aged 10 to 17 years old in Malaysia (Mohd Zaki et al., 2016).
4	Anthropometric measurement	2	(WHO, 2000)	Height, weight and BMI measurements of children collected by trained enumerator are sufficiently accurate for research purposes (Catherine et al., 2012).
5	Urinary iodine analysis	1	(Jooste & Strydom, 2010; Zimmermann, 2008)	The Sandell-Kolthoff method using microtiter plate technique presented here is a simple, inexpensive semi-automated method to determine urinary iodine with very little toxic waste (Haap et al., 2016)

6	Raven's Coloured Progressive Matrices (RCPM)	36	(Raven, 2008)	The Cronbach's alpha values were between 0.70 and 0.87 (Hamid, 2011).

3.8.1 Socio-demographic questionnaire

Socio-demographic statuses reflect the demographic and social roles and achievements of an individual(s) in a population (Abdullahi, 2020). This questionnaire was included to understand more about the background and upbringing of the fishermen's children. Other than that, socio-demographic variables of a society or an individual have mostly been explored in research to give a connected explanation of a phenomenon. Some studies did prove that socio-demographics does have an effect on cognitive performance in children (Asawa et al., 2014; Poh et al., 2019; Sathe & Gokhale, 2019).

The socio-demographic questionnaire was administered by the mother of the children. It involves seven questions such as gender, ethnicity, age, mother's educational level, mother's occupation, number of family members and household income. The variable chosen for the question is based on previous studies that related to children (Hwee Shan et al., 2018; Ocke et al., 2012) and fishermen communities (Miza & Alfian; 2019; Tietze et al., 2000; Zainuddin et al., 2019).

3.8.2 24-hour Dietary Recall

Dietary intakes were measured using 24-hour dietary recall. The 24-hour dietary recall is a subjective assessment that collects real consumption information over the preceding 24 hours using open-ended questions administered by a trained interviewer (Bailey, 2021; Lombard et al., 2015; Shim et al., 2014). Two days of 24-hour dietary recall were administered which are one during weekdays and another during weekends. Each respondent was asked to disclose their dietary intake within the past 24 hour on a weekday and a weekend to compute the average dietary intake with assistance from their parents. All food and drinks, including ingredients and preparation methods, were recorded on the questionnaire that provided in detail by well-trained researchers and enumerators. The responses were reported on paper and later entered the software for analysis. The measurements were standardized using units of a gram (g) and millilitres (ml), which were later verified and cross-checked for inconsistencies. *Album Makanan Malaysia* (Institute for Public Health, 2011) was used as an aid to facilitate dietary recall by illustrating household measurements (Drewnowski et al., 2020; Mohamed et al., 2015; Zainuddin et al., 2019).

The data collected through the recall assessed by Nutritionist Pro™ Nutrition Analysis Software version 5.3 (Axxya Systems LLC, Redmond, WA). Based principally on the Nutrient Composition of Malaysian Foods for calculating nutrient intake (Drewnowski et al., 2020; Mohamed et al., 2015; Zainuddin et al., 2019). The nutrients included in this study are selected based on the Malaysian Food Composition Table/Food Composition Database (FCT/FCD) 1997 (Tee et al., 1997) as the study objective is to assess the dietary intake of the fishermen's children. This is due to the current updated version of the Malaysian Food Composition Database (MyFCD) (2017) is still ongoing. Thus, energy, protein, fat, carbohydrates, dietary fibre, thiamine, riboflavin, niacin, vitamin B6, folate, vitamin B12, vitamin C, vitamin A, vitamin E, calcium, zinc, iron, sodium, and potassium were chosen to assess in this study.

After that, the data was compared to RNI Malaysia (Table 3.2) and calculate the fulfilment percentage to know the adequacy of the nutrient intake. The estimated average requirement (EAR) is recommended by IOM (2005) for assessing diets for individuals and groups. For the group, the EAR is used to estimate the prevalence of inadequacy (or adequacy) of usual intake within a group (IOM, 2005; RNI, 2017). Figure 3.2 shows the conceptual framework for IOM/FNB's DRIs, which the RNI 2017 for Malaysia adopted but replaced the term 'RDA' with 'RNI'. The estimated average requirement (EAR) is the average daily intake required to prevent a deficit in half of the population. Thus, an individual is considered adequate intake when his/ her nutrient intake is more than or equal to 50% of recommended intake (RNI, 2017).

Table 3.2: Recommended Nutrient Intakes (RNIs) 2017

Nutrients	**Age**	**Recommended intake**	
		Boys	**Girls**
Energy (kcal/day)	7-9 years	1750	1610
	10-12 years	1930	1710
Protein (g/day)	7-9 years	23	
	10-12 years	30	31
Fat (g/day)	7-9 years	49-68	45-63
	10-12 years	54-75	48-67
Carbohydrates (g/day)	7-9 years	219-284	201-262
	10-12 years	241-314	214-278
Dietary fibre (g/day)	All ages	20-30	
Thiamine (mg/day)	7-9 years	0.9	
	10-12 years	1.2	1.1
Riboflavin (mg/day)	7-9 years	0.9	
	10-12 years	1.3	1.0
Niacin (mg/day)	7-9 years	12	
	10-12 years	16	
Vitamin B6 (mg/day)	7-9 years	1.0	
	10-12 years	1.3	1.2
Folate (µg/day)	7-9 years	300	
	10-12 years	400	
Vitamin B12 (µg/day)	7-9 years	2.5	
	10-12 years	3.5	
Vitamin C (mg/day)	7-9 years	35	
	10-12 years	65	
Vitamin A (µg/day)	7-9 years	500	
	10-12 years	600	
Vitamin E (mg/day)	7-9 years	7	
	10-12 years	10	7.5
Calcium (mg/day)	7-9 years	1000	
	10-12 years	1300	
Zinc (mg/day)	7-9 years	5.7	5.6
	10-12 years	7.0	6.3

Iron (mg/day)	7-9 years		9.0	
	10-12 years	15.0		14.0
Sodium (mg/day)	7-8 years		1200	
	9-11 years		1500	
Potassium (g/day)	7-8 years		3.8	
	9-11 years		4.5	

Source: RNI (2017)

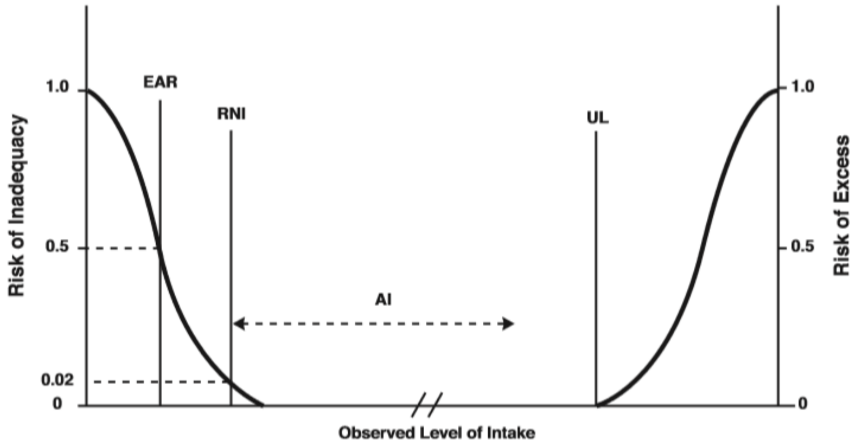

Figure 3.3: Conceptual framework for IOM/FNB’s DRIs

Below is an example of how to calculate dietary adequacy: given the mean energy intake of 7-9 years old boys is 1200 kcal/day. In order to calculate, the mean intake of the group is divided by the RNI of the nutrient and then multiplied by 100:

$$\frac{1200}{1530} \times 100 = 78.43\%$$

Therefore, the energy intake of 7-9 years old boys was adequate as the percentage of fulfilment was more than 50%.

3.8.3 Physical Activity Assessment

The Physical Activity Questionnaire for Children (PAQ-C), which is a valid tool for assessing physical activity at various ages, was used in this research (Janz et al., 2008; Voss et al., 2017). PAQ-C was developed to assess the general levels of physical activity throughout children aged approximately 7 to 14 years old, where it is difficult to precisely measure the intensity, frequency, and duration of young child activities, especially with self-report (Treuth et al., 2005).

Several studies suggested that the PAQ-C has moderate to good reliability and validity in assessing physical activity among older children and adolescents (Gobbi et al., 2016; Janz et al., 2008; Mohd Zaki et al., 2016; Thomas & Upton, 2014). This study calculated that the internal consistency of PAQ-C assessment was $\alpha = 0.75$. A similar finding can be seen in the study by Mohd Zaki et al. (2016). The internal consistency of the PAQ-C assessment calculated was $\alpha = 0.75$ among 73 students aged 10 to 17 years old in Malaysia. Moreover, a study by Dan et al. (2011) also recorded the internal consistency (Cronbach's alpha) of this assessment was 0.79 among 400 13-year-old adolescents in Kuantan, Pahang. This shows that PAQ-C was a reliable method to measure physical activity among children.

For this questionnaire, respondents had to recall physical activities that they have been doing for the last 7 days. There are 10 items in the PAQ-C regarding the activity done accordingly to the time spent by children during the whole day activity (Appendix E). Series of question items on spare time activity, physical education participation, activity done during recess, activity done after the school session, activity during the evening, activity during the weekend and describe the respondents the best based on rates. The questionnaire provides a summary physical activity score derived from each item, each scored on a 5-point scale, the scores in between score 1 as 'no activity' till score 5 as '7 times or more' for each of the items of the questionnaire to indicate subject frequencies of activities done. The total mean scores of the questionnaire were classified into three categories, as shown in Table 3.3, of either 'low physical activity' with a score from 1.00 to 2.33, 'moderate physical activity' with a score from 2.34 to 3.66 or classified as 'high physical activity' with the score from 3.67 till 5.00 (Kowalski et al., 2004).

Table 3.3: Classification of physical activity level

Mean Score PAQ-C	Physical Activity Level (PAL)
1.00 – 2.33	Low
2.34 – 3.66	Moderate
3.67 – 5.00	High

Source: Kowalski et al. (2004)

Below is an example of how to calculate the score for the PAQ-C questionnaire: given the score for Q1=2, Q2=4, Q3=4, Q4=4, Q5=4, Q6=3, Q7=3, Q8=5, and Q9=4. To find the mean score of PAQ-C, all the scores from Q1 – Q9 were added and divided with 9:

$$\text{Mean score} = \frac{2+4+4+4+4+3+3+5+4}{9} = 3.67$$

Then, the score was compared to Table 3.2 to know the Physical Activity Level (PAL). Thus, in this example, the PAL was a high level of physical activity.

3.8.4 Anthropometry measurement

Anthropometric assessment has been used by several researchers to determine the rate of growth of respondents (Oui et al., 2016: Ahmad et al., 2017: Azli et al., 2019). BMI-for-age was beneficial for comparing the weight and height of respondents with their age to determine if they were thin, normal, overweight, or obese (WHO, 2008), whilst determining height-for-age of respondents allowed for the possible detection of stunting or tallness (WHO, 2009). Thus, the process for measuring weight and height was followed to obtain the z-score of BMI-for-age and height-for-age (Mohd Taib et al., 2012).

For the body weight of the children, the first step in weighing fishermen's children was to set a Tanita Body Fat Analyzer (Tanita, Japan) with the electronic weight scale settings on a smooth, level platform. The weight balance was then tested, and the reading was reset to zero. After that, the researcher noted that the children were dressed in light clothing. The children then stood in the centre of the scale's surface. When the children were calm and the weight reading was stable, the weight of the children was recorded, and the researcher ensured that no one held the children throughout the weighing since they were standing freely and clutching nothing. The weight of the children was recorded with an accuracy of 0.1 kg (Hamid, 2011). The measurement was taken twice, and the average reading was taken. Figure 3.3 shows a picture of how the measures are taken by one of the researchers.

For the body height of the children, to begin, the Stadiometer 222 (SECA, Germany) was placed on a flat, sturdy surface. The children then took off their shoes and headgear. The children were then told to step on the stadiometer while standing upright in the middle by the researcher. While the measurer placed the head and cursor, the fishermen's children's heels and knees were firmly pressed on the board. The board is touched by the children's heads, shoulders, buttocks, knees, and heels. The measurement was given to the closest 0.1 cm (Hamid, 2011). Same as weight, the measurement will be taken twice, and the average reading will be taken.

After that, the data was analysed using WHO AnthroPlus software version 1.0.4 (Geneva, Switzerland) to obtain a z-score. Then, the z-score of BMI-for-age and height-for-age were referred to WHO growth charts to determine the nutritional status of the children. Table 3.4 shows the cut-off criteria for both BMI-for-age and height-for-age. Using the WHO z-score for interpretation is better as the scale is linear and it has fixed intervals for the height difference, in cm, and weight differences, in kg, for all children. It is also sex-dependent that allows the child’s growth evaluation. Then, it allows a computation summary of the means, standard deviations, and standard errors to classify population growth’s status.

Table 3.4: Growth indicators for children, WHO z-score

BMI-for-age		Height-for-age	
Category	**Z-score (SD)**	**Category**	**Z-score**
Severe thinness	≤ -3.00	Severely stunted	-3.00 – -3.99
Thinness	-2.00 – -2.99	Stunted	-2.00 – -2.99
Normal	-1.99 – 0.99	Normal	-1.99 – 2.99
Overweight	1.00 – 1.99	Tallness	≤ 3.00
Obesity	≤ 2.00		

Source: WHO (2000)

3.8.5 Urinary iodine analysis

The laboratory method commonly used to evaluate the concentration of urinary iodine is based on the Sandell-Kolthoff reaction. Removals of interfering substances in the initial digestion step will be carried out prior to the Sandell-Kolthoff reaction. The readings will be acquired by using spectrophotometry or colorimetry. The principle of the Sandell-Kolthoff reaction is to measure the iodine concentration, which can reduce the yellow-coloured ceric ammonium sulphate (Jooste & Strydom, 2010). A constant period is used to measure the decolorization of the yellow colour by using a spectrophotometer. The higher the iodine concentration, the faster the solution decolorizes, resulting in lower absorbance reading. Finally, a standard curved will be constructed with known iodine concentration. The data obtained from the standard iodine graph will be used to sketch the standard graph by using Microsoft Excel. The data from the urine sample was analysed using the standard graph gradient or $y = mx+C$.

The urinary iodine analysis procedure is illustrated in Figure 3.4. Respondents' urine samples were obtained using the 24-hour urine collection method. To ensure the accuracy of the collection and minimize errors, the enumerator provided clear instructions to the mothers and children prior to the initiation of the collection process. Participants were given a sterile, screw-top jar, labelled with the sample code and start time. The initial urine sample was discarded, and all subsequent specimens were collected up until the same time the following day (Asakura et al., 2014; Katagiri et al., 2016). The collected urine samples were then stored in a freezer at a temperature of -20°C. Prior to the analysis, the samples were thawed at room temperature (25°C), with the thawing duration dependent on the volume of the urine samples. Larger volumes required more time for complete thawing. The range volume of urine collected is 800 to 2000 millilitres. All urine collections commenced in the morning and were retrieved the subsequent morning. The analysis was conducted in the afternoon or evening of the same day the samples were collected.

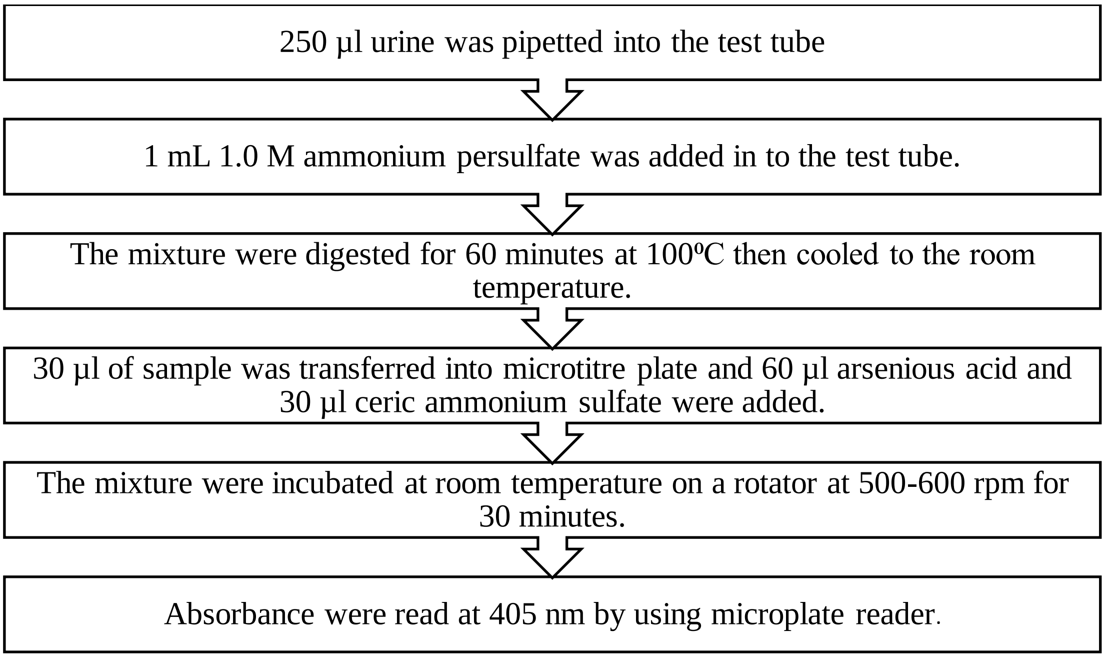

Figure 3.4: Procedure of urinary iodine analysis

The standard for urinary iodine was prepared before the analysis was carried out, and which concentrations used will be 0, 10, 40, 80, 120, 200, 280, and 300 µg/L through a dilution solution of iodine (1.0 X 104). Each standard sample (250 µl) and the urine sample (250 µl) were pipetted into the test tube (13 X 100 mm). After that, 1 ml 1.0 M ammonium persulfate was pipetted into each of the standard samples and sample test tubes. Next, the mixtures were heated at 100ºC for 60 minutes and cooled down at room temperature.

About 30 µl of standard sample and sample was pipetted into the microtiter plate, and 60 µl arsenious acid solutions were pipetted to each well. Then, 30 µl ceric ammonium sulphate solutions were pipetted rapidly into each well within 15 seconds. After that, the samples were incubated at room temperature at 500-600 rpm for 30 minutes, followed by reading the absorbance at 405 nm (Hussain et al., 2006). In this study, microplate reader Multiskan Ascent models 96 & 384 (Thermo Fisher Scientific, US) were used to read the absorbances of iodine. After the readings were obtained, the result was compared to the classification shown in Table 3.5.

Table 3.5: Classification of median urinary iodine (6 years or older)

Median urinary iodine (µg/L)	Iodine intake	Iodine status
<20	Insufficient	Severe iodine deficiency
20-49	Insufficient	Moderate iodine deficiency
50-99	Insufficient	Mild iodine deficiency
100-199	Adequate	Adequate iodine nutrition
200-299	Above requirement	May pose a slight risk of more than adequate iodine intake in these populations
≥300	Excessive	Risk of adverse health consequences (iodine-induced hyperthyroidism, autoimmune thyroid disease)

Source: WHO (2013)

3.8.6 Cognitive assessment

The cognitive assessment used for this research is Raven’s Coloured Progressive Matrices (RCPM). Raven’s Coloured Progressive Matrices is internationally recognized as a culture-fair or culture-reduced test of non-verbal intelligence for young children. It is designed for young children, the elderly, and people with moderate or severe learning difficulties (Cotton et al., 2005). The primary goal of RCPM is to assess one's ability for education, which is comparable to fluid intelligence as stated in the most recent version of the psychometric theory of intelligence, the Cattell-Horn-Carroll Theory of Cognitive Abilities (Schneider & McGrew, 2012). The benefits of this test compared to any other tests are this test is nonverbal, does not require communication, and is reading-free. Thus, it will be less burden to a subject who has disadvantages in language and communication.

According to Ghazali et al. (2018), the RCPM is a reliable and valid instrument for assessing intelligence in Malaysian children. The Cronbach's alpha values for the subset scores and the overall score for the RCPM were in the range of 0.70 to 0.87, which is regarded as good for the instrument's internal consistency (Hamid, 2011). This demonstrates that the RCPM is not only a reliable and valid tool for assessing intelligence in Malaysian children but also a consistent instrument. Furthermore, studies by Tai & Ali (2018) and Ali et al. (2018) also utilized this approach to assess cognitive performance in fishermen's children, which is the same aim as our study.

The assessment contained 36 questions, and each question is a picture with a missing part at the corner of the right bottom. RCPM is divided equally into three subsets, which are Subset A, AB, and B (Raven, 2008). Subset A in RCPM that children’s ability to find the missing part of each pattern or puzzle; it is the easiest part of the RCPM test. Subset AB aims to determine children’s ability to recognize the association of patterns and relatedness to the alternatives given. Next, Subset B consists of the most challenging items to test children’s ability in abstract thinking (Kazem et al., 2009). Thus, this RCPM test has been created to distinguish between degrees of intellectual maturity by quantifying a child’s ability to form comparisons and reason by analogy.

Each respondent was assessed individually by the same set of questions, and 15 to 20 minutes of time were given to answer all the questions. Before the assessment start, the respondent moves to different room to avoid any disturbance. After the briefing, a flashcard that contained the question was displayed to the respondents, and then they were required to tell the researcher their choices before proceeding to the next question. Figures 3.7 shows some examples of the question that include in the test. The correct answer was given one score, whereas the wrong answer was given zero, and thus the raw score on the RCPM test ranges between zero and 36. Then, RCPM standard scoring system will be applied to convert their raw total score into percentile rank by referring to Raven’s standard table (Table 3.6). Total raw was converted to percentile rank with respect to his /her biological age. After that, the respondent was categorized into seven categories which were extremely low, borderline, low average, average, high average, superior, and very superior. Furthermore, for the purpose of analysis of objectives 3 and 4, the standard scores were also grouped into the low and high groups, as it is shown in Table 3.7. Figure 3.6 shows how the RCPM test was answered by the children.

Figure 3.5: One of the respondents answering the RCPM test.

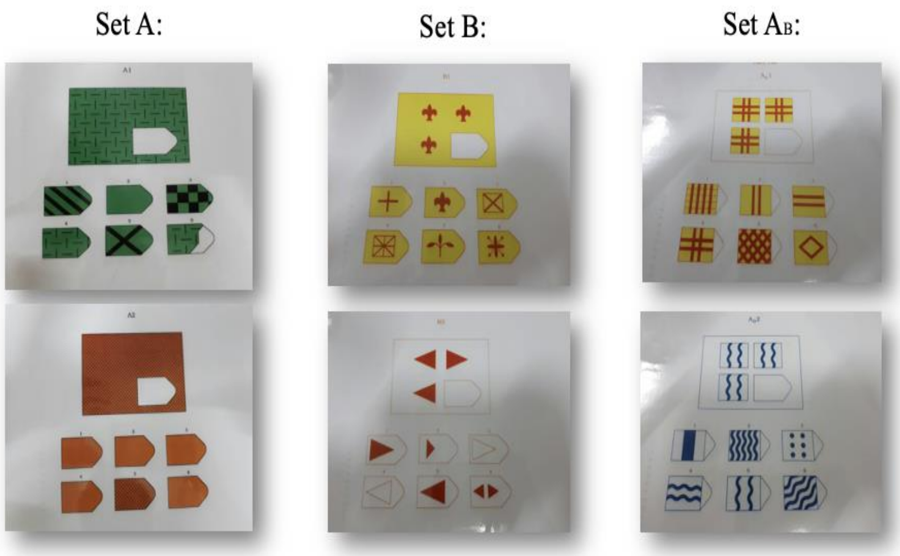

Figure 3.6: Example of the diagrammatic puzzle of RCPM.

Table 3.6: Conversion table of RCPM test from raw score to a standard score.

Age in years, months, and days					**Standard score**
7y0m0d-7y11m30d	**8y0m0d-8y11m30d**	**9y0m0d-9y11m30d**	**10y0m0d-10y11m30d**	**11y0m0d-11y11m30d**	
1-11	1-14	1-16	1-18	1-20	<60
12	15	17	19	21	60
12	16-17	18	20	22-23	65
14-15	18-19	19	21	24-25	70
16-17	20-21	20-21	22-23	26-27	75
1-8-19	22-23	22-23	24-25	28	80
20-21	24-25	24-25	26-27	29	85
22-23	26	26-27	28-29	30	90
24-25	27	28	30	1-32	95
26-27	28	29-30	31-32	33	100
28	29	31	33	-	105
29	30	32	-	34	110
30-31	31	33	34	35	115
32	32	34	35	-	120
33	33	35	36	36	125
34	34	-	-	-	130
35	35	36	-	-	135
36	36	-	-	-	140

Source: Raven (2008)

Table 3.7: Categories for RCPM test standard score.

Group	**Category**	**Standard score**
Low	Extremely low	<70
	Borderline	70-80
	Low average	80-90
High	Average	90-110
	High average	110-120
	Superior	120-130
	Very superior	>130

Source: Raven (2008)

Below is an example of how to calculate the RCPM score: given 10 years 4 months, the old boy joined the survey and scored 28 out of 36 questions during the cognitive assessment. The score was then compared to Raven's standard table (Table 3.6). Thus, the standard score was 90. After that, the standard score was compared to Table 3.7 to know which category the boy fell into. As a result, he was categorized as average, which required good general ability from a nonverbal perspective.

3.9 Pilot study

The study's pilot test involved 30 respondents, all of whom were fishermen's children residing in Kuala Nerus and Kuala Terengganu. The objective of the pilot test was to determine the feasibility of the questionnaire and the approach used during data collection on the research. The questionnaire was presented along with a brief explanation of the study's goals and objectives. The purpose of the test was to determine how long it took a respondent to finish the questionnaire. Aside from that, the aim was to record and predict the response of the responder for future reference to make the data-gathering process easier. In addition, throughout the pilot test, any faults that were overlooked were also identified. The following, Table 3.8, is a summary of the pilot test:

Table 3.8: Summary of the pilot test

Item	Details
Date	12th July - 21st July 2019
Location	Kuala Nerus
Respondent	30 children aged 7-11 years old
Objective	- To determine the time taken for children to finish up every section in the questionnaire - To determine the feasibility of the study approach. - To prevent overlooking errors in the questionnaires. - To familiarize with the environment of research
Average time spent	From 20 to 30 minutes
Respondent response	Good, friendly, willing to participate, and full cooperation gave the respondent.

During the pilot test, a few issues were discovered. To begin, an item had to be added to the questionnaire, such as the respondents' birthdates used in anthropometric measurement calculation and Raven's Coloured Progressive Matrices test calculation. Second, during the pilot test, the daily survey schedule was also patterned. According to the results of the pilot test, the most practical timetable for sorting out daily schedules was to restrict follow-up sessions to no more than three families in the morning and to go to at least two houses for the first day collecting data in the evening. This is to ensure the ease of data collection and avoid any errors or time constraints.

3.10 Data collection

The data collection was conducted in Kuala Nerus and Kuala Terengganu on 12th July and ended on 18th October 2019. In order to achieve 94 respondents, profiling of the fisheries communities was obtained from East Coast Economic Region Development Council (ECERDC), which constantly keeps up with the fisherman community with their tuition program conducted especially for the children from the low socio-economic status group. In addition to that, the "meet and greet" with the community itself also were included in the data collection process. Then, a subject information sheet and informed consent were given to respondents prior to data collection.

Those who voluntarily agreed to participate were given each set questionnaire and interviewed face to face either by the researcher. Figure 3.7 shows the flowchart on how the data were collected. The first part of the questionnaire is about the socio-demographic status of the household, which was collected from the parents. The data consist of the mother's educational status, monthly household income, children's age and gender, and the number of households.

Then, they proceeded to anthropometric measurements, where the height and weight of the children were collected. The third part of the data collection was the two-day, 24-hour dietary recall questionnaire. The children were assisted and guided by the researcher to fill up the questionnaire. Then, they will follow up on another day to fill up the questionnaire again. The next part is the physical activity assessment. The researcher yet again guided the children for this section. After that, they proceed with the assessment of the cognitive function of the children. At this point, the assessment was done solely to the ability of the children. The last part of the data collection was to collect a urine sample for urinary iodine analysis via the 24-hour urine collection method. A sterile, screw-top container with a sample code and the labelled start time was given to all the participants. Participants discarded the first urine sample at that time, and then, all following specimens were gathered until the same time as the next day's start time (Asakura et al., 2014; Katagiri et al., 2016). The sample was then stored in the freezer until needed to analyse After all the assessments were done, the questionnaire was collected, and the respondent was given some token as a sign of appreciation for participating in the study. Data collected were then analysed accordingly.

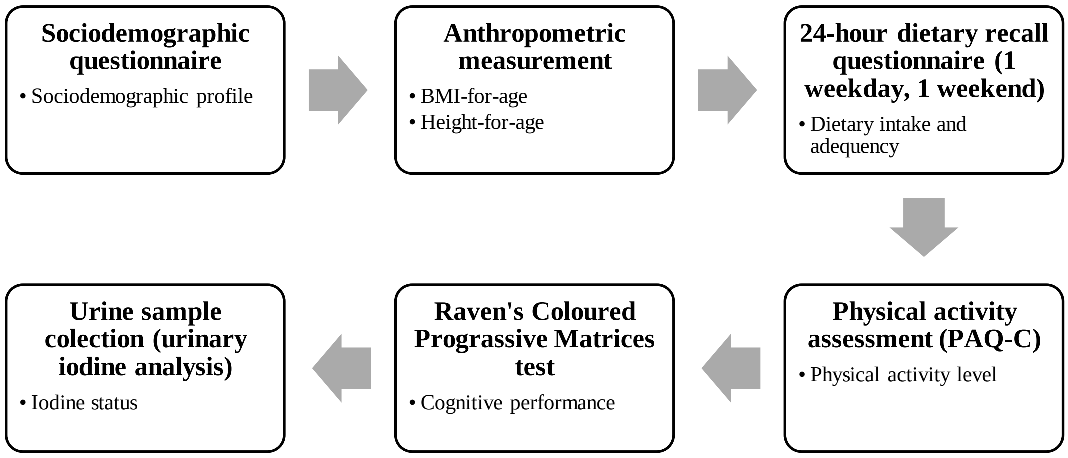

Figure 3.7: Flowchart of data collection

3.11 Data analysis

Data were analysed using Statistical Package for Social Sciences (SPSS version 20.0). Categorical data were described using count, percentages, and 95% confidence intervals when applicable. Numerical data were checked for normal distribution and described as mean and standard deviation if normally distributed and as median and inter-quartile range if not normally distributed. Normality tests including Kolmogrov-Smirnov test (n > 50).

Firstly, for objectives 1, descriptive tests were used, and the data were presented in frequency, percentage, and graphs. For objective 2, Pearson Chi-square were used to determine the association between 2 categorical variables. However, if more than 20% of cells have an expected count of less than 5, Fischer exact test was used. In this study, the relationship between cognitive performance with age, gender, monthly household income, energy, carbohydrates, protein, fats, dietary fiber, thiamine, riboflavin, niacin, vitamin B6, folate, vitamin B12, vitamin C, vitamin A, vitamin E, calcium, zinc, iron, sodium, potassium, BMI-for-age, height-for-age, median urinary iodine, and physical activity score was analysed by using Pearson Chi-square, while the relationship between cognitive performance and number of household members, mother's educational level, and mother's occupation was examined by using Fischer exact test value. A dummy variable was created beforehand for variables that have more than two categories, and the highest frequency becomes references.

Lastly, for objective 3, binominal logistic regressions were performed on the factors that have a relationship with cognitive performance (mother's educational level, BMI-for-age, protein, and niacin) to identify the most risk factor that influences cognitive performance among fishermen's children in Terengganu. In all analyses, the significance level was set at $p < 0.05$. The summary of the data analysis is shown below in Table 3.9.

Table 3.9: Summary of data analysis

Objective	**Types of analysis**
Objective 1: To determine diet adequacy, nutritional status, physical activity, cognitive performance, and socio-demographic profile that contribute toward the cognitive performance of all the selected fishermen's children in Terengganu.	Descriptive analysis
Objective 2: To determine the relationship between factors (dietary intake, nutritional status, physical activity, and socio-demographic profile) and cognitive performance of all the selected fishermen's children in Terengganu.	Pearson Chi-square (age, gender, monthly households income, energy, carbohydrates, protein, fats, dietary fibre, thiamine, riboflavin, niacin, vitamin B6, folate, vitamin B12, vitamin C, vitamin A, vitamin E, calcium, zinc, iron, sodium, potassium, BMI-for-age, height-for-age, median urinary iodine, and physical activity score) Fischer exact test (number of household members, mother's educational level, and mother's occupation)

Objective 3: To determine risk assessment towards cognitive performance and identify the most risk factor that influences cognitive performance via logistic regression of all the selected fishermen’s children in Terengganu through children’s anthropometry, biomedical assessment, dietary assessment, physical activity, and the fishermen’s socio-demographic profile.	Binominal logistic regressions

CHAPTER 4

RESULT AND DISCUSSION

4.1 Socio-demographic profile

For this study, there were 94 fishermen’s children whose willing and able to join this study. Based on Table 4.1, the children comprised 46.8% males and 53.2% females, with a median age of 9.0 (3.0) years. The higher number of female respondents in the current study are consistent with earlier studies by Ali et al. (2020) and Tai & Ali (2018), which were also done on fishermen household in Terengganu. Most participants [88.3% (n = 83)] belong to families with a monthly income of less than RM 1,500, while the rest, 11.7%, were in the range between RM1500 to RM2999. Based on the monthly household income, more than half of the fishermen's households are living in poverty, as Malaysia’s poverty line income is RM2,208 (Landau, 2020). Similarly, a study by Yeo et al. (2007) shows only about one-third of the households of the fishers on the East Coast of Malaysia were above the monthly poverty line income. One probable explanation is that current environmental change has an influence on marine productivity, particularly the number of fish caught (Idris et al., 2018; Johnson & Welch, 2010; Nursyazwin and Zein, 2019). Climate change, such as changes in rain patterns (Idris et al., 2018; Subramaniam et al., 2011; Wan Azli, 2010), monsoon pattern imbalance (Kajikawa, 2012; Suhaila et al., 2010; Yaakob & Chau, 2005) and high wind and waves and dangerous occurrences (Tangang, 2007), disrupted the fishermen's fishing schedule, preventing them from working for days owing to safety concerns. Income is considered important as it is one of the main factors influencing the enhancement of the fishermen’s quality of life (QoL) due to it being crucial for their survival (Ghani et al., 2017; Zain et al., 2018). Thus, having an income below the poverty line can influence the household’s lifestyle. Furthermore, children living in poverty usually experience fewer cognitive encouragements and enrichments in comparison to children from wealthier backgrounds (Hair et al., 2015; Mutaza et al., 2019) which could influence the cognitive development among the fishermen's children.

Table 4.1: Socio-demographic profile of fishermen's children (n = 94)

Characteristics	Distribution n (%)	Median (IQR)
Gender		-
Male	44 (46.8)	
Female	50 (53.2)	
Age		9.0 (3.0) years
7	20 (21.3)	
8	19 (20.2)	
9	15 (16.0)	
10	14 (14.9)	
11	26 (27.7)	
Monthly household income[a]		-
< RM1500	83 (88.3)	
RM 1500 – RM2999	11 (11.7)	
Number of household members		-
1-5	44 (46.8)	
6-10	44 (46.8)	
11-15	6 (6.4)	
Mother's education level		-
Primary school	20 (21.3)	
Secondary school	68 (72.3)	
Certificate/Diploma	5 (5.3)	
Degree	1 (1.1)	
Mother's occupation		-
Small business	5 (5.3)	
Shop helper	8 (8.5)	
Babysitter	3 (3.2)	
Housewife	64 (68.1)	
Others	14 (14.9)	

[a]The division of income level was adapted from a previous study that conducted a socioeconomic profile comparison of the fishermen's community in Terengganu (Zainuddin et al., 2019)

The household members distribution for 1 to 5, 5 to 10 and 11 to 15 people were 46.9% (n = 44), 46.9% (n = 44) and 6.3% (n = 6), respectively. According to Rhoumah (2016), as the number of household members rises by one unit, the likelihood of being poor rises by 28.51% as more people add expenses. Rhoumah's study shows that household members had a correlation with poverty. As mentioned above, the fisheries community is prone to poverty. Studies were done by Ilhab et al. (2014), and Hui et al. (2014) also revealed that the number of family members contributes to food insecurity which influences their dietary intake and nutritional status.

Based on the data that collected, more than half of the participants mothers [72.3% (n = 68)] had completed their formal education until secondary school, 21.3% (n = 20) attended primary school only, 5.3% (n = 5) had qualification in certificate/diploma, while only 1.1% (n = 1) has a degree/higher learning qualification. The mother's educational level is important as it is one of the factors that contribute to food insecurity and undernutrition (Baker-French, 2013; Hui et al., 2014; Iftikhar et al., 2017; Ilhab et al., 2014; Moshy et al., 2013). This is probably due to knowledge exposure from the education that they receive. Maternal education has been associated with improved nutritional status throughout pregnancy and after birth (Khattak et al., 2017). This has been demonstrated to be an indirect predictor of a child's long-term health (Prickett & Augustine, 2016; Victora et al., 2008).

The last component of the sociodemographic profile is the mother's occupation. With the head of the family having a low income, they must also have at least one additional source of income to secure the financial security of themselves and their family, as fishing entails a high level of risk (Ghani et al., 2017; Zaimah et al., 2012). Thus, some of the mothers chose to run small businesses [8.5% (n = 8)], work as shop helpers [5.3% (n = 5)], babysitters [3.2% (n = 3)] or take up other jobs [14.9% (n = 14)] to help with the family's financial. However, most mothers still preferred to become a housewife [68.1% (n = 64)].

To conclude, we can see that most fishermen's households were prone to having low socioeconomic status. In terms of income, the majority of the household's monthly income falls under the poverty line. Moreover, more than half of the mothers did not work and just stayed home, being a housewife. This is concerning as it can influence the quality of the lifestyle of the household. Additional to that, the price of goods keeps increasing nowadays. Thus, there will be increasing in expenditure. This will put more struggle in their financing that could have a negative effect on many aspects such as health and life's comfort.

4.2 Dietary intake and adequacy[3]

In the study, both macronutrient and micronutrient intakes were analysed to better understand the dietary patterns of fishermen's children and investigate their relationship with cognitive performance. This analysis addressed the first objective of the study: determining the dietary intakes among fishermen's children in Terengganu. By examining these nutrient intakes, the study was able to identify which nutrients were being consumed in adequate amounts and which were not. Moreover, it determined the average intakes of all selected nutrients in the study. This information was subsequently used for further analyses to achieve the second and third objectives.

Table 4.2 provided a summary of the dietary adequacy of the fishermen's children. According to the RNI (2017), dietary adequacy is achieved when nutrient consumption is equal to or exceeds 50% of the recommended nutrient intake. The findings indicated that the children in this study had adequate intakes of calories/energy, carbohydrates, protein, riboflavin, niacin, vitamin B6, vitamin B12, vitamin A, iron, and sodium. However, they exhibited inadequate intakes of fat, dietary fibre, thiamine, folate, vitamin C, vitamin E, calcium, zinc, and potassium. By presenting a comprehensive assessment of the nutrient intakes of the fishermen's children, the study established a solid foundation for further exploring the potential links between diet and cognitive performance, ultimately contributing to a better understanding of the factors influencing their well-being.

[3] This part has been published in Journal of Taibah University Medical Sciences (2022) – (Appendix I)

Table 4.2: Dietary intake and dietary adequacy of fishermen's children (n = 94)

Nutrients	**Gender**	**Age group**					
		7-9 years (n=54)			**10-11 years (n=40)**		
		RNI	**Mean ± SD / Median (IQR)**	**% of fulfilment**	**RNI**	**Mean ± SD / Median (IQR)**	**% of fulfilment**
Energy (kcal)	Boys	1750	884.65 (443.22)	50.55	1930	1315.57 ± 354.52	68.16
	Girls	1610	1047.09 (284.98)	65.04	1710	1130.60 ± 274.97	66.12
Carbohydrates (g)	Boys	219-284	142.44 ± 45.23	65.04	241-314	174.70 ± 51.83	72.49
	Girls	201-262	145.83 (47.42)	72.55	214-278	154.43 ± 41.75	72.16
Protein (g)	Boys	23	41.61 ± 12.46	180.91	30	52.52 ± 16.15	175.07
	Girls	23	46.45 ± 9.21	201.96	31	44.77 ± 12.35	144.42
Fat (g)	Boys	49-68	26.70 (15.14)	39.26	54-75	45.23 ± 14.10	60.31
	Girls	45-63	41.82 ± 10.42	66.38	48-67	37.72 ± 12.95	56.30
Dietary fibre (g)	Boys	20-30	1.56 (1.33)	7.80	20-30	2.11 (1.71)	10.55
	Girls	20-30	2.51 ± 1.81	12.55	20-30	2.10 ± 0.89	10.50
Thiamine (mg)	Boys	0.9	0.26 (0.18)	28.89	1.2	0.34 ± 0.80	28.33
	Girls	0.9	0.34 ± 0.12	37.78	1.1	0.30 ± 0.13	27.27
Riboflavin (mg)	Boys	0.9	0.69 ± 0.29	76.67	1.3	0.84 ± 0.23	64.62
	Girls	0.9	0.81 ± 0.31	90.00	1	0.72 ± 0.24	72.00
Niacin (mg)	Boys	12	8.08 ± 3.46	67.33	16	10.96 ± 3.65	68.50
	Girls	12	9.97 ± 3.96	83.08	16	9.67 ± 3.33	60.44
Vitamin B6 (mg)	Boys	1.0	0.65 ± 0.34	65.00	1.3	0.90 ± 0.29	69.23
	Girls	1.0	0.79 ± 0.32	79.00	1.2	0.76 ± 0.289	63.33
Folate (µg)	Boys	300	38.61 (22.10)	12.87	400	52.05 ± 20.25	13.01
	Girls	300	54.7 ± 24.90	18.23	400	36.80 ± 19.16	9.20
Vitamin B12 (µg)	Boys	2.5	2.14 ± 1.37	85.60	3.5	2.43 ± 1.81	69.43
	Girls	2.5	1.62 (1.22)	64.80	3.5	1.79 ± 0.99	51.14
Vitamin C (mg)	Boys	35	27.07 ± 25.63	77.34	65	27.93 ± 17.52	42.97
	Girls	35	19.58 (39.62)	55.94	65	29.39 ± 20.33	45.22
Vitamin A (µg)	Boys	500	587.47 (354.98)	117.49	600	990.07 ± 348.73	165.01
	Girls	500	903.28 (657.63)	180.66	600	1028.90 (624.57)	171.48
Vitamin E (mg)	Boys	7	2.20 ± 1.40	31.43	10	3.48 ± 1.53	34.80
	Girls	7	3.05 ± 1.40	43.57	7.5	2.86 ± 2.08	38.13
Calcium (mg)	Boys	1000	210.90 (1.39)	21.09	1300	377.32 ± 147.56	29.02
	Girls	1000	336.33 ± 136.49	33.63	1300	323.57 ± 105.83	24.89

Zinc (mg)	Boys	5.7	2.66 (1.71)	46.67	7	2.99 (1.83)	42.71
	Girls	5.6	3.61 ± 1.34	64.46	6.3	3.31 ± 1.51	52.54
Iron (mg)	Boys	9	7.87 (5.25)	87.44	15	16.00 ± 6.92	106.67
	Girls	9	16.45 ± 10.57	182.78	14	11.24 (16.78)	80.29
			7-8 years (n=39)[a]			**9-11 years (n=55)[a]**	
Sodium (mg)	Boys	1200	1047.72 (749.19)	87.31	1500	1608.81 ± 684.25	107.25
	Girls	1200	1528.48 ± 626.30	127.37	1500	1696.13 ± 615.44	113.08
Potassium (g)	Boys	3.8	0.63 ± 0.24	16.58	4.5	0.86 ± 0.30	19.11
	Girls	3.8	0.74 ± 0.22	19.47	4.5	0.79 ± 0.26	17.56

[a]Different age group was used referred to RNI for Malaysia (2017).

Energy for the metabolic and physiological functions of humans is derived from the chemical energy bound in food carbohydrates, fats, proteins, and alcohol, which act as substrates or fuels (Elia & Cummings, 2007; FAO, 2003; RNI, 2017). When we look at boys aged 10-11 years old, girls aged 7-9 years old, and girls aged 10-11 years old group, they achieve more than 60% of fulfilment. This reflects in their carbohydrates, fats, and proteins intakes, where most of them exceed the recommendation. However, there is a low rate of the fulfilment of energy for boys aged 7-9 years old, which is 50.55%. Even though the intake is adequate, it is still lower compared to the other group. This finding is contradicted by previous studies, which found that the dietary energy intake among boys is higher compared to girls (Abdul Majid et al., 2016; Ng et al., 2019; Poh et al., 2013). A possible explanation is that there is less intake of carbohydrates and fats that may contribute to low energy intake. As mentioned earlier, energy is derived from the chemical energy bound in food carbohydrates, fats, proteins, and alcohol. With this, having lower carbohydrate and fat intake could lower energy intake.

An interesting finding that can be concluded from the results in terms of macronutrient intakes is that the protein intakes are almost twice the RNI recommendation compared to carbohydrates and fats intakes. There are several studies conducted in various part of Malaysia that also recorded high intakes of protein (Table 4.3). Table 4.3 offers a comprehensive overview of selected studies conducted in Malaysia, investigating protein intakes among children. The following brief summary of each study highlights the unique insights provided by each investigation. Poh et al. (2013) executed an extensive SEANUTS survey across Malaysia, discovering diverse protein intakes across different age groups, genders, and geographic regions. For instance, urban 4-6.9-year-old boys consumed 56.7 ± 1.1g of protein, while rural boys in the same age group consumed 57.3 ± 1.6g. Additional data on protein intakes were reported for 4-6.9-year-old girls and 7-12-year-old boys and girls in urban and rural areas. Protein intakes in this study surpassed those observed in the present study (41-52g) and exceeded the RNI recommendation (23-31g). Hwee Shan et al. (2018) investigated protein intakes among 7-9 and 10-11-year-old boys and girls in Terengganu. Their findings revealed fluctuating protein consumption patterns across age and gender groups. For example, boys aged 7-9 years old consumed 53.45 ± 13.56g of protein, while girls in the same age group consumed 42.84 ± 10.18g. Some age groups displayed protein intakes comparable to the present study, while others exceeded the RNI recommendation. Zalilah Mohd Shariff et al. (2015) conducted a study in Wilayah Persekutuan and Selangor, focusing on 7-10-year-old children from low, middle, and high-income families. Their results demonstrated a positive correlation between protein intakes and income levels, with high-income children consuming the highest amount of protein (71.24 ± 1.76g). All income groups displayed protein intakes higher than those observed in the present study (41-52g) and exceeded the RNI recommendation (23-31g). Foo et al. (2006) assessed protein intakes among 12-15-year-old boys and girls in the Tuaran District, Sabah. Their data indicated that boys in this age group consumed 57.8g of protein, while girls consumed 52.5g. These protein intakes were higher than those observed in the present study (41-52g) and surpassed the RNI recommendation (23-31g). Abdul Majid et al. (2016) examined protein consumption among 13-year-old boys and girls in Kuala Lumpur, Selangor, and Perak. Their results showed protein intakes of 65.7g for boys and 58.7g for girls. These protein intakes exceeded those observed in the present study (41-52g) and surpassed the RNI recommendation (23-31g). Mohd Nasir et al. (2017) conducted the innovative MyBreakfast study in Malaysia, comparing protein intakes between children who consumed ready-to-eat cereals (RTEC) and those who did not (non-RTEC). Their findings revealed that RTEC consumers had a marginally higher protein intake (81.1 ± 26.1g) than non-RTEC consumers (79.8 ± 23.8g). Both RTEC and non-RTEC consumers exhibited protein intakes higher than those observed in the present study, exceedingly nearly four times the RNI recommendation.

Table 4.3: Selected studies regarding protein intakes in Malaysia

Study	Location	Protein intakes
Poh et al. (2013)	Malaysia (SEANUTS survey)	- 4-6.9 years old boys - urban (56.7 ± 1.1g) - rural (57.3 ± 1.6g) - 4-6.9 years old girls - urban (53.6 ± 1.1g) - rural (55.1 ± 1.5g) - 7-12 years old boys - urban (74.9 ± 1.0g) - rural (72.5 ± 1.2g) - 7-12 years old girls - urban (70.8 ± 0.8g) - rural (68.8 ± 1.5g)
Hwee Shan et al. (2018)	Terengganu	- boys aged 7-9 years old (53.45 ± 13.56 g) - girls aged 7-9 years old (42.84 ± 10.18 g) - boys aged 10-11 years old (48.76 ± 15.00 g) - girls aged 10-11 years old (50.95 ± 15.92 g)
Zalilah Mohd Shariff et al. (2015)	Wilayah Persekutuan and Selangor	- 7-10 years old - Low Income (60.74 ± 2.15g) - Middle income (64.26 ± 1.81g) - High income (71.24 ± 1.76g)
Foo et al. (2006)	Tuaran District, Sabah	- boys 12-15 years old (57.8g) - girls 12-15 years old (52.5g)
Abdul Majid et al. (2016)	Kuala Lumpur, Selangor, and Perak	- 13 years old boys (65.7g) - 13 years old girls (58.7g)
Mohd Nasir et al. (2017)	Malaysia (MyBreakfast study)	- 81.1 ± 26.1g (RTEC) - 79.8 ± 23.8g (non-RTEC)

A plausible explanation for the elevated protein intake observed in our study could be the high consumption of protein-rich foods, particularly meat and poultry. Zalilah Mohd Shariff et al. (2015) reported that children in their study consumed an average of 1.43 servings of meat and poultry, which exceeds the recommended one serving. This finding contributed to the high protein intakes among 316 children aged 7-10 years in Wilayah Persekutuan and Selangor. Similarly, in our study of fishermen's children, we observed a marked preference for protein-rich foods, such as chicken. Detailed information on the types of food consumed by the children in our study can be accessed via the following link:

https://docs.google.com/spreadsheets/d/1EcdOfNxZbxkhy6prCpXnPUeN3Hy-46VDvDO5TXhQeyk/edit?usp=sharing.

In summary, the six studies highlighted in Table 4.3 consistently reported higher protein intakes among children compared to the present study, often exceeding the RNI recommendations. This observation raises the question of whether such high protein intakes could potentially be a cause for concern. While it is important to ensure children receive adequate nutrition, excessive protein intake might also have implications for their health. Further research and analysis are necessary to determine the potential short-term and long-term health consequences of these elevated protein intakes among Malaysian children.

Dietary fibre does not classify as a necessary nutrient. However, it has grown to be recognized as a key part of a nutritious diet that plays a role in both health and illness over time (Barber et al., 2020; Dhingra et al., 2012; Lunn & Buttriss, 2007). Based on Table 4.2, for the fishermen's children population in Terengganu, there is a low intake of dietary fibre. The respondents were able to fulfil only between 7.80% and 12.55%. Boys aged 7-9 years old had the lowest rate of fulfilment, with only 7.80%, followed by girls aged 10-11 years old, boys aged 10-11 years old, and girls aged 7-9 years old, with 10.50%, 10.55%, and 12.55%, respectively. These results are consistent with those of other studies and suggest that there are low dietary fibre intakes among children. In Kelantan, Malaysia, 170 Malaysian adolescents were found to have a low intake of dietary fibre (2.7 ± 7.3 g/day) (Nurul Fadhilah et al., 2012). Besides that, Ng et al. (2016) found that the mean daily consumption of dietary fibre among Malaysian teenagers was still lower than the recommended dietary fibre daily intake (20-30g/day) (NCCFN, 2017), with a mean of 12.4 ± 5.3 g/day dietary fibre. This is probably due to a lack of consumption of vegetables, fruits, whole grains, nuts, and legumes which contain high dietary fibre (Bandoh and Kenu, 2017; Murillo-Castillo et al., 2020; Nurul Fadhilah et al., 2012). In the current study, based on the 24-hour dietary recall, there is very low consumption of fruits, where there are only apples, watermelon, oranges, and pineapple recorded in the recall. As for vegetable consumption, there is more variety, such as carrots, water spinach, and fiddlehead fern. However, the amount of consumption is still low and does not meet the three servings of vegetables everyday recommendation. This is probably due to the lack of fruit and vegetable availability at home may have a substantial impact on children's actual intake (Woon et al., 2014); this also emphasizes the need for parents to foster a healthy eating environment (Hall et al., 2011; Pollard et al., 2011).

As for micronutrients, there are some that meet fulfilment, some are not, and some that are exceeded. For thiamine intake, the respondents were able to fulfil between 27.27% and 37.78%. Girls aged 10-11 years old had the lowest rate of fulfilment, with just 27.27%, followed by boys aged 10-11 years old, boys aged 7-9 years old, and girls aged 7-9 years old, with 28.33%, 28.89%, and 37.78%, respectively. This shows that thiamine intakes among fishermen’s children are inadequate. A similar finding was found in a study by Foo et al. (2006), where there are lower RNI levels were attained for the intake of thiamine (56.6%) among 94 male and 105 female adolescents aged 12-19 years old in a rural fishing community in Tuaran District, Sabah. Contradict, in Kelantan, Malaysia, 115 Malaysian children aged 11 years old were found to have an adequate intake of thiamine (1.11mg for boys, 0.91mg for girls) (Wan Dali et al., 2018). This contradiction is probably due to the different populations targeted where our study and Foo et al. (2006) were conducted among fishermen children while Wan Dali et al. (2018) targeted the general population. As we know, fishermen's communities are synonymous with having a low income. Thus, their budget for buying food might be restricted. Other than that, even though some groups, which are boys aged 10-11 years old and girls aged 7-9 years old, meet the adequacy of thiamine, the intake of this micronutrient is still considered below the RNI recommendation. If this is prolonged and no improvement is made, it could affect the health of the children. A lack of thiamine can cause weakness, fatigue, psychosis, and nerve damage, and thiamine deficiency could lead to a disease called beriberi (Markell & Siddiqi, 2022; Sachdev & Shah, 2020).

For riboflavin intakes, the respondents were able to fulfil between 64.62% and 90.00%. Boys aged 10-11 years old had the lowest rate of fulfilment, with just 64.62%, followed by girls aged 10-11 years old, boys aged 7-9 years old, and girls aged 7-9 years old, with 72.00%, 76.67%, and 90.00%, respectively. This shows that riboflavin intakes among boys meet the RNI, while among girls, the intakes exceed the RNI. Contradicting our finding, a study by Anto Cordelia et al. (2019) recorded riboflavin in both genders, which is less than 50% of RNI amongst 4-6 years old indigenous children in Perak. Aside from that, a study by Koo et al. (2014) also shows that there are low mean intakes of riboflavin among children aged 10 and 11 years in Kuala Lumpur, Malaysia. It is difficult to explain this result, but it might be related to food consumption among the fishermen's children. Based on the observation from the 24-hour recall form, there is high consumption of yellow dhal gravy. Dhal is a high amount of riboflavin (Tee et al., 1997; USDA Food Composition Database, 2016) which may highly contribute to the riboflavin intake. Higher intakes of riboflavin are also related to adequate intake of the meat/poultry group (Chong et al., 2017; Koo et al., 2016; Zalilah et al., 2015). As mentioned in the protein part above, there is high consumption of protein-rich food such as chicken, egg, and fish among the fishermen's children. Thus, it is likely to have a high intake of riboflavin.

As for niacin intake, the respondents were able to fulfil between 60.44% and 83.08%. Girls aged 10-11 years old had the lowest rate of fulfilment, with 60.44%, followed by boys aged 7-9 years old, boys aged 10-11 years old, and girls aged 7-9 years old, with 67.33%, 68.50%, and 83.08%, respectively. This shows that the fishermen's children have an adequate intake of niacin. Several studies also reported that there is high intake of niacin among children (Hanazaki & Begossi, 2003; Wan Dali et al., 2018). The study by Wan Dali et al. (2018) in Kelantan recorded a high intake of niacin, especially among boys (17.55±6.30 mg) compared to girls (14.75±5.62 mg). However, a study by Koo et al. (2014) shows that mean intakes of niacin were lower compared to the Malaysian Recommended among children aged 10 and 11 years in Kuala Lumpur, Malaysia. A possible explanation for this might be that there is easier access to fish that contain high niacin. Both Terengganu and Kelantan are well-known for their fisheries activity (Rhoumah, 2016); hence fish may be more accessible to those communities. Another possible explanation for this is that, based on observation from the 24-hour recall use in this study, there is high consumption of Indian mackerel and anchovy in *'nasi lemak'*. This may contribute to the high intake of niacin as it is found abundantly in fish and shellfish (Hanazaki & Begossi, 2003; Tee et al., 1997; USDA Food Composition Database, 2015).

For vitamin B6 intakes, the respondents were able to fulfil between 63.33% and 79.00%. Girls aged 10-11 years old had the lowest rate of fulfilment, with 63.33%, followed by boys aged 7-9 years old, boys aged 10-11 years old, and girls aged 7-9 years old, with 65.00%, 69.23%, and 79.00%, respectively. This shows that the fishermen's children in Terengganu have an adequate intake of vitamin B6. This finding is in agreement with Annan et al. (2019) findings which showed that there is adequate intake of vitamin B6 among 438 schoolchildren aged 9–13 years from Ghana. This is further supported by Bailey et al. (2021), where there is also adequate intake of vitamin B6 among children aged 1–6 years in the United States. Another study conducted by Denney et al. (2018) also shows adequate intakes of vitamin B6 among 2427 young Filipino children aged 3-5 years old. It seems possible that these results are due to high protein intake. Vitamin B6 is available in a wide variety of foods, particularly in meat, fish, and poultry (Mielgo-Ayuso et al., 2018; Roth-Maier et al., 2002; USDA, 2015). These findings may help us to understand that there is a relationship between vitamin B6 and protein intake. Another finding to highlight is that there are few studies regarding vitamin B6 intake among children in Malaysia. This is probably due to deficiency in vitamin B6 is rare because the amount absorbed exceeds physiological needs, except in individuals with autoimmune disorders (RNI, 2017). However, it will be interesting to know more regarding this topic as this study only cover the fishermen's children population.

As for folate intake, the respondents were able to fulfil between 9.20% and 18.23%. Girls aged 10-11 years old had the lowest rate of fulfilment, with just 9.20%, followed by boys aged 7-9 years old, boys aged 10-11 years old, and girls aged 7-9 years old, with 12.87%, 13.01%, and 18.23%, respectively. This show that there is a low intake of folate among fishermen's children population as none of the age group and gender exceed 50% of the RNI. These results are consistent with those of other studies and suggest that there is a low intake of folate among children and adolescents, generally. According to research by Yilma et al. (2021) among adolescent girls in south-central Ethiopia, 83.9% reported insufficient consumption of folate. Other than that, a study by Annan et al. (2019) also shows that 53.0% of 438 schoolchildren aged 9–13 years in Ghana had inadequate folate intake. It is possible that this is related to the current study's low intake of fresh green vegetables. A diet rich in fresh green vegetables (more than three servings daily) is a good source of folate (Chew et al., 2012). Furthermore, the foods consumed in this research were heavily cooked, which might result in significant folate loss during the cooking process (Chew et al., 2012; Yilma et al., 2021). Inadequate intake of folate is very concerning as it is one of the important nutrients for growth, especially among children. Deficiency in folate in children throughout the primary school can increase morbidity and significantly impair classroom attention and cognitive ability, wreaking havoc on optimal schooling and academic success (Fiorentino et al., 2017; Lam & Lawlis, 2017).

For vitamin B12 intakes, the respondents were able to fulfil between 51.14% and 85.60%. Girls aged 10-11 years old had the lowest rate of fulfilment, with 51.14%, followed by girls aged 7-9 years old, boys aged 10-11 years old, and boys aged 7-9 years old, with 64.80%, 69.43%, and 85.60%, respectively. This shows that there is a adequate intake of vitamin B12, especially among boys. Similarly, a study by Khor et al. (2011) shows that most primary-aged school children in Kuala Lumpur had adequate concentrations of vitamin B12 (n = 402). However, the concentrations of vitamin B12 in girls are higher compared to boys, which is contrary to this study's findings. The detail of self-reported dietary history was not shown in Khor et al. (2011) study. Thus, it is quite difficult to explain the difference between gender. A study by Chakraborty et al. (2018) shows males had a considerably greater rate of vitamin B12 insufficiency than females among 2403 school-going adolescents (11–17 years) from Haryana, India. Moreover, the circulatory vitamin B12 concentration of female schoolchildren is higher than that of their male contemporaries, according to studies on adolescents from Europe and South American nations (Guatemala and Columbia) (Iglesia et al., 2014; Rogers et al., 2003; Villamor et al., 2008). This is due to their need for more micronutrients than girls need to support fast muscle development during adolescence. However, the findings of the current study do not support the previous research. With this contrasting finding, it seems possible that these results are due to protein intake, as the source of vitamin B12 is exclusively animal. Based on the protein intake, boys have a higher intake compared to girls, which might explain the higher intake among boys compared to girls.

In terms of vitamin C intake, respondents ranged from 13.52% to 46.37%. Girls aged 10-11 years old had the lowest rate of fulfilment, with just 13.52%, followed by boys aged 10-11 years old, girls aged 7-9 years old, and boys aged 7-9 years old, with 15.55%, 34.57%, and 46.37%, respectively. This shows that there is inadequate intake of vitamin C among fishermen's children. Contradicts to our results, Foo et al. (2006) recorded that there are high intake of vitamin C (87-117% of RNI) among 199 healthy adolescents in a fishing community in Tuaran District, Sabah. However, a study by Hwee Shan et al. (2018) conducted among 7 to 12 years old fishermen's children in Terengganu shows inadequate intake of vitamin C. When compared to recommended vitamin C intake, the average intake of vitamin C among fishermen's children aged 7-9 years old was substantially greater than fishermen's children aged 10-12 years old. This finding matched Poh et al. (2013) study, which found that as the children's age grew, the proportion of vitamin C consumption was substantially lower than the recommended dietary intake. A possible explanation for these results may be the lack of consumption of fresh fruit and vegetable. A study by Pysz et al. (2015) mention that children and adolescents' daily meals should include more fresh produce that is high in vitamin C and other natural antioxidants. The rapid increase in fruit and vegetable prices in Malaysia in recent years might be one factor for the fishermen's children's low fruit and vegetable intake (Department of Statistics, 2017). Because of their poor incomes, the fisherman may be able to only purchase critical food sources that supply energy and macronutrients, limiting their access to other food categories such as fruits and vegetables. Other than that, preference, attitude, and parental intake are all possible contributors to children's poor fruit and vegetable eating (Rasmussen et al., 2006).

For vitamin A intakes, the respondents were able to fulfil between 117.49% and 180.66%. Boys aged 7-9 years old had the lowest rate of fulfilment, with 117.49%, followed by boys aged 10-11 years old, girls aged 10-11 years old, and girls aged 7-9 years old, with 165.01%, 171.48%, and 180.66%, respectively. This shows that there is a high intake of vitamin A among fishermen's children in Terengganu. This finding corroborates the ideas of Hwee Shan et al. (2018), who suggested that the average vitamin A consumption was substantially greater than the recommended vitamin A intake in both age groups (p=0.000) among 7 to 12 years old fishermen's children in Terengganu (n=100). This conclusion matched that of Foo et al. (2006), who found a high level of vitamin A consumption among 199 adolescents in a rural fishing village in Sabah's Tuaran District. Some researchers have speculated that the fishermen's community may have a high vitamin A consumption since high-vitamin tuber crops, vegetables, and poultry are available all year (Foo et al., 2006; Hwee Shan et al., 2018). Carrots, chicken eggs, chicken, sweet potatoes, and Indian mackerel were all sources of vitamin A for these fishermen's children, according to Hwee Shan et al. (2018). Similar consumption was observed in this study, based on the 24-hour dietary recall, especially for chicken, egg, carrot, and Indian mackerel. On the other hand, the intake of vitamin A is relatively high for both ages group; however, it is still under the tolerable upper intake level (UL) of vitamin A for children aged 9-13 years which is 1,700 µg/day. The different cases were seen in children aged 7-8 years, as the UL is 900 µg/day. Vitamin A toxicity is a rather rare condition (Carazo et al., 2021; WHO/FAO, 2004). Toxicity is frequently linked to the misuse of dietary supplements, although it can also occur as a result of a higher intake of preformed vitamin A-rich foods such as liver, eggs, and others (Beltrán-de-Miguel et al., 2015; Trumpo et al., 2001). Additionally, some side effects have been reported with vitamin A administration (loose stools, headache, agitation, fever, nausea, and vomiting), although they are uncommon and usually disappear rapidly when vitamin A is stopped (Carazo et al., 2021). As long-term regular consumption of large amounts of vitamin A can result in toxic symptoms, further work is required to establish this. However, this may not be the case with these fishermen's children.

For vitamin E intakes, the respondents were able to fulfil between 31.43% and 43.57%. Boys aged 7-9 years old had the lowest rate of fulfilment, with just 31.43%, followed by boys aged 10-11 years old, girls aged 10-11 years old, and girls aged 7-9 years old, with 34.80%, 38.13%, and 43.57%, respectively. This shows that among the fishermen's children do not reach the adequacy level of vitamin E. A similar can be found in a study by Joquiño et al. (2021). The study found that all vitamin intakes were inadequate for both seasons, which are the northeast monsoon (November–March) and summer (March–June) seasons, including vitamin E among 315 fishermen's children in the Philippines. Even with very poor diets, vitamin E insufficiency is uncommon in humans unless a person has particular disorders including protein-energy malnutrition, fat malabsorption syndromes, or genetic anomalies in the synthesis of the -tocopherol transfer protein (α-TTP) (Litwack, 2011). Based on fats intake of the fishermen's children, boys aged 7-9 years old recorded the low intake of dietary fats which could contributes to low intake of vitamin E as it is fat-soluble vitamin. Another possible explanation for low intake of vitamin E is probably due to a lack of intake of high tocopherols such as vegetable oils, fat spreads from vegetable oils, seeds and nuts, and whole grains in their diet. Aside from that, children with autism spectrum disorder (ASD) also did not meet the RNI requirements for vitamin E (74.6%) in Malaysia, primarily due to food selectivity exhibited by children with ASD. Reflecting on the current study result, the low intake of vitamin E might also be due to food selectivity, as it is still can occur among typically developing children (Bandini et al., 2019). However, it is still uncertain as there is still a lack of strong evidence regarding low intake of vitamin E among children generally. Thus, future studies on the current topic are therefore recommended.

In terms of calcium intake, respondents were able to meet between 21.09% and 33.63% of the requirements. Boys aged 7-9 years old had the lowest rate of fulfilment, with just 21.09%, followed by, girls aged 10-11 years old, boys aged 10-11 years old, and girls aged 7-9 years old, with 24.89%, 29.02%, and 33.63%, respectively. This shows that the calcium intakes among fishermen's children were not adequate. These findings are consistent with Yang et al. (2017), where a large proportion of children did not meet the RNI for calcium (83.1%–100%) among 236 children aged 8 to 12 years in Kuala Lumpur and Selangor. Besides that, Hwee Shan et al. (2018) also found that the average calcium intake of the fishermen's children was considerably lower than the RNI for both age groups ($p = 0.000$). The findings were consistent with those of Foo et al. (2006), who found a low RNI level of 33.4% for calcium consumption among adolescents from rural fishing villages in Sabah. Calcium intakes are important for bone development (Frary et al., 2004; Munro, 2010; Yang et al., 2017). From infants through children in primary school, fewer children (17%–65%) were fulfilling the RNI for calcium, according to Poh et al. (2013). A possible explanation for these results may be the lack of milk/dairy consumption (Du et al., 2002). This is probably due to only a few people prefer or can afford to take milk or other dairy products, which have high calcium content. Furthermore, reduced milk and dairy product intake among the children of fishermen may be due to low accessibility of milk products among the poor (Hwee Shan et al., 2018). Babolian Hendijani and Ab Karim (2010) found that the only factor that had a significant impact on the intention to consume milk in Selangor's rural regions was the availability of milk products at home. Besides that, according to a previous study by Khor et al. (2015), children from low-income homes consumed much less milk than children from high-income households in Malaysia. It can thus be suggested that income and food availability may affect the calcium intake of the fishermen's children.

As for zinc intake, the respondents were able to fulfil between 42.71% and 64.46%. Boys aged 10-11 years old had the lowest rate of fulfilment, with 42.71%, followed by boys aged 7-9 years old, girls aged 10-11 years old, and girls aged 7-9 years old, with 46.67%, 52.54%, and 64.46%, respectively. This shows that there is adequate intake of zinc among girls while there is inadequate intake of zinc among boys. This finding is similar to study by Chin et al. (2020) where they found the consumption of zinc is required to be improved, especially among boys aged 10 to 12 who only met less than 50% of their needs among 120 homeless children aged 7-12 years living in Klang Valley. A possible explanation is there are higher requirement of zinc intake among male children and low intake of zinc from the diet and also picky eating behaviours in their daily diet (Chin et al., 2020; Volger et al., 2017). A higher requirement for zinc is needed for higher growth rate and greater proportion of muscle per kilogram body weight as muscle contains a higher content of zinc than fat (Hotz & Brown, 2004; Marcos et al. 2019). Besides that, several studies also show that being male was one of the significant risk factors for zinc deficiency reported among school children (Gibson et al., 2007; Marcos et al. 2019; Thurlow et al., 2006).

For iron intake, the respondents were able to fulfil between 80.29% and 182.78%. Girls aged 10-11 years old had the fulfilment of 80.29%, followed by Boys aged 7-9 years old, boys aged 10-11 years old, and girls aged 7-9 years old, with 87.44%, 106.67%, and 182.78%, respectively. This shows that there is a high intake of iron among fishermen's children in Terengganu, especially girls. The findings of the present study have been found to match with those by Hwee Shan et al. (2018), where it was discovered that the iron intake of subjects aged 7-9 years old was significantly higher than the recommended nutrient intake in both boys (p=0.007) and girls (p=0.001) among fishermen's children in Terengganu. This might be explained by the fact that many everyday food items in Malaysia, such as canned sardines, chicken, eggs, and anchovies, provide a convenient source of iron for children (Andersson et al., 2005; Chin et al., 2020; RNI, 2017). Another possible explanation for this is the availability of food assistance since most of the children involved in this study were enrolled in the *Rancangan Makanan Tambahan* program (RMT). A study by Tai & Ali (2018) mentions that iron achieved the highest fulfilment in breakfast intake among fishermen's children aged 7 to 12 years old in Terengganu due to food items that were prepared by RMT at schools, such as noodles soup (mee bandung) and malted drink. This can further be supported by Chin et al. (2020), who mentions that an increasing number of food assistance received from the Malaysian government and non-government organizations help with iron consumption among homeless children in Klang Valley, Malaysia. Aside from that, Hwee Shan et al. (2018) also discovered that female participants aged 10-12 years old who had begun menstruation had considerably lower average iron consumption than recommended (p=0.001). For this study, we did not record menstruation among girls aged 10-11 years for this research although some of them had most likely already begun. This might explain why this study discovered high iron consumption in that group. As a result, future research should take this into account because the recommended intakes fluctuate, and there is a risk of iron deficiency anaemia (IDA) in children. As there is an increased risk of iron deficiency with age among Malaysian children aged 6 months to 12 years old (Poh et al., 2013), this issue is quite worrying, especially when it involves a venerable group.

As for sodium intake, the respondents were able to fulfil between 87.31% and 127.37%. Boys aged 7-9 years old had the lowest rate of fulfilment, with 87.31%, followed by boys aged 10-11 years old, girls aged 10-11 years old, and girls aged 7-9 years old, with 107.25%, 113.08%, and 127.37%, respectively. This shows that there is a high intake of sodium among fishermen's children in Terengganu, especially among boys. These results match with a study by Palaniveloo et al. (2021), where the boy's intake of sodium (3371.7mg/d) was significantly higher compared to the girl's (2602.5mg/d). Alongside with it, the current result is also consistent with a study by Abdul Majid et al. (2016) and suggests that the overall sodium intake (2289.5 ± 920.9 mg/d) exceeded the recommended intake, as necessitated by the Malaysian RNI (<2000 mg/d) among 794 adolescents (aged 13-years) in Perak, Kuala Lumpur, and Selangor. Further explaining what was previously indicated, some research revealed that adolescents frequently ate the salty local snack known as *"keropok,"* which is formed from shrimp or fish combined with flour (Huat et al., 2006; Moy et al., 2006; Zalilah et al., 2006). Reflecting on this study, there is also frequent consumption of *"keropok keping"* and *"keropok lekor"* among the fishermen's children. Considering Terengganu is renowned for producing *"keropok"* (Hamat et al., 2019), this snack is widely accessible to children. Aside from that, fried rice, omelette, *"nasi lemak",* thick soy sauce, *"roti canai",* meat soups, and fried mee were also major sources of sodium, followed by oyster sauce and tomato/chili sauce (IPH, 2016; RNI, 2017) which also frequent consume among the fishermen's children especially fried rice, omelette, *"nasi lemak"* and *"roti canai"*. In Malaysia, there is a lack of studies on sodium intake among children and adolescents (Abdul Majid et al., 2016). This is critical as it will assist in teaching the children and preventing them from participating in behaviours that may affect their long-term health or encourage the onset of noncommunicable diseases such as strokes, fatal stroke, fatal coronary heart disease, and hypertension (Abdul Majid et al., 2016; Batcagan-Abueg et al., 2013; Dora et al., 2020). Future research on the current issue is thus advised.

For potassium intakes, the respondents were able to fulfil between 16.58% and 19.47%. Boys aged 7-9 years old had the lowest rate of fulfilment, with just 16.58%, followed by girls aged 10-11 years old, boys aged 10-11 years old, and girls aged 7-9 years old, with 17.56%, 19.47%, and 19.11%, respectively. This shows that there is inadequate intake of potassium among fishermen's children. The findings of the current study are consistent with those of Palaniveloo et al. (2021), who also found that there is a low intake of potassium among 999 adolescents between 13-17 years old in Malaysia, where the boy's intake of potassium is 1416.1mg/d, and girls intake of potassium is 1170.8mg/d. A possible explanation for these results may be the lack of adequate intake of fruits and vegetables. Adolescent Nutrition Survey (ANS) (2017) showed a very high prevalence of adolescents not meeting the recommended daily serving sizes of fruits and vegetables as stipulated in the Malaysian Dietary Guidelines 2010 (MDG, 2010). Approximately 70-76% of adolescents eat fewer than two servings of fruits per day, whereas 91-94% consume fewer than three servings of vegetables per day (NCCFN, 2010). Lack of fruit and vegetable consumption can be attributed to family environment factors such as parental modelling and monitoring, availability and accessibility of fruits and vegetables, structure and location of family meals, television viewing, and parenting or feeding style (Gross et al., 2010; Blisset, 2011). Considering fruits and vegetables are high in potassium, children should be encouraged to consume more of these food categories on a regular basis (Loftfield et al., 2015). Having a low potassium intake is very concerning, especially with a high intake of sodium which was also observed in this study. This is because they have been associated with a variety of cardiovascular problems, such as hypertension, in people of all ages (D'Elia et al., 2011; Lava et al., 2015). This pattern of intake also concurred with results from studies conducted locally and internationally on the intakes of these two minerals (Ahmad Majid et al., 2016; Campanozzi et al., 2015; Chmielewski & Bryan, 2017).

Overall, we can see there is a high intake of protein among the fishermen's children. This high intake of protein from chicken, eggs and Indian mackerel also contributed to several micronutrient intakes such as riboflavin, niacin, vitamin B6, vitamin B12, zinc, and iron, as they share the same food source. However, even though there is a similar food source among those micronutrients, the rate of fulfilment of each of them is different. For example, the rate of fulfilment of niacin and vitamin B6 was lower compared to riboflavin, vitamin B12, zinc, and iron. This is probably due to the different amounts of nutrients that contain in the food source and also different recommendations for each nutrient. For instance, the egg is considered a good source of both riboflavin (0.58mg/100g) and vitamin B6 (0.1mg/100g); however, the recommendations for riboflavin and vitamin B6 are different, 0.9-1.3mg and 1.0-1.3mg respectively (RNI, 2017; Tee et al., 1997; USDA, 2015). With this, we can see that it will only take 200g of egg to meet the recommendation of riboflavin, but 1000g of the egg is needed for vitamin B6. Another possible explanation is there are other food sources that help increase the intake of certain nutrients. For example, niacin food sources are mostly meat and fish, whereas iron is also present in fruit, vegetables, and fried rice, based on the observation from 24-hour recall in this study, making there was here intake of iron compared to niacin. This explains the differences in the fulfilment intake between certain nutrients even though they have common food sources.

Besides that, fruits and vegetables are the foundation of a healthy diet. They include vitamins, minerals, fibre, and a variety of other nutrients, such as plant sterols, flavonoids, and antioxidants. Their regular consumption aids in the prevention of non-infectious disorders such as cardiovascular disease, diabetes, and cancer. To promote general health and lower illness risk, the World Health Organization advises eating more than 400 g of fruits and vegetables each day (WHO, 2020). Despite greater awareness of the health benefits of vegetables, low consumption remains a chronic problem (Łuszczki et al., 2019; Piqueras et al., 2014; Vereecken et al., 2005). Based on the result, low consumption of fruit and vegetables can lead to inadequate of several nutrients such as dietary fibre, folate, vitamin C, and potassium. A possible explanation for this lack of consumption is most likely due to the availability and accessibility of fruit and vegetables (Blisset, 2011; Gross et al., 2010; Woon et al., 2014). It is less helpful than the fact there has been a rapid increase in fruit and vegetable prices in Malaysia in recent years (Department of Statistics, 2017). This will be restricted the fishermen's households from buying fruits and vegetables due to their low earnings, which may only allow them to buy essential food sources that provide energy and macronutrients. Additional to that, having low income also affects other nutrient intakes such as thiamine and calcium. Besides that, maternal education also could be a factor in consuming low fruit and vegetables. In the Dutch INPACT Study, children of mothers with high education levels consumed more fruits and vegetables per day than children of low-educated mothers (van Ansem et al., 2014).

Other than that, we observed that there is a low intake of several nutrients which are dietary fibre, thiamine, folate, vitamin C, vitamin E, calcium, and potassium. This is very concerning because if this is prolonged, it will have an effect on the children as they are growing up. For instance, a lack of dietary fibre and potassium could lead to a variety of cardiovascular problems, such as hypertension (Acosta et al., 2021; D'Elia et al., 2011; McKeown et al., 2004; Lava et al., 2015). Besides that, thiamine deficiency could lead to a disease called beriberi (Markell & Siddiqi, 2022; Sachdev & Shah, 2020). Other than that, folate deficiency can have an effect on brain development in children (Black, 2008), and vitamin C deficiency can lead to scurvy (Agarwal et al., 2015; Fortenberry et al., 2020). As vitamin E deficiency in children, it can cause slow reflexes, difficulty walking, loss of coordination, loss of position sense, and muscle weakness (Kemnic & Coleman, 2022). As for calcium, lack of the nutrient can lead to decreased loss of bone mass, which can also lead to rickets (Huncharek et al., 2008; Pettifor, 2014), and if it is prolonged until adulthood, there will be a high risk of having osteoporosis (Arnold et al., 2021; Sunyecz, 2008). With these various health effects, it is important to not overlook this problem and find a solution, such as developing health interventions for this population in order to reduce the risk of these negative effects.

4.3 Nutritional status

Table 4.4 and 4.5 provides a summary of the nutritional status and iodine status of fishermen's children that consists of BMI-for-age, height-for-age, and median urinary iodine. The BMI-for-age median is -0.86 (2.11), indicating this group has a normal BMI-for-age. More than half of the participants [60.6% (n = 57)] had normal BMI-for-age, while 17.0% (n = 16) exhibited thinness, 8.5% (n = 8) demonstrated severe thinness, 8.5% (n = 8) exhibited overweight and 5.3% (n = 5) demonstrated obesity. Meanwhile, the mean height-for-age was -1.01 ± 1.03. Most participants [87.22% (n = 82)] had normal height-for-age, while 10.6% (n = 10) of them suffered from stunting and two (2.1%) was identified as severe stunting. Moreover, the biochemical assessment revealed that the median iodine concentration was 83.90 (102.00). Only 33.0% (n = 31) of the children had adequate iodine levels, while 10.6% (n = 10) exceeded the adequate daily iodine intake. In addition, more than half [56.4% (n = 53)] of the participants exhibited iodine deficiency at varying levels: mild [21.2% (n = 20)], moderate [23.4% (n = 22)] and severe [11.8% (n = 11)]. This analysis fulfils a part of this study first objective which is to determine the nutritional status among the fishermen's children in Terengganu. From this analysis we can see which BMI-for-age and height-for-age based on the children's height and weight. Furthermore, we able to know the iodine status among the fishermen's children. This data was used to further analysis to achieve second and third objective.

Table 4.4: Nutritional status of fishermen's children (n = 94)

Nutritional status	Distribution n (%)	Mean ± SD / Median (IQR)
BMI-for-age (z-score)[a]		-0.86 (2.11)
Severe thinness	8 (8.5)	
Thinness	16 (17.0)	
Normal	57 (60.6)	
Overweight	8 (8.5)	
Obesity	5 (5.3)	
Height-for-age (z-score)[a]		-1.01 ± 1.03
Normal	82 (87.2)	
Stunted	10 (10.6)	
Severely stunted	2 (2.1)	

[a]Based on WHO growth chart (2006) guidelines.

Table 4.5: Iodine status of fishermen's children (n=94)

	Distribution	**Mean ± SD / Median (IQR)**
	n (%)	
Median urinary iodine (µg/L)[a]		83.9 (102)
Severe iodine deficiency (<20)	11 (11.7)	
Moderate iodine deficiency (20-49)	22 (23.4)	
Mild iodine deficiency (50-99)	20 (21.3)	
Adequate iodine nutrition (100-199)	31 (33.0)	
May pose a slight risk of more than adequate iodine intake (200-299)	9 (9.6)	
Risk of adverse health consequences (≥300)	1 (1.1)	

[a]Based on the classification of median urinary iodine (6 years or older) by WHO (2013).

For BMI-for-age, more than half of the fishermen's children have normal BMI. However, there are also some respondents that experience thinness and severe thinness (25.5%), which is considered acute malnutrition. The prevalence of thinness was reported by more than 20% of total respondents in this study, which was greater than in a prior study by Ahmad et al. (2017), where there were 8.4% incidences of thinness among adolescents (n=62567) in Terengganu. These differences probably differentiate the targeted population between those two studies, where Ahmad et al. (2017) were more focused on the general population of children in Terengganu. This is most likely due to the prevalence of poverty was found to be high in the fishermen's community. As mentioned before, there are more than half of the fishermen's household are living in poverty as their income fall below the poverty line. A study by Whye Lian et al. (2012) discovered that total household income and total expenditure showed a significant association with being underweight. Similarly, Pearce et al. (2015) also discovered that children from less fortunate groups had a higher risk of being thin compared to others. This finding confirms the relationship between poverty and BMI-for-age. With this, we can interpret that economic struggle does influence children's BMI-for-age.

Another interesting finding is that the prevalence of thinness and severe thinness (25.5%) is higher than overweight/obesity (13.8%). These results agree with the findings of other studies, in which there is a high prevalence of childhood thinness among the fishermen's children community compared to overweight and obesity

(Baker-French, 2013; Capanzana et al., 2018; Khor & Tee, 1997; Mario et al., 2018; Moshy et al., 2013; Whye Lian et al., 2012). According to research by Capanzana et al. (2018), which involved 13,423 pre-schoolers and 16,398 students in the Philippines, this situation is caused by the children' lack of access to high-calorie snacks and fast food, which is hard to purchase. This shows that the fishermen's children are more prone to thinness compared to those overweight/obese. Furthermore, a study by Wong et al. (2014) among 274 children in Terengganu also stated that lower socio-economic status and household food insecurity are associated with undernourished children. Another explanation for this might be that the children participated in more physically demanding activities than their peers did (Goon et al., 2011).

When it comes to height-for-age, stunting is the biggest concern. About 1 in 5 children under 5 years old in Malaysia suffer from stunting (NHMS, 2017). Surprisingly, the pattern of stunting cases among fishermen's children in Terengganu coincided with the findings of the NHMS study. According to the NHMS research, there were 8.2% occurrences of stunting in Malaysia, with the incidence being greater in rural regions (NHMS, 2017). While in this study, 12.7% of the children experienced stunted, while the majority were normal. Even though the target population in both studies is different, it is quite a concern as the current finding have higher indices among the middle childhood population compared to the finding from NHMS (2017), which focuses on children under 5 years old. The results of this study will now be compared to the findings of previous work by Ali Naser et al. (2014). Ali Naser's study investigated the relationship between household food insecurity and the nutritional status of children in low-income households among 223 non-pregnant, non-lactating mothers aged 18 to 55 years with their youngest children aged 2 to 12 years in north-eastern Peninsular Malaysia. The prevalence of stunting in children was 61.4% which is higher compared to our finding. A possible explanation for these results may be due to the difference in the age group of the study samples, where the age range in Ali Naser's study is bigger than in this study. Even though there are different findings in Ali Naser's and this study, the percentage of the prevalence is still concerning. If this is prolonged, it will have immediate and long-term effects on children. The effects of childhood stunting include increased morbidity and mortality, poor child development and learning ability, increased risk of infections and non-communicable illnesses, greater susceptibility to store fat, particularly in the central area of the body, reduced fat oxidation, lower energy expenditure, insulin resistance and a higher risk of developing diabetes, hypertension, dyslipidaemia, impaired working capacity, and unfavourable maternal reproductive outcomes in adulthood (Black et al., 2008; Dewey & Begum, 2011; Gluckman et al., 2009; Hanifah et al., 2018; Soliman et al., 2021)

Iodine intake is a critical concern in this study, given its well-established relationship with cognitive performance. Despite the potential availability of iodine-rich foods, such as seafood, the findings indicate that the majority of the fishermen's children in this study suffer from iodine deficiency (56.4%, n = 94). The median urinary iodine level among these children is 83.9 (102) µg/L, lower than the RNI recommendation of 100-141 µg/L per day (Rusidah et al., 2010). Previous studies in the region have also reported similarly low median urinary iodine levels among school-aged children (Rusidah et al., 2010; Lim et al., 2012).

Several factors may contribute to this apparent paradox of low iodine levels despite high seafood availability. One possible explanation is the economic constraints faced by these fishing families. Many households in this study have low incomes and are living in poverty (Varela et al., 2015). As a result, fishermen may prioritize selling their catch to generate income rather than consuming it themselves (Lim et al., 2012). This financial trade-off could lead to infrequent consumption of iodine-rich seafood among the children.

Another factor to consider is the impact of environmental changes on local fish populations. During our fieldwork, fishermen reported that the construction of a wave breaker along the coast had disrupted marine life habitats in the area, resulting in a decline in fish catches over time. Consequently, fishermen are now required to venture further into the ocean to find fish, which may further limit the availability of seafood for family consumption.

In summary, the low iodine levels observed among the fishermen's children in this study may be attributed to a combination of economic constraints and environmental factors affecting seafood availability and consumption patterns. Future research should further explore these factors to inform targeted interventions aimed at improving iodine status and cognitive performance in this population.

Overall, we can see that nutritional status among fishermen's children is a concern as approximately 1 in 5 children suffer from thinness and stunting, and more than half have an iodine deficiency. This can have immediate and long-term effects on children, especially on their development. Besides that, we can conclude that household income can give influence this poor nutritional status among fishermen's children, especially when it comes to thinness and iodine deficiency. Having budgetary constraints will limit the expenditure on daily meals. As this is prolonged, it will affect the children's nutritional status.

4.4 Physical activity

Physical Activity Questionnaire for Children (PAQ-C) consists of nine items of daily activities, which items are the activity done in their spare time, activities during recess period while in school, activities during the after-school session, and other seven items, frequency of activities that the children have done in the last 7 days. This analysis fulfils a part of this study first objective which is to determine the physical activity among the fishermen's children in Terengganu. From this analysis we can see the frequency of activity done in a certain period and the overall physical activity level. This data was used to further analysis to achieve second and third objective. Table 4.6 shows the result of the questionnaire about physical activity.

Table 4.6: Physical activity of fishermen's children (n = 94)

Series of items	**Frequency (%)**
Item 1: Spare Time Activity	
No activity	0 (0.0)
Low activity	75 (79.8)
Moderate activity	19 (20.2)
High activity	0 (0.0)
Very high activity	0 (0.0)
Item 2: Physical Education Activity	
No activity	0 (0.0)
Low activity	6 (6.4)

Moderate activity	21 (22.3)
High activity	43 (45.7)
Very high activity	24 (25.5)
Item 3: Recess Period Activity	
No activity	43 (45.7)
Low activity	10 (10.6)
Moderate activity	5 (5.3)
High activity	32 (34.0)
Very high activity	4 (4.3)
Item 4: Lunch Time Activity	
No activity	44 (46.8)
Low activity	5 (5.3)
Moderate activity	12 (12.8)
High activity	27 (28.7)
Very high activity	6 (6.4)
Item 5: After-School Activity	
No activity	9 (9.6)
Low activity	8 (8.5)
Moderate activity	43 (45.7)
High activity	10 (10.6)
Very high activity	24 (25.5)
Item 6: Evening Activity	
No activity	67 (71.3)
Low activity	6 (6.4)
Moderate activity	15 (16.0)
High activity	5 (5.3)
Very high activity	1 (1.1)
Item 7: Weekend Activity	
No activity	9 (9.6)
Low activity	6 (6.4)
Moderate activity	54 (57.4)
High activity	12 (12.8)
Very high activity	13 (13.8)
Item 8: Self-Rate Physical Activity	
No activity	3 (3.2)
Low activity	21 (22.3)
Moderate activity	30 (31.9)
High activity	23 (24.5)
Very high activity	17 (18.1)
Item 9: Daily Frequency of Physical Activity	
No activity	0 (0.0)
Low activity	3 (3.2)

Moderate activity	15 (16.0)
High activity	40 (42.6)
Very high activity	36 (38.3)

For item 1, the majority of the children respond to having a low activity (79.8%). According to Rahim et al. (2011), youth spent more time with various sorts of media than they did with physical activities such as sports and games or with community service or cultural activities. This can further be supported by Singer et al. (2009), who mentions that the most common activity performed by children is watching TV. Additional to that, with current technology, children might like to spend time on gadgets rather than playing outside, especially during spare time. Next is item 2. For item 2, more than 90% of the children really filled the physical education period with physical activity, which classified them to be from the moderate to a very high physical activity level. Based on the 2018 Japan Report Card, Japanese children and youth have favourable levels of organized sports participation (Tanaka et al., 2019). Joining physical education activities might be more attractive to them as they have their peer doing the same thing. The third item was a recess period activity, which showed that 45.7% of children were classified as having no activity level because they tend to fill the period with eating and resting, while 34% were classified as having a high activity level because they prefer to fill their recess period with physical activity rather than resting. An almost similar pattern can be noticed in item 4. 46.8% of the children tend to have no activity, while some prefer doing a high activity (28.7%).

The following section of the questionnaire dealt with activity during after-school sessions, with most children (45.7%) falling into the moderate activity category, as children of school age would normally schedule their after-school time with the co-curriculum activity that their school had provided for them. In terms of evening activity, 71.3% of those who responded claimed that they were in the no-activity category because they considered relaxing after a long day in school from early in the morning to midday or around 6 hours of school hours, excluding co-curricular activities. The next item was weekend activity, with more than half of the children (57.4%) spending their weekends in moderate exercise. The following question on the questionnaire was about self-rate physical activity, which asked the children to assess themselves on a scale of one to ten, with most children rating themselves as having a moderate to a very high level of activity. The final question in the survey focused on daily physical activity frequency, with 42.6% of the children indicating that they engage in a high degree of physical activity.

In summary, the items depict the distribution of respondent physical activity levels throughout the course of a week's worth of activity. According to Lee et al. (2015), Malaysian children have a low level of physical activity and a high level of sedentary activities, with an average of 6.7 hours per day spent in sedentary rather than active exercise. These findings suggest that, based on the items in the questionnaire, physical activity education items assigned by schools have a strikingly high percentage of respondents participating, resulting in a high level of physical activity. This was corroborated by Salimin et al. (2015), who said that physical education in schools strongly encourages children to engage in physical exercise.

The distribution of respondents according to their Physical Activity Questionnaire for Children (PAQ-C) scores is shown in Table 4.5. Most of the children (75.5%) were classified as having a moderate level of physical activity, followed by a low level of physical activity (16%) and a high level of physical activity (8.5%). The overall physical activity score averaged 2.84, which is considered moderate physical activity. This can be supported by several studies where that also found that the majority of adolescents are in the moderate category (Dan et al., 2007; Mohd Fakree et al., 2020; Shariff et al., 2006; Wahida et al., 2011). Children under the age of six were the most energetic, and children from lower-income households were found to participate in more physical activity on average than children from higher-income households (Cottrell et al., 2015). According to a study conducted by Mohd et al. (2011), 400 adolescents aged 13 years old engaged in moderate-level physical exercise (61.5%). The physical activity level was in the same moderate category in both Mohd et al. (2011) and the current study, despite the modest age variations. This was because both studies were conducted on children on the east coast, where environmental variables are a large effect. Aside from that, both studies focused on people from poor socioeconomic backgrounds.

Table 4.5: Physical activity classification of fishermen's children (n = 94)

Physical Activity Mean Classification	Number of respondents	Percentage (%)	Mean ± SD
Total Physical Activity Score			2.84 ± 0.577
Low physical activity level (1.00-2.33)	15	16.0	
Moderate physical activity level (2.34-3.66)	71	75.5	
High physical activity level (3.67-5.00)	8	8.5	

*Min score=1.00, Max score=5.00

The present study's findings contrasted with those of Sharif et al. (2016), who reported that most Malaysian children and adolescents engaged in low levels of physical exercise but high amounts of screen time. Even though the mean total physical activity score in our study was 2.84 ± 0.577, which is classified as moderate physical activity, the mean score is near to low physical activity. Furthermore, Sharif et al. (2016) findings were broader since the children and adolescents were from various Malaysian states, whereas the current study focused primarily on the children of low-income fisherman families. As a result, there will be a variance in the outcomes depending on the degree of physical exercise.

4.5 Cognitive performance

This analysis fulfils a part of this study first objective which is to determine the cognitive performance among the fishermen's children in Terengganu. From this analysis we can see the cognitive performance among fishermen's children via RCPM. This data was used to further analysis to achieve second and third objective. The cognitive performance of fishermen's children was reported in Table 4.7. The results show that the respondents' cognitive performance varies similarly for each group, apart from the high average category. The RCPM median score is 80.0 (21.0), and this result is classified as a low average score. Only several participants recorded average [23.4% (n = 22)] and high average [5.3% (n = 5)] scores. Furthermore, most participants 71.3% (n = 67) below average cognitive performance, where 26.6% (n = 25) scored extremely low, 21.3% (n = 20) had borderline scores, and 23.4% (n = 22) had low average scores.

Table 4.7: Cognitive performance of fishermen's children (n=94)

Category	**Distribution**	**Median (IQR)**
	n (%)	
Cognitive score		80.0 (21.0)
Extremely low (Grade V) (0.00-69.99 points)	25 (26.6)	
Borderline (Grade IV) (70.00-79.99 points)	20 (21.3)	
Low average (Grade III) (80.00-89.99 points)	22 (23.4)	
Average (Grade II) (90.00-109.00 points)	22 (23.4)	
High average (Grade I) (110.00-119.99 points)	5 (5.3)	

* Min value = 0.00, Max value = 119.99

These results match those observed in earlier studies (Ali et al., 2020; Asawa et al., 2014; Sathe & Gokhale, 2019; Tai & Ali, 2018). A study by Tai and Ali (2018) discovered that 67% of the children are Grade V (intellectually impaired), and 27% are Grade IV (below average). The Tai and Ali (2018) study were conducted among 100 fishermen's children aged 7 to 12 years old in Terengganu, Malaysia. Furthermore, this can be supported by a study by Ali et al. (2020), which was also conducted among 7 to 11 years-old fishermen's children in Terengganu (n=97). The study recorded the level of cognitive performance as below average, where most of the students (66.3%) were categorized into Grade V (intellectually impaired), where the percentile rank was less than or equal to 5th for their cognitive performance. This result may be explained by the fact that studies by Tai and Ali (2018) and Ali et al. (2020) have the same setting and target population. Hence, the background and environmental exposure are similar to this study. It can therefore be assumed that the cognitive performance among fishermen's children in Terengganu is indeed low as there is a consistent result among the studies.

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Previous studies have identified a few factors related to cognitive performance, including inadequate nutritional intake (Nasir et al., 2012), family socioeconomic status (Al- Mekhlafi et al., 2014), and living environment conditions (Ejekwu et al., 2012; Nampijja et al., 2018; Whaley et al., 2003) are some of the variables that may contribute to impaired cognitive performance. Two studies conducted in Terengganu among the fishermen's children show that there is no correlation between nutrient intake and cognitive performance (Ali et al., 2020; Tai & Ali, 2018). Foods with high sodium and cholesterol content and little fruit and vegetable intake demonstrated that these factors had an impact on children's diet quality, however this diet quality was not associated with respondents' cognitive performance (Ali et al., 2020). However, a study by Sathe & Gokhale (2019) had a different opinion where they found that increased consumption of soybean and fish correlated with better anthropometric measurements and higher intelligence quotient (IQ) scores. This inconsistency may be due to different targeted populations, as a study by Sathe & Gokhale (2019) carried out among children in India. Different places acquired different food cultures, which might influence the result. Thus, further work is required to establish this, especially among fishermen’s children, as it is the targeted population.

As mentioned before, the amount of poverty among fishermen has reached a critical point, and they have been classified as having a poor socioeconomic status. One of the numerous factors contributing to the fisherman's children's low cognitive function is the family's minimal household income. This is owing to the fact that children from low-income families have fewer opportunities to learn and are less likely to be exposed to cognitively stimulating tasks. According to Al-Mekhlafi et al. (2014), school students in rural areas or those with low socioeconomic positions have a low IQ, and the majority of these children have received minimal educational training. Furthermore, low IQ was found to be substantially linked to low household income (Asawa et al., 2014; Poh et al., 2019). Further explanations regarding factors associated with cognitive performance will be discussed in sections 4.6 and 4.7.

4.6 Assessment of dietary intake, nutritional status, physical activity, and associated factors toward cognitive performances[4]

The relationship between cognitive performance and dietary intake, nutritional status, physical activity, and associated factors, as shown in Table 4.8, was determined by using Pearson-Chi Square analysis and Fischer exact test. Overall result is mother's education level (χ^2 (2, N = 94) = 0.050, p = 0.037), BMI-for-age (χ^2 (2, N = 94) = 6.271, p = 0.012), protein (χ^2 (2, N = 94) = 5.407, p = 0.020), and niacin (χ^2 (2, N = 94) = 4.608, p = 0.032) have significant relationship with cognitive performance.

Table 4.8: Relationship between dietary intake, nutritional status, physical activity, and associated factors, and cognitive performance of fishermen's children (n = 94)

Variables	**Cognitive performance[a]**		**χ^2**	**p-value**	**Fisher exact test value (If necessary)**	**Odd ratio (OR)**
	High (%)	**Low (%)**				
Age						
7-9 years	13 (13.8)	41 (43.6)	1.340	0.247		0.589
10-11 years	14 (14.9)	26 (27.7)				
Gender						
Male	12 (12.8)	32 (34.0)	0.085	0.771		0.875
Female	15 (16.0)	35 (37.2)				

[4] This part has been published in Journal of Taibah University Medical Sciences (2022) – (Appendix I)

Monthly households income						
< RM1500	22 (23.4)	61 (64.9)	1.703	0.192		0.433
RM 1500 – RM2999	5 (5.3)	6 (6.4)				
Number of households members[b]						
1-5	9 (9.6)	35 (37.2)		Ref.		
6-10	15 (16.0)	29 (30.9)		0.281	0.362[c]	0.611
11-15	3 (3.2)	3 (3.2)		0.234	0.349[d]	0.375
Mother's education level[b]						
Primary school	2 (2.1)	18 (19.1)		0.037*	0.050[e]	4.592
Secondary school	24 (25.5)	44 (46.8)		Ref.		
Certificate/Diploma	1 (1.1)	4 (4.3)		0.658	1.000[f]	1.651
Degree	0 (0.0)	1 (1.1)		0.523	1.000[g]	0.710
Employment status of mother						
Housewife	17 (18.1)	47 (50.0)	0.457	0.499		0.723
Working	10 (10.6)	20 (21.3)				
BMI-for-age						
Not normal	5 (5.3)	31 (33.0)	6.271	0.012*		0.264
Normal	22 (23.4)	36 (38.3)				
Height-for-age						
Stunted/severely stunted	5 (5.3)	7 (7.4)	1.126	0.289		1.948
Normal	22 (23.4)	60 (63.8)				
Median urinary iodine						
Not normal	20 (21.3)	43 (45.7)	0.852	0.356		1.595
Normal	7 (7.4)	24 (25.5)				
Physical activity level[b]						
Low	5 (5.3)	10 (10.6)	0.185	0.667		0.772
Moderate	21 (22.3)	50 (53.2)		Ref.		
High	1 (1.1)	7 (7.4)	1.124	0.289		3.033

Energy (kcal)[b]					
Q1 (≤950.37)	10 (10.6)	14 (14.9)	2.637	0.104	0.449
Q2 (950.38 - 1056.28)	6 (6.4)	17 (18.1)	0.103	0.748	1.190
Q3 (1056.29 - 1339.92)	7 (7.4)	17 (18.1)		Ref.	
Q4 (≥ 1339.93)	4 (4.3)	19 (20.2)	1.910	0.167	2.276
Carbohydrates (g)[b]					
Q1 (≤ 125.56)	10 (10.6)	14 (14.9)	2.637	0.104	0.449
Q2 (125.57 – 147.82)	6 (6.4)	17 (18.1)	0.103	0.748	1.190
Q3 (147.83 – 180.26)	7 (7.4)	17 (18.1)		Ref.	
Q4 (≥ 180.27)	4 (4.3)	19 (20.2)	1.910	0.167	2.276
Protein (g)[b]					
Q1 (≤ 38.36)	7 (7.4)	17 (18.1)	0.003	0.956	0.971
Q2 (38.37 – 45.38)	10 (10.6)	13 (13.8)	3.238	0.072	0.409
Q3 (45.39 – 52.68)	8 (8.5)	17 (18.1)		Ref.	
Q4 (≥ 52.69)	2 (2.1)	20 (21.1)	5.407	0.020*	5.319
Fats (g)[b]					
Q1 (≤ 28.78)	8 (8.5)	16 (17.0)	0.335	0.563	0.745
Q2 (28.79 – 36.74)	6 (6.4)	17 (18.1)	0.103	0.748	1.190
Q3 (36.75 – 48.54)	8 (8.5)	16 (17.0)		Ref.	
Q4 (≥ 48.55)	5 (5.30	18 (19.1)	0.726	0.394	1.616
Dietary fibre (g)[b]					
Q1 (≤ 1.31)	8 (8.5)	16 (17.0)	0.335	0.563	0.745
Q2 (1.32 – 1.92)	3 (3.2)	20 (21.1)	3.657	0.056	3.404
Q3 (1.93 – 3.11)	10 (10.6)	14 (14.9)		Ref.	
Q4 (≥ 3.12)	6 (6.4)	17 (18.1)	0.103	0.748	1.190
Thiamine (mg)[b]					
Q1 (≤ 0.23)	8 (8.5)	16 (17.0)	0.335	0.563	0.745
Q2 (0.24 – 0.32)	9 (9.6)	16 (17.0)		Ref.	
Q3 (0.33 – 0.39)	5 (5.30)	19 (20.2)	0.980	0.322	1.742
Q4 (≥ 0.40)	5 (5.30)	16 (17.0)	0.319	0.572	1.380
Riboflavin (mg)[b]					
Q1 (≤ 0.55)	8 (8.5)	17 (18.1)	0.179	0.673	0.808

Q2 (0.56 – 0.75)	7 (7.4)	16 (17.0)	0.044	0.835	0.896
Q3 (0.76 – 0.97)	7 (7.4)	18 (19.1)		Ref.	
Q4 (≥ 0.98)	5 (5.30)	16 (17.0)	0.319	0.572	1.380
Niacin (mg)[b]					
Q1 (≤ 6.98)	7 (7.4)	17 (18.1)		Ref.	
Q2 (6.99 – 9.04)	5 (5.30)	18 (19.1)	0.726	0.394	1.616
Q3 (9.05 – 11.77)	11 (11.7)	13 (13.8)	4.608	0.032*	0.350
Q4 (≥ 11.78)	4 (4.3)	19 (20.2)	1.910	0.167	2.276
Vitamin B6 (mg)[b]					
Q1 (≤ 0.54)	7 (7.4)	17 (18.1)	0.003	0.956	0.971
Q2 (0.55 – 0.76)	7 (7.4)	18 (19.1)		Ref.	
Q3 (0.77 – 0.98)	7 (7.4)	15 (16.0)	0.134	0.714	0.824
Q4 (≥ 0.99)	6(6.4)	17 (18.1)	0.103	0.748	1.190
Folate (µg)[b]					
Q1 (≤ 31.03)	9 (9.6)	15 (16.0)		Ref.	
Q2 (31.04 – 42.37)	6 (6.4)	17 (18.1)	0.103	0.748	1.190
Q3 (42.38 – 58.50)	5 (5.30)	19 (20.2)	0.980	0.322	1.742
Q4 (≥ 58.51)	7 (7.4)	16 (17.0)	0.044	0.835	0.896
Vitamin B12 (µg)[b]					
Q1 (≤ 1.10)	7 (7.4)	18 (19.1)		Ref.	
Q2 (1.11 – 1.67)	8 (8.5)	14 (14.9)	0.819	0.365	0.627
Q3 (1.68 – 2.72)	7 (7.4)	17 (18.1)	0.003	0.956	0.971
Q4 (≥ 2.73)	5 (5.30)	18 (19.1)	0.726	0.94	1.616
Vitamin C (mg)[b]					
Q1 (≤ 12.60)	6 (6.4)	18 (19.1)		Ref.	
Q2 (12.61 – 22.40)	8 (8.5)	15 (16.0)	0.546	0.460	0.685
Q3 (22.41 – 39.48)	9 (9.6)	15 (16.0)	1.213	0.217	0.577
Q4 (≥ 38.49)	4 (4.3)	19 (20.2)	1.910	0.167	2.276
Vitamin A (µg)[b]					
Q1 (≤ 539.96)	4 (4.3)	20 (21.3)		Ref.	
Q2 (539.97 – 837.95)	9 (9.6)	14 (14.9)	1.611	0.204	0.528
Q3 (837.96 – 1193.85)	9 (9.6)	15 (16.0)	1.213	0.271	0.577
Q4 (≥ 1193.86)	5 (5.3)	18 (19.1)	0.726	0.394	1.616

Vitamin E (mg)[b]					
Q1 (≤ 1.73)	8 (8.5)	17 (18.1)		Ref.	
Q2 (1.74 – 2.76)	7 (7.4)	15 (16.0)	0.134	0.714	0.824
Q3 (2.77 – 3.72)	9 (9.6)	15 (16.0)	1.213	0.271	0.577
Q4 (≥ 3.73)	3 (3.2)	20 (21.3)	3.657	0.056	3.404
Calcium (mg)[b]					
Q1 (≤ 232.90)	6 (6.4)	18 (19.1)		Ref.	
Q2 (232.91 – 307.46)	9 (9.6)	15 (16.0)	1.213	0.271	0.577
Q3 (307.47 – 394.49)	5 (5.3)	18 (19.1)	0.726	0.394	1.616
Q4 (≥ 394.50)	7 (7.4)	16 (17.0)	0.044	0.835	0.896
Zinc (mg)[b]					
Q1 (≤ 2.42)	8 (8.5)	16 (17.0)		Ref.	
Q2 (2.43 – 3.10)	6 (6.4)	17 (18.1)	0.103	0.748	1.190
Q3 (3.11 – 4.25)	7 (7.4)	17 (18.1)	0.003	0.956	0.971
Q4 (≥ 4.26)	6 (6.4)	17 (18.1)	0.103	0.748	1.190
Iron (mg)[b]					
Q1 (≤ 7.67)	9 (9.6)	15 (16.0)		Ref.	
Q2 (7.68 – 11.21)	4 (4.3)	19 (20.2)	1.910	0.167	2.276
Q3 (11.22 – 19.46)	9 (9.6)	15 (16.0)	1.213	0.271	0.557
Q4 (≥ 19.47)	5 (5.3)	18 (19.1)	0.726	0.394	1.616
Sodium (mg)[b]					
Q1 (≤ 1035.48)	9 (9.6)	15 (16.0)		Ref.	
Q2 (1035.49 – 1501.45)	7 (7.4)	16 (17.0)	0.044	0.835	0.896
Q3 (1501.46 – 1997.05)	4 (4.3)	20 (21.3)	2.288	0.130	2.447
Q4 (≥ 1997.06)	7 (7.4)	16 (17.0)	0.044	0.835	0.896
Potassium (g)[b]					
Q1 (≤ 0.55)	11 (11.7)	13 (13.8)		Ref.	
Q2 (0.56 – 0.75)	4 (4.3)	19 (20.2)	1.910	0.167	2.276
Q3 (0.76 – 0.94)	7 (7.4)	17 (18.1)	0.003	0.956	0.971
Q4 (≥ 0.95)	5 (5.3)	18 (19.1)	0.726	0.394	1.616

*Significant at $p<0.05$, Q1=first quartiles, Q2= second quartiles, Q3=third quartiles, Q4=fourth quartiles

[a]Catergorized into two dummy variables in order to fulfil the assumption of chi-square/fisher exact.

[b]Recorded into dummy variable. The category that has the highest frequencies were used as a reference.

[c]0 cells (0%) have an expected count of less than 5. The minimum expected count is 12.64.
[d]2 cells (50.0%) have an expected count of less than 5. The minimum expected count is 1.72.
[e]0 cells (0%) have an expected count of less than 5. The minimum expected count is 5.74.
[f]2 cells (50.0%) have an expected count of less than 5. The minimum expected count is 1.44.
[g]2 cells (50.0%) have an expected count of less than 5. The minimum expected count is 0.29.

For the relationship between the mother's education level and cognitive performance, based on the result, it is shown that a mother who has primary education is likely to be associated with the children's cognitive performance (χ^2 (2, N = 94) = 0.050, p = 0.037). Based on the odd ratio that was obtained (OR = 4.592), it shows that mothers who obtained primary education were 4.59 more likely to have children with low cognitive performance. These results match those observed in earlier studies. A study by Poh et al. (2019) found that children with mothers with the lowest levels of education were more likely to be classified as having low or borderline non-verbal IQ among 2406 Malaysian children aged 5 to 12 years. Similarly, a study by Harding (2015) also concluded that increases in maternal education were positively associated with children's cognitive development. In addition, research by Bogale et al. (2013) found that among 100 women and their 5-year-old children on Ethiopia, children of mothers with at least 5 years of schooling had 22% better scores for visual processing and 14% higher scores in tests combined to form a short-term memory index. This constant result proves that the mother's education level does have an influence on the children's cognitive performance. A possible explanation for this might be that higher-educated parents may be more inclined to spend time and money on their children's education (Dotti Sani & Treas, 2016; Harding, 2015). In addition, compared to mothers with lower education levels, the mother with higher education typically has more health literacy and participate in more quality interactions with their children (Lundborg et al., 2012; Violato et al., 2011). Interactions like homework viewing and modelling the value and importance of education could have a positive effect on children (Sommer et al., 2012). Besides that, increases in maternal education have been associated with higher ratings of the home learning environment (Magnuson, 2007; Magnuson et al., 2009) and more parental engagement in the educational process (Crosnoe & Kalil, 2010; Domina & Roksa, 2012), both of which can help children's cognitive development. All in all, we can say that quality interactions and the mother's involvement in their child's life could have a positive influence on their cognitive development. In addition to psychosocial aspects of the home environment, genetic heritage may also have a significant role in the development of children's cognitive function (Poh et al., 2019).

Other demographic factor such as monthly household income reveal that there is no relationship with cognitive performance (χ^2 (2, N = 94) = 1.703, p = 0.192). In contrast, Hamid et al. (2011), a study conducted among 249 children aged 7 to 9 in a rural area in Malaysia, showed that academic and cognitive function scores were significantly correlated ($p < 0.05$) with family income in their research. Haile et al. (2016), a study among 131 school-age students from primary schools in Ethiopia, found that socioeconomic status is significantly correlated ($p < 0.05$) with school-age children's cognitive performance. Furthermore, Al-Mekhlafi et al. (2011), a study conducted among Aboriginal schoolchildren aged 7-12 years living in remote areas in Pos Betau, Pahang, Malaysia, discovered that children from households with greater monthly wages had better IQ scores. It is difficult to explain this result, but it might be related to how the income was calculated or categorized in the study. Hamid et al. (2011) used an open-ended question for household income which means the income can be obtained, while Haile et al. (2016) used the wealth index. Al-Mekhlafi et al. (2011) use categorical answers, which is the same as this study but with smaller values, and just use two groupings which either less than RM450 or higher. With this, the method used to calculate their household income does matter, as it can produce different outcomes. Thus, further work is required to establish this. These findings are rather disappointing. As mentioned before, the fishermen's community are synonymous with having low income as it may affect the life quality of their family member. Thus, it might unintentionally affect the opportunity for the children to learn or study. Poverty also hinders educational accomplishment in a variety of ways, such as forcing impoverished children to work, which discourages their attendance and performance in school (Al-Mekhlafi et al., 2011). Aside from that, the relationship between socioeconomic status and academic performance is complicated and includes various elements such as diet, school environment, family living environment, material assistance, and so on (Haile et al., 2016).

As for nutritional status, the results reveal that there is relationship between BMI-for-age and cognitive performance (χ^2 (2, N = 94) = 6.271, p = 0.012). Based on the odd ratio that was obtained (OR = 0.264), it shows that children who had normal BMI-for-age were 73.6% less likely to have children with low cognitive performance.

Similarly, the prior study had found a significant relationship between BMI-for-age with low cognitive performance among 6746 school-aged children (aged 6-12 years) in four Southeast Asian countries: Indonesia; Malaysia; Thailand; Vietnam (Sandjaja et al., 2013). Moreover, this finding is also consistent with Poh et al. (2019) where they found that children with severe obesity are more likely to have poor non-verbal IQ among 2406 Malaysian children aged 5 to 12 years and Meo et al. (2019) where they discovered that cognitive functions were substantially impaired in 400 significantly obese children Riyadh. One possibility could be linked to diet, such as getting enough macro- and micronutrients, which are essential for brain and cognitive development, especially in the early years of life. A normal BMI indicates that the children receive enough nutrients from their diet. It is necessary to have a sufficient intake of micronutrients including iron, iodine, zinc, and vitamin B12 since these substances play crucial roles in neuropsychological development (Black, 2003; Poh et al., 2019). Thus, children should consume enough micronutrients and suitable amounts of acceptable macronutrients, as these nutrients are crucial for cognitive development (Benton, 2010).

Other than that, there are no relationship between height-for-age and cognitive performance of the children (χ^2 (2, N = 94) = 1.126, p = 0.289). The findings of this study contradicted those of a prior study, which found that stunted children fared worse in cognitive tests in 151 infants recruited at 2–5 months and were visited at home at 12–13 months in Malaysia (Nurliyana et al., 2020). Furthermore, another previous study also mentioned that stunting children performed more badly in cognitive tests ($p < 0.01$) among children up to the age of 8 years in Ethiopia (Woldehanna et al., 2018). Height-for-age represents the accumulation of dietary deprivation over time, which may have an impact on children's educational achievement (Shariff et al., 2000). Stunted children have been found to exhibit higher levels of anxiety, despair, and low self-esteem than their non-stunted peers (Walker et al., 2007). It is difficult to explain this result, but a possible explanation is probably due to the majority of the fishermen’s children having a normal height-for-age, and only a small percentage had stunting; it may be concluded that the low cognitive performance seen was due to variables other than height-for-age. This shows that poor nutritional status alone does not account for children’s cognitive deficits (Crookston et al., 2011; Grantham-McGregor, 2002).

As for median urinary iodine, there is no relationship with cognitive performance, χ^2 (2, N = 94) = 0.852, p = 0.356. This conclusion, on the other hand, contradicted a review by Melse-Boonstra and Jaiswal (2010), who found that urinary iodine concertation was strongly linked with cognitive function. Chinese ecological research by Qian et al. (2005) also found that children who lived in an iodine-deficient area scored 12.5 IQ points higher than those who lived in an area with a severe iodine shortage. Furthermore, children with urinary iodine excretion of 100 g/L had a substantially lower IQ score than children with urinary iodine >100 g/L in a minor iodine-deficient location in southeast Spain (Santiago-Fernandez et al., 2004). Moreover, a study by Zimmermann et al. (2006) conducted among 310 10–12 years old children in primary schools in Albania found that children with higher iodine intake showed better non-verbal fluid intelligence. A possible explanation for this might be that different cognitive performance tests are applied to respondents, so the result might come out differently. Previous studies use Cattell's g-factor test and a battery of seven cognitive and motor tests, which included measures of information processing, working memory, visual problem solving, visual search, and fine motor skills, while this study only used RCPM to measure cognitive performance. Another possible explanation for this is that Zimmermann et al. (2006) study is a randomized, controlled, double-blind study to ascertain whether providing iodized oil to iodine-deficient children would affect their cognitive and motor performance. Thus, a different result may produce due to different study designs. These findings are rather disappointing as iodine is expected to have an effect on brain development. According to Gordon et al. (2009), the good effect of iodine on nonverbal learning is due to enhanced frontal brain myelination, which is engaged in higher-order cognitive functions like reasoning and problem-solving. Zimmermann et al. (2006) also noted that decreased thyroid function due to iodine deficiency would result in lower regional cerebral blood flow, which would influence cognitive performance. The reason for this is not clear, but it may have something to do with the population of the fishermen’s children only considered as having mild iodine deficiency; thus, that might not be given a lot of effect on cognitive as other factors would. These findings may help us to understand that urinary iodine did not have an effect on this population’s cognitive performance.

The results reveal that there is no relationship between physical activity and cognitive performance, $p > 0.05$. As a result, physical exercise has no effect on the children's cognitive performance in this study. The study did not reveal a significant relationship between physical activity levels and cognitive performance scores, contrary to expectations. Much earlier research, including one by Schmidt et al. (2015) conducted among 181 children aged between 10 and 12 years in Bern, Switzerland, has suggested a substantial correlation between physical exercise and cognitive performance. The study also found that a lack of physical exercise throughout childhood can contribute to poor perception and developmental disorders. Furthermore, according to research by Bai et al. (2021) conducted among 56 children aged 3-5 years old in Perth, Australia, overall physical activity was positively and strongly associated with cognitive school preparation. In addition to overall physical activity, moderate-vigorous physical activity (MVPA) was found to be favourably and substantially associated with cognitive school readiness. A study conducted by Tee et al. (2018) shows that higher physical activity levels predicted better executive function among 513 Malaysian adolescents aged between 12 and 16 years in Selangor, Malaysia. Theoretically, physical activity can improve circulation, which improves oxygen flow to the brain as well as gives nutrients to the brain. Increased physical activity benefits all systems, including the motor, cardiovascular, respiratory, hormonal, and neurological systems (Fels et al., 2015). However, the present study's findings still revealed no meaningful relationship between these two factors. It is difficult to explain this result, but it might be related to a moderate level of physical activity among the fishermen’s children. As mentioned before, children from lower-income households were found to participate in more physical activity on average than children from higher-income households (Cottrell et al., 2015). It can thus be suggested that the level of physical activity may not influence the cognitive performance among the fishermen’s children. Moreover, this study only assesses general levels of physical activity where it does not provide an estimate of caloric expenditure or specific frequency, time, and intensity. Based on the meta-analysis in the literature review, the intervention duration for physical activity was found to be important because longer research periods were sufficient for evaluating significant improvements in cognitive performance, particularly attention.

In terms of dietary intake, there are significant relationship between cognitive performance with protein specifically Q4 (≥ 52.69g) group (χ^2 (2, N = 94) = 5.407, p = 0.020). Based on the odd ratio that was obtained (OR = 5.319), it shows that children who place in the fourth quartile in protein intake were 5.319 times more likely to have low cognitive performance compared third quartile. This conclusion, on the other hand, contradicted a study by Wang et al. (2021), where they found that 'High protein' pattern was positively associated with cognitive ability in 2029 Chinese children. This contradiction probably due to different type of cognitive assessment were used. Previous studies (Wang et al., 2021) used vocabulary and mathematics tests. Different type of cognitive assessment measure different types of IQ. For example, vocabulary and mathematics tests measure one's crystal intelligence while RCPM test measured one's non-verbal general human intelligence and abstract reasoning and is regarded as a non-verbal estimate of fluid intelligence. With this, we could say that different types of cognitive ability may produce different result. Besides that, a review by de Rest et al. (2013) mention that unexpectedly few research has been conducted on how protein diet affects cognitive performance, and many of those that have been done date back a long time. Overall, there has been little study done, and the results have been inconsistent. As a result, it is impossible to draw any definitive conclusions about how much protein affects cognitive performance. As a result, it is advised that future research on the subject take into consideration methods for assessing the different types of cognitive ability.

Aside from protein, there is also significant relationship between cognitive performance with niacin specifically Q3 (9.05mg – 11.77mg) group (χ^2 (2, N = 94) = 4.608, p = 0.032). Based on the odd ratio that was obtained (OR = 0.350), it shows that children who place in the third quartile in niacin intake were 65% less likely to have low cognitive performance compared to the first quartile. Similarly, a study by Qin et al. (2017) found that total intake of niacin was significantly associated with the Digit Symbol Substitution Test (DSST) among 5115 18–30 years old black and white men and women in United States. A possible explanation for this might be that the main function of niacin is to helps convert nutrients into energy and believed to protect brain cells from stress and injury (Gasperi et al., 2019; Kennedy, 2016). However, up to date, there is still lack of study when it comes to relationship between niacin and cognitive function especially among children. Most studies are more focusing on the older adults and had proved that higher intake of niacin was correlated with better performance on cognitive tests (Lee et al., 2001; Smith & Refsum, 2016). Thus, future research on the current problem is thus advised, with a focus on the children's population.

Contrary to expectations, there is no significant relationship between cognitive performance with vitamin B12 ($p > 0.05$), zinc ($p > 0.05$) and iron ($p > 0.05$). Contradictory, those three micronutrients are known to the brain and cognitive development (Bhatnagar & Taneja, 2001; Constant et al., 2001; Todorich et al., 2009; Youdim & Yehuda, 2000). A review by Nyaradi et al. (2013) believed that iron status or anaemia had been associated with cognitive development in children. Furthermore, another study conducted among 249 children, seven to nine years of age, from six primary schools in a rural area in Malaysia also shows that there is a significant and strong association between iron status with cognitive function score (Hamid et al., 2011). In addition, children with iron deficiency performed considerably lower on cognitive function tests than their healthy counterparts in prior research by the same team (Hamid Jan et al., 2010). For iron intake, a study conducted by Chin et al. (2020) shows there is an association between cognitive performance and zinc adequacy among 120 homeless children aged 7-12 years living in Klang Valley. As for vitamin B12, a review by Swaminathan et al. (2013) found that better school performance (Ahmadi et al., 2009; Duong et al., 2015; Masalha et al., 2008), developmental indices (Kvestad et al., 2015; Strand et al., 2013) and cognitive performance (Gewa et al., 2009; Louwman et al., 2000) were all associated with increased child vitamin B12 intake. For iron intake, a study conducted by Chin et al. (2020) shows there are association between cognitive performance and zinc adequacy among 120 homeless children aged 7-12 years living in Klang Valley. A possible explanation for this might be that there is a adequate intakes of those three nutrients from the consumption of fish and poultry among fishermen’s children in this study. Thus, it may not have a strong influence on cognitive development, and other factors might have caused more effect on the low cognitive performance among them.

4.7 Risk assessment of low cognitive performance

The factor's risk was assessed as there are factors that are significantly associated with cognitive performance. Moreover, an initial objective of the study was to identify the factor's risk of low cognitive performance among the fishermen's children. Thus, a logistic model was used to find the significant odd ratio. Any variables that have a significant relationship with cognitive performance were added to the logistics regression model. Thus, based on the above assessment, primary school (dummy variable for 'mother's education level'), BMI-for-age, fourth quartiles of protein intake (≥ 52.69g) (dummy variable for 'protein') and third quartiles of niacin intake (9.05 – 11.77) (dummy variable for 'niacin') are included in the regression model. Table 4.9 shows logistic regression that performs on the low cognitive performance of fishermen's children.

Table 4.9: Logistic regression on low cognitive performance of fishermen's children (n=94)

Logistic regression on low cognitive performance[a]	**Adjusted OR**	**95% CI**	**p-value**
Primary school (dummy variable for *'mother's education level'*)	4.445	0.872 – 22.649	0.073
BMI-for-age	0.290	0.91 – 0.920	0.036*
Q4 (≥ 52.69g) (dummy variable for *'protein'*)	7.565	1.470 – 38.926	0.015*
Q3 (9.05mg – 11.77mg) (dummy variable for *'niacin'*)	0.349	0.112 – 1.092	0.071

*Significant at p<0.05, Q3=third quartiles, Q4=fourth quartiles
[a]only variables that have a significant relationship are selected for the regression.

Binomial logistic regression was performed to determine the effects of primary school (dummy variable for 'mother's education level'), BMI-for-age, fourth quartiles of protein intake (≥ 52.69g) (dummy variable for *'protein'*) and third quartiles of niacin intake (9.05mg – 11.77mg) (dummy variable for *'niacin'*) on the likelihood that participants have low cognitive performance. The logistic regression model was statistically significant, $\chi^2(4, N = 94) = 18.099$, p = 0.001. The model explained 29.3% (Nagelkerke R^2) of the variance in low cognitive performance and correctly classified

71.3% of cases. Of the four predictor variables, only two was statistically significant: BMI-for-age and fourth quartiles of protein intake (≥ 52.69g) (dummy variable for *'protein'*).

Based on result of the regression, children who had normal BMI-for-age were 71% less likely to have low cognitive performance (OR = 0.290, 95%Cl [0.91,0.920]). These findings are consistent with those found in past research. According to a study by Hjorth et al. (2016), among 834 Danish children aged 8 to 11 who took cognitive tests, children who were normal weight performed up to 89% and 48% better than underweight and overweight children. In addition, study by Li et al. (2012) found that children's impaired visuospatial organisation and general mental capacity are independently related with increased body weight. This constant result proves that BMI-for-age do have influence on the children' cognitive performance. A possible explanation for this might be that some of the cognitive functions tend to be negatively impacted by obesity include memory, executive function, and impulsivity (Cheke et al., 2016; Gunstad et al., 2006; Li et al., 2012; Meo et al., 2019). Besides that, underweight also can give impact to cognitive development. This is because it is frequently accompanied with undernutrition, which may include protein-energy malnutrition, micronutrient deficiencies, such as iron and iodine deficit, and persistent illnesses that may have an adverse effect on the children brain development (Jirout et al., 2019; Sandjaja et al., 2013). With this, having a normal BMI can reduce the risk of having low cognitive performance.

Contrary to expectations, our logistic analysis revealed that children in the fourth quartile of protein intake were 7.565 times more likely to exhibit low cognitive performance compared to children in other quartiles (OR = 7.565, 95%Cl [1.470,38.926]). It is well-established that protein is essential for brain development, and its deficiency can lead to numerous detrimental effects on brain function and structure (Bonatto et al., 2006; Jirout et al., 2019). Furthermore, previous studies have shown that protein supplementation can improve cognitive function in undernourished children, particularly during the first two years of life (Grantham-McGregor & Baker-Henningham, 2005).

However, our findings suggest that excessively high protein intake may have adverse effects on cognitive performance. The protein consumption in the fourth quartile (greater than 52.69g) is nearly double the recommended dietary requirement for children. Excessive protein intake can place metabolic stress on the liver, kidneys, and bones, potentially impacting overall health (Delimaris, 2013). Additionally, excessive protein intake can be converted into adipose fat in the body, leading to an increase in adipose tissue, which may also affect cognitive performance (de A Boleti, 2023). It is plausible that the observed negative association between high protein intake and cognitive performance is mediated by these adverse health effects.

Another factor to consider is the source of protein in our study population. Wang et al. (2021) found a positive association between a 'high protein' diet focused on milk, beans, and eggs and cognitive ability in Chinese children. In contrast, our study population exhibited low intakes of milk and beans, which might contribute to the observed differences in cognitive performance. Prior research has also indicated that milk and dairy product consumption is positively associated with academic performance among adolescents (Hullet et al., 2013; Kim et al., 2016). The varying protein sources between our study and previous research may help explain the discrepancies in findings.

In summary, while protein is crucial for brain development and cognitive function, excessively high protein intake may have unintended consequences on children's cognitive performance. The potential impact of protein sources on cognitive performance warrants further investigation. Future research should focus on elucidating the relationship between protein intake, protein sources, and cognitive performance in children, considering the potential for varying effects depending on protein intake levels and sources.

Furthermore, it is important to acknowledge that we should not promote a reduction in protein intake based solely on the findings of this study, as there are various factors to consider and a more comprehensive understanding of the relationship between protein and cognitive performance is needed. An experimental study design would be more appropriate to further investigate and clarify the complex interplay between protein intake, protein sources, and cognitive performance in children. By conducting controlled experimental studies, researchers can gain a better understanding of the potential impacts of varying protein intake levels and sources on cognitive performance, ultimately informing dietary guidelines and recommendations for promoting optimal cognitive development in children.

Additionally, it is worth mentioning that the protein intake levels observed among the fishermen's children in this study are consistent with findings from other local studies conducted in similar populations. This suggests that the protein consumption patterns in this population may be a reflection of broader dietary habits and cultural factors. Therefore, it is crucial to consider the context of these findings and recognize that a comprehensive approach to understanding and addressing the relationship between protein intake and cognitive performance should take into account the broader social, cultural, and environmental factors that may influence dietary behaviours and health outcomes in this population.

As there is high risk of children having low cognitive when there are imbalance diet and nutrient, one way to tackle this problem is thru improving the children knowledge on healthy eating thru nutrition education. With this, the children will understand more regarding the important of healthy eating and having balanced diet and nutrient for their cognitive development. Healthy eating promotion among school children is one of the strategies that introduce by Ministry of Health Malaysia to encourage healthy eating practices among students, parents as well as preschool/nursery and school residents. This strategy is in line with Malaysian National Nutrition Action Plan 2016-2025 (NPANM III). Nutritional promotion activities include lectures, coaching, training, workshops, and seminars for students, parents, teachers, preschool/nursery and school residents. In addition, nutrition education resources such as infographics, brochures, posters, activity sheets, animated movies, human digestive system aprons (teaching aids), and interactive games have been created for use in preschools/nurseries and schools.

In addition, there is the Healthy Kids Programme (HKP) in Malaysia, which was launched in August 2010 as a collaborative education programme between the Nutrition Society of Malaysia (NSM) and Nestle Malaysia with the goal of improving nutrition knowledge and promoting healthy lifestyle among school children in the country. This programme successfully lowers the rate of overweight and obesity among primary school children (Siew et al., 2020). As there are couple of strategy/programs that already implement in this country, in the future, this strategy/programs may be introduce to the fishermen's community as an alternative to reduce the prevalence of low cognitive performance among fishermen's children.

All in all, these results may help us comprehend that there are numerous factors other than dietary intake, nutritional status, physical activity and sociodemographic that can affect cognitive performance in children of fishermen, including quality of life, social environment, stress events, etc. Despite the contradictory findings of several other studies, this investigation provided a starting point for further research into potential causes of low cognitive performance among children of fishermen. Therefore, more research is required to determine the relationship between cognitive performance and other variables such as academic performance, heavy metal exposure, mother's child feeding knowledge, attitude, and practices (KAP), sleep quality, parasite infection, and haemoglobin status. Besides that, future interventions to improve the cognitive performance of fishermen's children could include promoting healthier lifestyles as they may have an influence on lowering the prevalence of low cognitive performance among fishermen's children in Terengganu.

CHAPTER 5

CONCLUSION

5.1 Conclusion

This study was set up to carry out every possible factor that may influence cognitive performance among fishermen's children. Thus, this study is to assess the risk of dietary intake, nutritional status, physical activity, and associated factors toward cognitive performances among fishermen's children aged 7 to 11 years old in Terengganu. This study showed that the fishermen's children have an adequate intake of energy, protein, fat, carbohydrates, riboflavin, niacin, vitamin B6, vitamin B12, vitamin A, zinc, iron, and sodium but inadequate intake of dietary fibre, thiamine, folate, vitamin C, vitamin E, calcium and potassium. As for nutritional status, most of the children have normal height-for-age and BMI-for-age. However, 56.4% of the fishermen's children have an iodine deficiency. There are 75.5% of the targeted fishermen's children have moderate physical activity levels in terms of physical activity. For cognitive performance, the fishermen's children were classified as a low average score with a median of 80.0(21.0). This result answers the first objectives which is to determine socio-demographic profile, dietary intake, nutritional status, physical activity, and cognitive performance among fishermen's children in Terengganu.

The second objective was fulfilled by conducting Pearson Chi-square and Fischer exact test between dietary intakes, nutritional status, physical activity, socio-demographic and cognitive performance of fishermen's children. as a result, mother's education level, BMI-for-age, protein, and niacin have significant relationship with cognitive performance. As there were significant relationship between the factor and cognitive performance, risk assessment was done to fulfil the third objective of this study via logistic regression. As the result, among those four variables, BMI-for-age and fourth quartiles of protein intake ($\geq$ 52.69g) (dummy variable for *'protein'*) are the risk factor for low cognitive performance among fishermen's children in Terengganu.

With this, balance diet and healthy lifestyles are important when it comes to child growth and development, specifically cognitive development. Therefore, interventions concentrating on promoting healthier lifestyles are recommended as they may have an influence on lowering the prevalence of low cognitive performance among fishermen's children in Terengganu. Considering together, these findings would give some insight into what actually contributes to the low cognitive among fishermen's children in Terengganu. However, a myriad of variables outside dietary intake, nutritional status, physical activity, and socio-demographics, such as quality of life, social environment, stress events, environmental factors, and others, are suggested in order to know more about the risk factors of low cognitive.

5.2 Limitation

Some of the limitations of this study are this was a cross-sectional study, and therefore causality between the factors associated with the children's cognitive performance could not be well established. This due to, without longitudinal data, it is not possible to establish a true cause and effect relationship. Other than that, the limitation of nutrients in the Malaysian food composition. Due to the fact that some value of certain nutrients, particularly iodine, was not included in the Nutritionist Pro software, certain nutrients could not be analysed in this study. As a result of the constraint, there were some dietary intake assessments that could not undergo. Besides that, this study only uses one type of method for dietary assessment. Aside from that, the physical activity questionnaire used was only meant to evaluate general levels of physical activity and does not offer an estimate of calorie expenditure or particular frequency, time, or intensity. Furthermore, the reliance on child self-report data should be reduced in order to prevent overestimation and assure data quality. Last but not least, there is no theoretical model or framework yet for risk assessment of cognitive performance, such as the ANGELO framework for obesity or Hazard Identification, Risk Assessment, and Risk Control (HIRARC) for worker safety. Thus, further study regarding the methodology for this issue is highly recommended.

5.3 Suggestion for further study

Despite these constraints, the study proposes that the Nutrient Composition of Malaysian Food be revised in order to identify the amount of iodine in food. With this, it is recommended to compare the amount of iodine received through diet recall with the concentration of iodine obtained from biochemical tests. Apart from that, future studies may also look at how the children of fishermen change in terms of diet and lifestyle between monsoon and non-monsoon seasons, as well as the impact it has on their dietary intake and nutritional status. Aside from the monsoon season, it is also recommended to look at the difference between coastal and deep-sea fishermen as it could affect household income; thus, it's also highly likely to affect many other variables, such as dietary intake, nutritional status, and even cognitive performance. As this is likely the first study to investigate the risk assessment of low cognitive performance among fishermen's children, the method used for evaluation may be insufficient. As a result, a more appropriate or improved approach should be investigated further.

Based on the findings of this study, it is suggested that a fully developed nutrition education promoting program be developed in the future to assess the impact of this type of information among vulnerable groups, particularly fishermen's children. If this work is successful, a specific module can be proposed to the relevant authorities as one of the important modules to improve the life quality of fishermen's children. At the moment, a current module entitled “S.P.A.C.E (Spiritual-Physical-Affective-Curiosity&Creativity-Eating): Cognitive enhancement based-intervention module on fishermen's children” has been constructed and received copyright. This module will further study to know its effectiveness toward the target population.

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APPENDICES

APPENDIX A

Ethical approval for the study

UMT
Universiti Malaysia Terengganu

UMT CRIM
PUSAT PENGURUSAN PENYELIDIKAN & INOVASI | UMT

Jawatankuasa Etika Penyelidikan UMT (JKEP)
UMT Research Ethics Committee (UMT REC)

Pusat Pengurusan Penyelidikan & Inovasi (CRIM), Universiti Malaysia Terengganu, 21030 Kuala Terengganu

Tel : 09-6684415/4951/5078
Faks : 09- 6684944

28th October 2019

Dr. Asma' binti Ali
Faculty of Fishery and Food Sciences
University Malaysia Terengganu
21030 Kuala Terengganu
Terengganu

Dear Dr.,

Research Ethics Approval

Project title : Profiling of Nutritional Status of Mother's and Fisherman Children in Terengganu

The UMT Research Ethics Committee (UMT REC) has approved the above research project.

No. of Human Ethics Approval	**: JKEPM/2019/37**
Title	**: Profiling of Nutritional Status of Mother's and Fisherman Children in Terengganu**
Name of Principal Investigator	**: Dr. Asma' binti Ali**
Name of Co-Investigator	**: 1) Muhammad Musyammel bin Mustapa**
	2) Muhammad Fakhrullah bin Badurisham
	3) Badriah Aisyah binti Bahtiar
	4) Nur Shafikah binti Hashim
	5) Nur Shamimi binti Zakaria
	6) Amni Ajwa Laila binti Abdullah
	7) Nurhafizah Husna binti Zakaria

(Please notify UMT Research Ethics Committee (UMT REC) if there are additional staff/students who will be involved in handling for this project)

Jawatankuasa Etika Penyelidikan UMT **JKEP UMT**
UMT Research Ethics Committee (UMT REC)

Members of the UMT Research Ethics Committee (UMT REC) who reviewed the documents as follows:

Member (Title and Name)		Occupation (Designation)
Chairman : Prof. Dr. Mohd. Effendy bin Abd Wahid		Dean, Faculty of Fishery and Food Sciences
Chairperson of Human Ethics Committee : Associate Prof. Dr. Ruhani binti Mat Min		Lecturer, Faculty of Business, Economics and Social Development
Evaluator :		
1.	Associate Prof. Dr. Zakaria bin Mohamad	Senior Lecturer, Faculty of Business, Economics and Social Development
2.	Profesor Dr. Asyraf bin Hj. Ab Rahman	Senior Lecturer, Centre for Fundamental and Continuing Education
3.	Associate Prof. Dr. Noor Rohana binti Mansor	Senior Lecturer, Centre for Fundamental and Continuing Education

Thank you.

"OCEAN OF DISCOVERIES FOR GLOBAL SUSTAINABILITY"

Yours sincerely,

PROFESOR DR. MOHD. EFFENDY BIN ABD. WAHID
Chairman,
UMT Research Ethics Committee (UMT REC)

Cc : File

Jawatankuasa Etika Penyelidikan UMT **JKEP UMT**
UMT Research Ethics Committee (UMT REC)

APPENDIX B

Ethical approval for the study

Jawatankuasa Etika Penyelidikan UMT
(UMT Research Ethics Committee)

Pusat Pengurusan Penyelidikan & Inovasi (CRIM),
Universiti Malaysia Terengganu,
21030 Kuala Terengganu

Tel : 09-6684415/4951/5078
Faks : 09- 6684944

22nd June 2021

Dr. Asma' binti Ali
Faculty of Fisheries and Food Science
Universiti Malaysia Terengganu
21030 Kuala Terengganu
Terengganu

Dear Dr.,

Research Ethics Approval

Project title : Risk Assessment of Poor Cognitive Performance Among Fisherman's Children in Terengganu

The UMT Research Ethics Committee (UMT REC) has approved the above research project :

No. of Human Ethics Approval	**: UMT/JKEPM/2021/64**
Title	**: Risk Assessment of Poor Cognitive Performance Among Fisherman's Children in Terengganu**
Name of Principal Investigator	**: Dr. Asma' binti Ali**
Name of Co- Investigator	**: Assoc. Prof. Dr. Hayati Mohd Yusof**
Name of Student Investigator	**: 1. Ms. 'Atiah Munirah binti Meli**

Thank you.

"OCEAN OF DISCOVERIES FOR GLOBAL SUSTAINABILITY"

Yours sincerely,

PROF. DR. MOHD. EFFENDY BIN ABD. WAHID
Chairman
UMT Research Ethics Committee (UMT REC

cc : File

Jawatankuasa Etika Penyelidikan UMT **JKEP UMT**
UMT Research Ethics Committee (UMT REC)

APPENDIX C

Informed consent

Consent form

UNIVERSITI MALAYSIA TERENGGANU (UMT)

21030 KUALA TERENGGANU,
TERENGGANU, MALAYSIA. Tel: 09-668 4235
Laman Web: http://www.umt.edu.my Fax: 09-668 4143

BORANG KEIZINAN RESPONDEN

Tandatangan

Untuk menyertai kajian ini, anda mesti menandatangani mukasurat ini.
Dengan menandatangani mukasurat ini, saya ______________________________ (Nama) ____________________ (No.Kad Pengenalan) mengesahkan yang berikut:

- Saya telah membaca semua maklumat dalam Borang Maklumat dan Keizinan Responden ini termasuk apa-apa maklumat berkaitan risiko yang ada dalam kajian dan saya telahpun diberi masa yang mencukupi untuk mempertimbangkan maklumat tersebut.
- Semua soalan-soalan saya telah dijawab dengan memuaskan.
- Saya, secara sukarela, bersetuju menyertai kajian penyelidikan ini, mematuhi segala prosedur kajian dan memberi maklumat yang diperlukan kepada para penyelidik yang berkaitan apabila diminta.
- Saya boleh menamatkan penyertaan saya dalam kajian ini pada bila-bila masa.
- Saya telahpun menerima satu salinan Borang Maklumat dan Keizinan Responden untuk simpanan peribadi saya.
- Semua subjek yang mengambil bahagian dalam projek penyelidikan ini tidak dilindungi insuran.

Sekian, terima kasih.

…………………………

Tandatangan Peserta Kajian

Tarikh:

Kod Peserta: ______________________

Nama saksi: ______________________

No. Kad Pengenalan: ______________________

Tandatangan Saksi: …………………………

Tarikh:______________________

Nama Penyelidik:

No. Kad Pengenalan:

Tandatangan : …………………………

Consent form

UNIVERSITI MALAYSIA TERENGGANU (UMT)

21030 KUALA TERENGGANU,
TERENGGANU, MALAYSIA. Tel: 09-668 4235
Laman Web: http://www.umt.edu.my Fax: 09-668 4143

BORANG KEIZINAN IBU BAPA/ PENJAGA

Tandatangan

Untuk menyertai kajian ini, anda mesti menandatangani mukasurat ini.

Dengan menandatangani mukasurat ini, saya ____ (nama) ____________________(No.Kad Pengenalan) merupakan ibubapa/penjaga kepada ___________ _________(nama anak) mengesahkan yang berikut:

- Saya telah membaca semua maklumat dalam Borang Maklumat dan Keizinan Responden ini termasuk apa-apa maklumat berkaitan risiko yang ada dalam kajian dan saya telahpun diberi masa yang mencukupi untuk mempertimbangkan maklumat tersebut bagi pihak anak saya.
- Semua soalan-soalan saya telah dijawab dengan memuaskan.
- Saya, secara sukarela, bersetuju untuk membenarkan anak saya menyertai kajian penyelidikan ini, mematuhi segala prosedur kajian dan memberi maklumat yang diperlukan kepada para penyelidik yang berkaitan apabila diminta.
- Saya boleh menamatkan penyertaan anak saya dalam kajian ini pada bila-bila masa.
- Saya telahpun menerima satu salinan Borang Maklumat dan Keizinan Responden untuk simpanan peribadi saya.
- Anak-anak yang mengambil bahagian dalam projek penyelidikan ini tidak dilindungi insuran.

Sekian, terima kasih.

…………………………

Tandatangan Ibubapa/penjaga Peserta Kajian

Tarikh:

Kod Peserta: ___________________

Nama saksi: ___________________

No. Kad Pengenalan: ___________________

Tandatangan Saksi: …………………………

Tarikh: ___________________

Nama Penyelidik: ___________________

No. Kad Pengenalan: ___________________

APPENDIX D

Letter of invitation to conduct research in Setiu

Tarikh **: 28 April 2021**
Bersamaan **: 16 Ramadhan 1442H**

Para nelayan di daerah Setiu, Terengganu

Tuan,

Kaji Selidik Bilangan Anak-Anak Nelayan di Daerah Setiu, Terengganu

Dengan segala hormatnya merujuk kepada perkara di atas.

2. Saya merupakan ketua penyelidik bagi projek '*Risk Assessments of Poor Cognitive Performance among Fishermen's Children in Terengganu, Malaysia'* di bawah geran Kementerian Pendidikan Malaysia FRGS-RACER. Objektif utama projek ini adalah untuk menjalankan penilaian faktor-faktor risiko yang mempengaruhi prestasi pembelajaran di kalangan anak-anak nelayan.

3. Oleh yang demikian, kami amat memerlukan kerjasama tuan-tuan untuk mendapat data-data seperti berikut bagi membantu perjalanan projek ini;

a) Nama, alamat, nombor telefon dan juga bilangan anak

4. Data-data berkenaan amat penting bagi kami untuk memudahkan kerja pencarian sampel projek. Segala kerjasama yang diberikan daripada pihak tuan amat kami hargai dengan ucapan ribuan terima kasih.

Sekian.

Yang benar,

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APPENDIX E

Team member meeting with the leader of fishermen community

APPENDIX F

Data collection pictures


MELAKA


Foodies
PASSION


MEROKOK

APPENDIX G

Questionnaire for fishermen's children aged 7-11 years old

SEKSYEN 1: IBU ATAU PENJAGA

BAHAGIAN A: PROFIL SOSIO-DEMOGRAFI

Sila isi tempat kosong atau tandakan (/) pada kotak yang betul untuk setiap soalan. Hanya satu kotak yang harus dipilih.

1. Jantina anak

☐ Lelaki

☐ Perempuan

2. Umur anak

☐ 7

☐ 8

☐ 9

☐ 10

☐ 11

3. Pendapatan bulanan serumah:

☐ <RM1500

☐ RM 1500-RM2999

☐ RM3000-RM3999

☐ RM4000-RM4999

☐ >RM5000

4. Bilangan ahli rumah:

- ☐ 1-5
- ☐ 6-10
- ☐ 11-15

5. Tahap pendidikan ibu:

- ☐ Sekolah rendah
- ☐ Sekolah Menengah (SPM)
- ☐ Pendidikan pasca menengah (STPM / Matrikulasi/ A-level)
- ☐ Pendidikan tinggi (Diploma/Ijazah Sarjana Muda/Ijazah

6. Pekerjaan ibu

- ☐ Peniaga
- ☐ Pembantu kedai
- ☐ Pengasuh
- ☐ Suri rumah
- ☐ Lain-lain (sila nyatakan): ________________

SEKSYEN 2: KANAK KANAK (7-11 TAHUN)

STATUS NUTRISI

i) Maklumat anak

Jantina: ___________

Tarikh lahir: ___________

ii) Pengukuran Antropometri

Ukuran	Bacaan	Catatan
Tinggi (cm)		
Berat (kg)		
BMI (kg/m^2)		

iii) Biokimia

Pengukuran	Bacaan	Catatan
Median urinary iodine (µg/l) Kod: ___________		

iv) Borang Ingatan Diet 24 Jam

Hari Pertama

1. *Bahagian ini dijawab mengikut pengambilan makanan pada masa pagi, tengahari dan malam dalam tempoh 24 jam sebelum temu ramah dijalankan. Ia bertujuan untuk menentukan pengambilan makanan seharian, jumlah pengambilan kalori dan nutrien dalam sehari, makanan yang menjadi sumber tenaga dan nutrien serta corak pengambilan makanan dan minuman.*

2. *Ingatan Diet 24 Jam ini dijalankan secara temu ramah interaktif, dimana ianya melibatkan empat peringkat, iaitu:*
   Peringkat 1: Mengingatkan masa makan dan minum, serta makanan dan minuman

   yang diambil

   Peringkat 2:(i) Menerangkan masa makanan dan minuman yang diambil secara

   terperinci

   (ii) Menganggarkan berapa banyak makanan dan minuman yang dimakan

   dan diminum

   Peringkat 3: Mengkaji semula maklumat ingatan pengambilan makanan tersebut.

   Peringkat 4: Menukar anggaran berapa banyak makanan dan minuman yang

   dimakan dan diminum kepada berat yang setara.

3. *Untuk bahagian minuman alcohol, penemu ramah perlu bertanya samada responden ada mengambil minuman beralkohol atau tuak sehari sebelum temu ramah. Penemu ramah perlu mendapatkan penjelasan terperinci tentang jenis minuman beralkohol dan kuantiti yang diambil. Sekiranya responden telah menyebut minuman alcohol dalam ruangan minuman/makanan, penemu ramah tidak perlu bertanyakan sekali lagi di dalam ruangan minuman beralkohol.*

1. Meal and beverage / *Makanan dan minuman*

Date of interview: *Tarikh temu ramah*			Name of respondent: *Nama responden*					
Recall day: *Hari ingatan*:	Monday *Isnin*	Tuesday *Selasa*	Wednesday *Rabu*	Thursday *Khamis*	Friday *Jumaat*	Saturday *Sabtu*	Sunday *Ahad*	Circle recall day *Bulatkan hari ingatan*
a. Time / *Masa* Morning/ *Pagi*	b. Meal and beverage *Makanan dan minuman*		c. Meal and beverage description *Penjelasan terperinci bahan makanan dan minuman*			d. Amount *Jumlah*		e. Meal weight (gram/mL) *Berat makanan (gram/mL)*

Source: National Health and Morbidity Survey 2014: Malaysian Adult Nutrition Survey

1. Meal and beverage / *Makanan dan minuman*

a. Time/ *Masa* Afternoon/ *Tengah hari*	b. Meal and beverage *Makanan dan minuman*	c. Meal and beverage description *Penjelasan terperinci bahan makanan dan minuman*	d. Amount *Jumlah*	e. Meal weight (gram/mL) *Berat makanan (gram/mL)*

Source: National Health and Morbidity Survey 2014: Malaysian Adult Nutrition Survey

1. Meal and beverage / *Makanan dan minuman*

a. Time/ *Masa* Evening/ *Malam*	b. Meal and beverage *Makanan dan minuman*	c. Meal and beverage description *Penjelasan terperinci bahan makanan dan minuman*	d. Amount *Jumlah*	e. Meal weight (gram/mL) *Berat makanan (gram/mL)*

Source: National Health and Morbidity Survey 2014: Malaysian Adult Nutrition Survey

1. Meal and beverage / *Makanan dan minuman*

a. Time/ *Masa* Additional/ *Tambahan*	b. Meal and beverage *Makanan dan minuman*	c. Meal and beverage description *Penjelasan terperinci bahan makanan dan minuman*	d. Amount *Jumlah*	e. Meal weight (gram/mL) *Berat makanan (gram/mL)*

Source: National Health and Morbidity Survey 2014: Malaysian Adult Nutrition Survey

Hari Kedua

1. *Bahagian ini dijawab mengikut pengambilan makanan pada masa pagi, tengahari dan malam dalam tempoh 24 jam sebelum temu ramah dijalankan. Ia bertujuan untuk menentukan pengambilan makanan seharian, jumlah pengambilan kalori dan nutrien dalam sehari, makanan yang menjadi sumber tenaga dan nutrien serta corak pengambilan makanan dan minuman.*

2. *Ingatan Diet 24 Jam ini dijalankan secara temu ramah interaktif, dimana ianya melibatkan empat peringkat, iaitu:*
   Peringkat 1: Mengingatkan masa makan dan minum, serta makanan dan minuman

   yang diambil

   Peringkat 2:(i) Menerangkan masa makanan dan minuman yang diambil secara

   terperinci

   (ii) Menganggarkan berapa banyak makanan dan minuman yang dimakan

   dan diminum

   Peringkat 3: Mengkaji semula maklumat ingatan pengambilan makanan tersebut.

   Peringkat 4: Menukar anggaran berapa banyak makanan dan minuman yang

   dimakan dan diminum kepada berat yang setara.

3. *Untuk bahagian minuman alcohol, penemu ramah perlu bertanya samada responden ada mengambil minuman beralkohol atau tuak sehari sebelum temu ramah. Penemu ramah perlu mendapatkan penjelasan terperinci tentang jenis minuman beralkohol dan kuantiti yang diambil. Sekiranya responden telah menyebut minuman alcohol dalam ruangan minuman/makanan, penemu ramah tidak perlu bertanyakan sekali lagi di dalam ruangan minuman beralkohol.*

1. Meal and beverage / *Makanan dan minuman*

Date of interview: *Tarikh temu ramah*			Name of respondent: *Nama responden*					
Recall day: *Hari ingatan:*	Monday *Isnin*	Tuesday *Selasa*	Wednesday *Rabu*	Thursday *Khamis*	Friday *Jumaat*	Saturday *Sabtu*	Sunday *Ahad*	Circle recall day *Bulatkan hari ingatan*
a. Time / *Masa* Morning/ *Pagi*	b. Meal and beverage *Makanan dan minuman*		c. Meal and beverage description *Penjelasan terperinci bahan makanan dan minuman*			d. Amount *Jumlah*		e. Meal weight (gram/mL) *Berat makanan (gram/mL)*

Source: National Health and Morbidity Survey 2014: Malaysian Adult Nutrition Survey

1. Meal and beverage / *Makanan dan minuman*

a. Time/ *Masa* Afternoon/ *Tengah hari*	b. Meal and beverage *Makanan dan minuman*	c. Meal and beverage description *Penjelasan terperinci bahan makanan dan minuman*	d. Amount *Jumlah*	e. Meal weight (gram/mL) *Berat makanan (gram/mL)*

Source: National Health and Morbidity Survey 2014: Malaysian Adult Nutrition Survey

1. Meal and beverage / *Makanan dan minuman*

a. Time/ *Masa* Evening/ *Malam*	b. Meal and beverage *Makanan dan minuman*	c. Meal and beverage description *Penjelasan terperinci bahan makanan dan minuman*	d. Amount *Jumlah*	e. Meal weight (gram/mL) *Berat makanan (gram/mL)*

Source: National Health and Morbidity Survey 2014: Malaysian Adult Nutrition Survey

1. Meal and beverage / *Makanan dan minuman*

a. Time/ *Masa* Additional/ *Tambahan*	b. Meal and beverage *Makanan dan minuman*	c. Meal and beverage description *Penjelasan terperinci bahan makanan dan minuman*	d. Amount *Jumlah*	e. Meal weight (gram/mL) *Berat makanan (gram/mL)*

Source: National Health and Morbidity Survey 2014: Malaysian Adult Nutrition Survey

AKTIVITI FIZIKAL

Nama	Umur
Jantina	Darjah

Kami sedang berusaha untuk mengetahui tahap aktiviti fizikal anda dari 7 hari yang lalu (pada minggu lepas). Ini termasuk sukan atau tarian yang membuat anda berpeluh atau membuat kaki anda berasa letih, atau permainan yang membuat anda bernasib keras, seperti tag, melangkau, berlari, mendaki, dan lain-lain.

Peringatan:
1. Tidak ada jawapan yang betul dan salah - ini bukan ujian.
2. Sila jawab semua soalan dengan jujur dan tepat seperti yang anda boleh - ini sangat penting

1. Aktiviti fizikal dalam masa lapang anda: Pernahkah anda melakukan mana-mana aktiviti berikut dalam 7 hari terakhir (minggu lepas)? Jika ya, berapa kali? (Tandakan hanya satu bulatan setiap baris.)

	No	1-2	3-4	5-6	7-Lebih
Lompat Tali					
Merakit					
Papan Luncur					
Kejar-kejar					
Berjalan untuk senaman					
Berkayuh					
Jogging/Berlari					
Aerobics					
Berenang					
Baseball/Softball					
Menari					
Bermain bola sepak					
Badminton					
Hoki					
Bola Baling					
Hoki Lantai					
Bola Keranjang					
Lain-lain					

--------------------- -----					

2. Dalam 7 hari terakhir, semasa kelas pendidikan jasmani (PE), berapa kerap anda aktif (bermain keras, berlari, melompat, membuang)? (Semak satu sahaja.)

Saya tidak melakukan sebarang aktiviti pendidikan	
Jarang sekali	
Kadang-kadang	
Kerap	
Sangat Kerap	

3. Dalam 7 hari yang lalu, apa yang anda lakukan pada masa yang paling lama di waktu rehat? (Semak satu sahaja.)

Duduk (Bercakap, Membaca, Melakukan kerja sekolah)	
Berdiri dan berjalan	
Berlari dan bermain sedikit	
Berlari dan bermain	
Berlari dan bermain bersungguh-sungguh	

4. Dalam 7 hari terakhir, apa yang biasanya anda lakukan semasa makan tengah hari (selain makan tengahari)? (Semak satu sahaja.)

Duduk (Bercakap, Membaca, Melakukan kerja sekolah)	
Berdiri dan berjalan	
Berlari dan bermain sedikit	
Berlari dan bermain	
Berlari dan bermain bersungguh-sungguh	

5. Dalam 7 hari terakhir, berapa hari selepas sekolah, adakah anda melakukan sukan, tarian, atau bermain permainan di mana anda sangat aktif? (Semak satu sahaja.)

Tiada	
1 kali minggu lalu	
2 atau 3 kali minggu lalu	
4 kali minggu lalu	
5 kali minggu lalu	

6. Dalam 7 hari yang lalu, pada berapa malam anda melakukan sukan, menari, atau bermain permainan di mana anda sangat aktif? (Semak satu sahaja.)

Tiada	
1 kali minggu lalu	
2 atau 3 kali minggu lalu	
4 atau 5 kali minggu lalu	
6 atau 7 kali minggu lalu	

7. Pada hujung minggu lalu, berapa kali anda melakukan sukan, menari, atau bermain permainan di mana anda sangat aktif? (Semak satu sahaja.)

Tiada	
1 kali	
2 atau 3 kali	
4 atau 5 kali	
6 kali atau lebih	

8. Antara berikut yang manakah menerangkan anda terbaik untuk 7 hari yang lalu? Bacalah semua lima kenyataan sebelum memutuskan satu jawapan yang menggambarkan anda.

Semua atau sebahagian besar masa luang saya dibelanjakan untuk melakukan perkara-perkara yang melibatkan sedikit usaha fizikal	
Saya kadang-kadang (1 - 2 kali minggu lepas) melakukan perkara-perkara fizikal dalam masa lapang saya (mis. Bermain sukan, berlari, berenang, menunggang basikal, melakukan aerobik)	
Saya sering (3 - 4 kali minggu lepas) melakukan perkara-perkara fizikal dalam masa lapang saya	
Saya sering (5 - 6 kali minggu lepas) melakukan perkara-perkara fizikal dalam masa lapang saya	
Saya sangat kerap (7 atau lebih kali minggu lalu) melakukan perkara-perkara fizikal dalam masa lapang saya	

9. Tandakan seberapa kerap anda melakukan aktiviti fizikal (seperti bermain sukan, permainan, melakukan tarian, atau aktiviti fizikal yang lain) untuk setiap hari minggu lepas.

	Tiada	Sedikit	Sederhana	Kerap	Sangat kerap
Isnin					
Selasa					
Rabu					
Khamis					
Jumaat					
Sabtu					
Ahad					

10. Adakah anda sakit minggu lepas, atau melakukan apa-apa yang menghalang anda melakukan aktiviti fizikal anda? (Semak satu.)

Ya	
Tidak	

Jika ya, apa yang menghalang anda?

____

FUNGSI KOGNITIF

COLOURED PROGRESSIVE MATRICES (CPM) RECORD FORM

Nama: ____

Jantina: ____________________

	Tahun	Bulan	Hari
Tarikh Diuji			
Tarikh Lahir			
Umur			

Kesimpulan markah: __________________

Jumlah Markah Kasar		Raw Score Confidence Interval (75%, 97.5%, 99%) *bulatkan satu*	
Markah Standard		Standard Score Confidence Interval (75%, 97.5%, 99%) *bulatkan satu*	
Peringkat persentil		Umur bersamaan	

Skor Standard	Terjemahan Kualitatif
<70	Extremely low
70-80	Borderline
80-90	Low average
90-100	Average
110-120	High average
120-130	Superior
>130	Very superior

APPENDIX H

Publication in Malaysian Journal of Public Health Medicine, 21(1): 148-159 (2021)

Malaysian Journal of Public Health Medicine 2021, Vol. 21 (1): 148-159

ORIGINAL ARTICLE

DIETARY INTAKE, NUTRITIONAL STATUS AND COGNITIVE PERFORMANCE AMONG FISHERMEN'S CHILDREN: A REVIEW

Atiah Munirah Meli and Asma' Ali

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ABSTRACT

This paper highlights the dietary intake of fishermen's children, their nutritional status and cognitive performance. It will help to have a reasonable perspective of their dietary intake and their relationship with nutritional status and how it inevitably influences cognitive performance. This is relevant as it can provide the government and health authorities with insights into the execution of an action plan to improve the nutritional status of fishing communities, especially in Malaysia, where possible. A systematic search of the English scholarly papers on this subject was undertaken between 1997 and 2020. A total of 20 studies have been systematically chosen and reviewed. Studies are divided into two groups, based on the type of research conducted. Ten of the retrieved studies looked at dietary intake and nutritional status in fisherman's children, while another ten studies looked at cognitive performance in children and adolescents and the factors that contributed to it. In terms of dietary intake, three studies reported low energy consumption and low carbohydrate intake, one study reported high carbohydrate intake, four studies reported high protein intake, one study reported low fat intake, five studies reported low micronutrient intake (calcium, iron, vitamin A and vitamin C) and two studies reported high intake of niacin. As far as nutritional status is concerned, six studies recorded that children are stunted/underweight and three studies reported that children are obese/overweight. In comparison, one study recorded high cognitive performance, three studies reported average cognitive performance, and three studies reported poor cognitive performance. In the studies reviewed, it has been shown that there is a positive association between socio-economic status, dietary intake/nutritional status and cognitive performance among children in fishing communities in different regions. There is a need for nutrition education and intervention in these disadvantaged communities.

Keywords: *Dietary intakes, Nutritional status, Cognitive Performance, Fishermen's children.*

INTRODUCTION

Nutritional status refers to the condition of the human body influenced by the level of nutrients in the body and the ability of the level of nutrients to maintain the healthy body composition and function[1]. The nutritional status of an individual is influenced by several interrelated factors which include diet intake and physical activity. Malnutrition is a condition which results from imbalance in consumption of macronutrient and also micronutrient over a long period of time. Poor diet practices established during childhood have the potential to negatively impact growth of children and may increase the risk of diet related chronic disease such as obesity and cardiovascular diseases in later stages of life[2-3]. Aside from that, it also has an important and long-lasting influence on child cognitive development[4]. Adequate nutrients from diet are needed during the developmental stage for brain structure as well as function[5]. In addition to that, brain growth and development is most rapid and critical during the first 2 years of life, but development of the frontal lobes continues throughout early childhood[4].

Nutritional status of fishermen children is one of the main concerns due to the vulnerability of fishermen households towards food security. Previous studies showed that food insecurity was prevalent among fishing communities[6-8]. Fishing is one of the important global industries, however it is also one of the sectors with the highest incidence of poverty[9]. Fishermen were used to characterize as having low socioeconomic status[10-11] and poor standard of living[12]. Fishing communities depend on marine and coastal resources for their livelihood. Nevertheless, the fishing activities are susceptible to environmental changes such as rise of sea level, increased temperature on the sea surface and increased acidification of ocean which have reported to affect the abundance and distribution of fish species and also amount of fish caught by fishermen. Unpredictable fishing returns due to the environmental changes threaten their livelihood and may increase their vulnerability. Unlike the laborers from the other sectors, fishermen do not have monthly fixed income. Their income is primarily determined by the amount of fish caught through their fishing effort. Based on a study by Zainuddin et al.[13], the majority of fishermen's households earned an income between USD 250 to USD 500 and others earned between USD 500 to USD 700 which did not pass the Malaysian median household income. A study by Nursyazwin & Zein[4] also stated that the

APPENDIX I

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medicina MDPI

Systematic Review

Effects of Physical Activity and Micronutrients on Cognitive Performance in Children Aged 6 to 11 Years: A Systematic Review and Meta-Analysis of Randomized Controlled Trials

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Abstract: *Background and Objectives*: Cognitive performance is essential for children, given this is a critical stage of brain growth and development. This systematic review and meta-analysis aimed to ascertain if physical activity or micronutrients impact cognitive performance in children. *Materials and Methods*: Electronic databases (PubMed and Scopus®) were searched for relevant articles published between 2012 and 2021. We emphasized randomized controlled trials (RCTs) that examined the effect of physical activity and micronutrients on cognitive performance. Data from eligible studies were gathered and evaluated using random-, fixed- or pooled-effects models with 95% confidence intervals (95% CI). *Results*: Physical activity appeared to improve both Mathematics (d = 1.12, 95% CI: 0.56, 1.67) and attention (d = 0.65, 95% CI: 0.15, 1.14) performances. The micronutrient vitamin B12 had a positive effect on Mathematics (d = 2.39, 95% CI: 0.79, 3.98), English (d = 5.29, 95% CI: 2.76, 7.83), Geography (d = 5.29, 95% CI: 2.76, 7.83), Science (d = 3.39, 95% CI: 2.62, 4.16) and Arts (d = 3.32, 95% CI: 1.84, 4.79). Zinc was found to positively affect English (d = 3.78, 95% CI: 0.44, 7.13), Geography (d = 4.77, 95% CI: 0.56, 8.98) and Arts (d = 2.39, CI: 0.33, 4.45). Iron positively affected Mathematics (d = 1.29, 95% CI: 0.54, 2.06), English (d = 1.29, 95% CI: 0.44, 7.13), Geography (d = 4.77, 95% CI: 0.56, 8.98) and Arts (d = 2.39, 95% CI: 0.33, 4.45). *Conclusions*: A more comprehensive intervention with a specific dose/level of physical activity, an increased range of cognitive performance, and a well-designed study design that accounts for dietary intake and other health outcomes are required for future studies.

Keywords: physical activity; micronutrients; cognitive performance; children

check for updates

Citation: Meli, A.M.; Ali, A.; Mhd Jalil, A.M.; Mohd Yusof, H.; Tan, M.M. Effects of Physical Activity and Micronutrients on Cognitive Performance in Children Aged 6 to 11 Years: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. *Medicina* **2022**, *58*, 57. https://doi.org/10.3390/medicina58010057

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1. Introduction

Cognitive performance is described as the capacity for reasoning, problem-solving, scheduling, nonfigurative judgement, multi-idea comprehension, and experience-based learning and encompasses all elements of general mental competence [1]. It provides critical educational and social experiences for children during their middle childhood stages (ages 6–11 years), and the school years allow children to learn to read, calculate, and develop social skills for interacting with other children and significant adults, as well as acquire broader cultural and social values. Interactions between children and their social and physical environments continue to promote growth [2]. Therefore, it is critical to assist

APPENDIX J

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Taibah University

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Original Article

Risk assessments of low cognitive performance among Fishermen's children in Malaysia

Q14 Atiah Munirah Meli[a], Nurhafizah Husna Zakaria[a], Hayati Mohd Yusof[a],
Q2 Q3 Khairil Shazmin Kamarudin[a] and Asma' Ali[a,*]

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الملخص

أهداف البحث: يعد الأداء المعرفي المنخفض مصدر قلق رئيسي بين أطفال الصيادين في ماليزيا. وبالتالي، هدفت هذه الدراسة إلى تقييم المدخول الغذائي، والحالة التغذوية، والنشاط البدني، والعوامل المرتبطة بها (الوضع الاجتماعي والاقتصادي) تجاه الأداء المعرفي لدى 94 طفلا من أطفال الصيادين تتراوح أعمارهم بين 7 و 11 عاما في ترينجانو ومخاطر انخفاض الأداء المعرفي لديهم.

طريقة البحث: تم تحديد كفاية نظامهم الغذائي من خلال استدعاء غذائي لمدة يومين و 24 ساعة. تم تقييم القياسات الأنثروبومترية من خلال حساب مؤشر كتلة الجسم للأطفال مقابل العمر ودرجة الطول مقابل العمر، بينما تم إجراء اختبار اليود البولي لتحديد تركيز اليود. يتم قياس النشاط البدني باستخدام استبانة النشاط البدني للأطفال. تم استخدام مصفوفات رافين التقدمية الملونة لتحديد الأداء المعرفي للأطفال. تم إجراء الانحدار اللوجستي ذو الحدين على العوامل التي لها علاقة بالأداء المعرفي لتحديد العوامل التي تؤثر على الأداء المعرفي أكثر.

النتائج: باستثناء الألياف الغذائية والثيامين وحمض الفوليك وفيتامين "سي" وفيتامين "إي" والكالسيوم والبوتاسيوم، حصل أطفال الصيادين على جميع العناصر الغذائية التي يحتاجونها بشكل كاف. معظم الأطفال لديهم مؤشر كتلة الجسم للأطفال مقابل العمر طبيعي ودرجة طول مقابل العمر طبيعي. ومع ذلك، فإن أكثر من نصفهم يعانون من نقص اليود. حوالي 75.5٪ من أطفال الصيادين لديهم مستوى نشاط بدني معتدل ويصنف أدائهم المعرفي على أنه متوسط درجات منخفض. فقط مستوى تعليم الأم، والثيامين، وفيتامين ب12، فيتامين "إي"، والبوتاسيوم لها علاقة ذات دلالة إحصائية بالأداء المعرفي. من بين هذه المتغيرات، فإن مستوى تعليم الأم فقط هو عامل الخطر للأداء المعرفي المنخفض.

الاستنتاجات: مشاركة الأم مهمة عندما يتعلق الأمر بالتطور المعرفي. لذلك، يوصى بالتدخلات التي تركز على تعزيز الأبوة والأمومة الإيجابية وتشجيع الأمهات على قضاء المزيد من الوقت مع أطفالهن.

الكلمات المفتاحية: المدخول الغذائي؛ الحالة التغذوية؛ الأداء المعرفي؛ أطفال الصيادين؛ ماليزيا

Abstract

Objectives: Low cognitive performance is a primary concern among the children of fishermen in Malaysia. Thus, this study aimed to assess dietary intakes, nutritional status, physical activity, and their associated factors (socio-economic status) with regards to the cognitive performance of 94 fishermen's children aged 7–11 years in Terengganu; we also evaluated the risks associated with low cognitive performance.

Methods: Diet adequacy was identified by applying a 2-day 24-h dietary recall. Anthropometric measurements were assessed by calculating BMI-for-age Z-score (BAZ) and height-for-age Z-score (HAZ). In addition, a median urinary iodine test was conducted to determine the concentration of iodine. Physical activity was measured using the Physical Activity Questionnaire for Children (PAQ-C). Raven's coloured progressive matrices were used to

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APPENDIX K

Copyright of S.P.A.C.E (Spiritual-Physical-Affective-Curiosity&Creativity-Eating): Cognitive enhancement based-intervention module on fishermen's children.

AKTA HAK CIPTA 1987

PERATURAN-PERATURAN HAK CIPTA (PEMBERITAHUAN SUKARELA) 2012

SIJIL PEMBERITAHUAN HAK CIPTA
[Subperaturan 8(2)]

No. Pemberitahuan	:	**CRLY2021C01202**
Tajuk Karya	:	**S.P.A.C.E (SPIRITUAL-PHYSICAL-AFFECTIVE-CURIOSITY&CREATIVITY-EATING): COGNITIVE ENHANCEMENT BASED-INTERVENTION MODULE ON FISHERMEN'S CHILDREN**
Jenis Karya	:	**SASTERA**
Tarikh Permohonan	:	**07 APRIL 2021**

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Mukasurat 1/2

(Agensi di bawah Kementerian Perdagangan Dalam Negeri dan Hal Ehwal Pengguna)

APPENDIX L

Certificate of NIACIN (Nutrition Seminar and Charity for Children) Nutrition Fair 2021

CERTIFICATE

Is awarded to

Atiah Munirah binti Meli

as

Participant

At the International Webinar *NIACIN (Nutrition Seminar and Charity for Children)* Nutrition Fair 2021
with the theme *"Sustainable Food Security and Nutrition for Better Living"*

IPB University, September 19th 2021

Learning hours: 4,2 hours

Vice Dean for Academic and Student Affairs Faculty of Human Ecology	Head of Department of Community Nutrition IPB University	President of Food and Nutrition Society of Indonesia	Chief Executive of HIMAGIZI	Chief Executive of Nutrition Fair 2021
Dr. Ir. Siti Amanah, M.Sc NIP. 19670903 199212 2 001	Prof. Dr. Ir. Sri Anna Marliyati, M.Si NIP. 19600205 198903 2 002	Prof. Hardinsyah, M.S, Ph.D NIP. 19590807 198303 1 001	Nia Imaniar NIM. I14180047	Elmira Fairuz Khilda Machfud NIM. I14180091

No. 506/IAKMIPUSAT/SKP-IX/2021 : 2 SKP participants, 3 SKP speakers, 2 SKP moderators, and 2 SKP committee
No. 103/SK/SKP/PERGIZI/VIII/2021 : 1 SKP participants, 3 SKP speakers, 1 SKP moderators, and 1 SKP committee
No. 782/DPP-PERSAGI/SK/IX/2021 : 1 SKP participants, 1 SKP speakers, 1 SKP moderators, and 1 SKP committee

APPENDIX M

Certificate of 5th INHESION "International Nutrition and Health Symposium" 2021


787/DPP-PERSAGI/SK/IX/2021
Peserta : 1 SKP
Narasumber : 2 SKP
Moderator dan Panitia : 1 SKP

Certificate
of Appreciation

This Certificate is Proudly Presented to

Atiah Munirah Binti Meli

In recognition of valuable contribution as the Presenter of Oral Presentation
5th INHESION "International Nutrition and Health Symposium" 2021
Conducted by
Departement of Nutrition and Health, Faculty of Medicine, Public Health, and Nursing
Universitas Gadjah Mada

Sunday, 31 October 2021

Chairperson of Departement
Dr. Susetyowati, DCN, M.Kes
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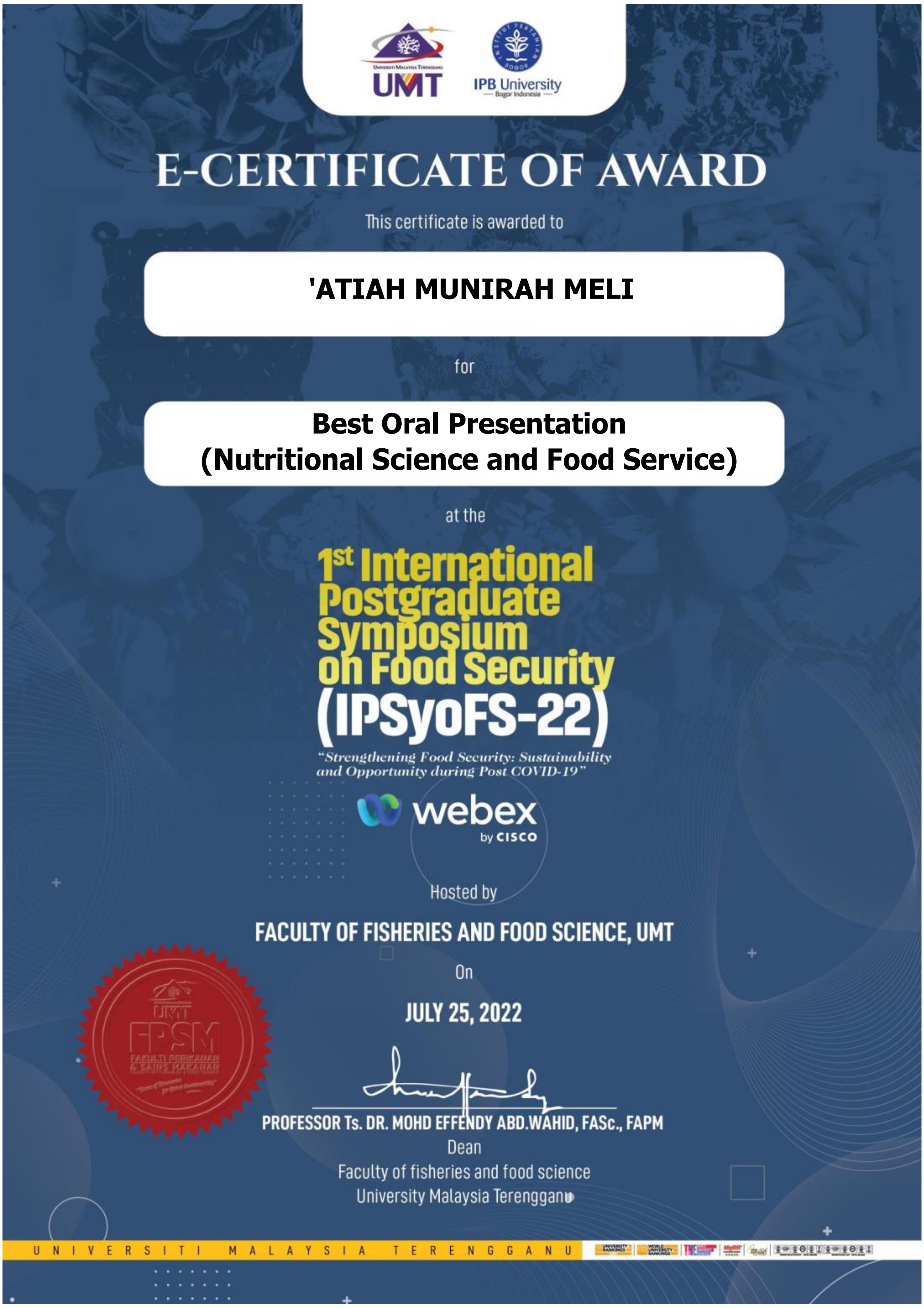
Chairperson of Nutrition Student Association FK-KMK UGM
Muhammad Rafi Arfiansyah
NIM. 19/441946/KU/21492

Chairperson of INHESION 2021
Isthafaina Dea Fairuz
NIM. 19/441937/KU/21483

APPENDIX N

Certificate of 1st International Postgraduate Symposium of Food Security (IPSyoFS-22)



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- Meta-Analysis Workshop by Faculty of Fisheries & Food Science, Universiti Malaysia Terengganu (2021)
- Kursus statistical package for the social sciences (spss) siri 4 by Hilwa Hannah Enterprise (2021)
- Introduction to Multivariate Statistics by Hilwa Hannah Enterprise (2021)
- A Workshop on Research Methodology in Applied Science (PPS5031) by Universiti Malaysia Terengganu (2021)
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- Participant, 1st International Postgraduate Symposium of Food Security (IPSyoFS-22) by Faculty of Fisheries & Food Science, Universiti Malaysia Terengganu (2022)
- Participant, 5th INHESION "International Nutrition and Health Symposium" 2021 by Universitas Gadjah Mada (2021)
- Participant, NIACIN (Nutrition Seminar and Charity for Children) Nutrition Fair by IPB University (2021)

Achievement :

- Best oral presentation at 1st International Postgraduate Symposium of Food Security (2022)

Publication :

- **Meli, A.M.,** Zakaria, N.H., Mohd Yusof, H., Kamarudin, K.S. and Ali, A. Risk Assessment of Low Cognitive Performance among Fishermen's Children in Malaysia. (2022). *Journal of Taibah University Medical Sciences.* (In-progress)
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