Utilization of Geographic Information System (GIS) in Mapping the Distribution of Malnutrition Among Primary School Children in Kuantan, Pahang, Malaysia

*** Wan Azdie Mohd Abu Bakar, PhD**
Department of Nutrition Sciences, Kulliyyah of Allied Health Sciences, International Islamic University Malaysia, 25200 Kuantan, Pahang, Malaysia
wazdie@iium.edu.my

Noor Atirah Yahya, MSc
Department of Nutrition Sciences, Kulliyyah of Allied Health Sciences, International Islamic University Malaysia, 25200 Kuantan, Pahang, Malaysia
nooratirah@iium.edu.my

Halimatun Saadiah Ab Ghalib, BSc.
Department of Nutrition Sciences, Kulliyyah of Allied Health Sciences, International Islamic University Malaysia, 25200 Kuantan, Pahang, Malaysia
halimatun.ghalib@gmail.com

Roselawati Mat Ya, PhD
Department of Nutrition Sciences, Kulliyyah of Allied Health Sciences, International Islamic University Malaysia, 25200 Kuantan, Pahang, Malaysia
roselawatimatya@gmail.com

Rozlin Abdul Rahman, PhD
Department of Physical Rehabilitation Science, Kulliyyah of Allied Health Sciences, International Islamic University Malaysia, 25200 Kuantan, Pahang, Malaysia
rozlin@iium.edu.my

Suriati Sidek, PhD
Department of Psychology, Kulliyyah of Islamic Revealed Knowledge and Human Sciences, International Islamic University Malaysia, 50728 Kuala Lumpur, Malaysia
suriatisidek@iium.edu.my

***Corresponding author:** Wan Azdie Mohd Abu Bakar, wazdie@iium.edu.my

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Abstract:

Objectives: This study aims to determine the nutritional status among primary school children in Kuantan, Pahang and to map its distribution using the Geographic Information System (GIS).
Materials and Methods: This community based cross sectional study was conducted in Kuantan, Pahang, Malaysia. A stratified random sampling method was used to select 760 primary school children aged 7 to 11 years old from six subdivisions of Kuantan district. The socio-demographics characteristics and anthropometric measurements were collected from the participants. The participants' home coordinates were obtained from the Google map based on their home address and the Geographical Information System (GIS) software was used to map and visualize the distribution of school children nutritional status.
Results and Findings: Based on the three anthropometric measurements, it was found that 16.1% (n=122) of the school children were overweight, 12% (n=91) were obese, 6.1% (n=46) of them were moderately thin and 1.7% (n=13) were severely thin. There were 9.5 % (n=72) moderately stunted and 0.5% (n=4) severely stunted school children respectively. The result of mapping shows that there was a cluster pattern of obesity in some places in the urban area of Kuantan. Likewise, the distribution of stunting was seen to be overlapping with the overweight/obesity distribution.
Conclusion: A high proportion of overweight and obesity among school children was identified in Kuantan and its distribution was mapped using GIS. The findings advocate the need for further investigation to identify the root cause of poor nutritional status in order to develop informed policy, guidelines and intervention program.

Keywords: School children, malnutrition, geographical information system (GIS), obesity

Introduction:

Malnutrition refers to deficiencies, excessive or imbalance intake of energy and/or other nutrients (World Health Organization, 2017). The term malnutrition could be under nutrition which includes stunting (low height-for-age), wasting (low BMI-for-age) and underweight (low weight-for-age), while contrary to that is over nutrition which includes overweight and obesity. The co-existence of malnutrition (over and under nutrition) affects the developed and developing countries including Malaysia (Haddad, Cameron, & Barnett, 2015). Moreover, it is quite common to find under and over nutrition within the same community or even household. Potential contributory factors that may cause malnutrition include environmental factors, household variables, childcare practices, economic condition, and sanitation (Matariya, Lodhiya, & Mahajan, 2016; Tette, Sifah, & Nartey, 2015).

An interesting finding has been reported by Abarca-Gómez et al. (2017) while analyzing the global trends in nutritional status. The authors reported that while the prevalence of obesity among children and adolescents increased worldwide from 1975 to 2016, the trend in the mean BMI has plateaued in many high-income countries, but with accelerating pattern in the Asian region. Surprisingly, it was also found that more children and adolescents are moderately or severely underweight than obese around the world.

In Malaysia, the National Health and Morbidity Survey (NHMS) revealed that the prevalence of childhood obesity (BMI-for-age >+2SD) is nearly doubled within four years, in which it rises from 6.1% in NHMS 2011 to 11.9% in NHMS 2015. Meanwhile, the prevalence of thinness (BMI-for-age <-2SD) had decreased from 12.2% in NHMS 2011 to 7.8% in NHMS 2015 (Institute for Public Health, 2015; Institute for Public Health Malaysia, 2011). These studies show that the double burden of malnutrition does exists in Malaysia. Double burden of malnutrition is characterized by the coexistence of under nutrition, which includes wasting, stunting and micronutrient deficiencies, alongside with overweight and obesity.

The Geographical Information System (GIS) is a computer-based tool that stores, analyses spatially referenced data and interprets the association between the data and the geographical characteristics. GIS involves the application of both the software and hardware that formulate the system of digital databases and layered maps. The mapping of diseases can be used to pinpoint the areas where outbreaks originate and affectively target high-risk areas for early prevention (Samat et al., 2010). Hence, GIS is currently recognized as a set of strategic and analytic tool in public health setting. It has been widely used for the development of epidemiological maps of tropical diseases including dengue and Zika virus (Duncombe et al., 2012; Rodriguez-Morales et al., 2016). In addition to that, GIS is being used globally to identify and analyze the risk of non-communicable diseases (NCD) and mapping out unhealthy risk factors related to NCD (Turnbull et al., 2020, Boda, 2013, Silva, 2016). The ability of GIS to visualize information on a map has indeed facilitate the stakeholders and policy makers for policy development. The results from GIS are also useful for planning and monitoring intervention programs, as well as assessing clusters of cases to help identify possible etiological factors.

Aligned with the WHO aspiration in adopting a resolution proclaiming a United Nations Decade of Action on Nutrition from 2016 to 2025, the world is now triggered to intensify actions to end hunger and eradicate all forms of malnutrition (WHO, 2017). While data and information regarding childhood malnutrition is developing, the capability to spread the data onto a map is still underexplored.

To investigate the usage of GIS in public health nutrition, the present study aimed to assess the nutritional status among school children in the district of Kuantan and to map the distribution digitally using GIS. The study also explored the capabilities and potential of GIS application in nutrition and health related field.

Materials and Methods:

Study design

This cross-sectional study was conducted in Kuantan, Pahang, Malaysia from July to November 2017. The list of schools together with the total number of students from each school in Kuantan were obtained from the Pejabat Pendidikan Daerah Kuantan. There are six sub-districts (mukim) of Kuantan which include Kuala Kuantan, Penor, Beserah, Ulu Lepar, Sungai Karang and Ulu Kuantan. From these sub-districts, eighteen primary schools were chosen based on a stratified random sampling namely Sekolah Kebangsaan (SK) Mat Kilau, SK Felda Sungai Panching Utara, SK Sungai Soi, SK Tanah Puteh Baru, SK Bukit Kuantan, SK Jaya Gading, SK Kampung Padang, SK Bukit Setongkol, SK Sungai Isap, SK Seri

Mahkota, SK Kuala Penor, SK Beserah, SK Lepar Hilir, SK Sungai Lembing, SK Sungai Baging, SK Balok Baru, SK Sungai Ular and SK Cherating.

The number of schools from Kuala Kuantan were more compared to other sub-districts as the proportion of students from the sub-district was the highest. Permission to conduct the study was obtained from the Ministry of Education and Pahang State Department of Education. The ethical approval was also granted from the International Islamic University Malaysia Research Ethics Committee (IREC).

Sampling method

Single mean formula was used to calculate the sample size based on the prevalence of obese school children at 16.4% (Khor et al., 2011). For all 6 sub-districts in Kuantan, a total of 760 participants were needed. Once access to schools were approved by the school principals, the name list of students were obtained. A systematic random sampling was done on the list to select students from the selected school. This study excluded students from Standard 6, boarding schools and schools other than *'Sekolah Kebangsaan'*.

Data collection

This study utilized two types of data, the non-spatial data for nutrition survey and the spatial data for the mapping part.

i. Nutrition survey

The instrument used for the nutrition survey comprises of two components with Part A consisted of the respondent's personal, social and demographic information; and Part B consisted of anthropometric measurements on body weight and height of the respondents.

The anthropometric measurements were taken using standard techniques. The height was measured using a portable height stadiometer (SECA body meter 208). The respondents were barefooted and wore minimal clothing. The respondents stood with their heels together, arm to the side, legs straightened, shoulder relaxed and head in the Frankfort horizontal plane. The heels, buttocks, scapula and the back of the head were against the vertical surface of the stadiometer. Any hair ornamentation was removed. The measurement taken was read twice to the nearest 0.1 cm.

The body weight was measured with a portable weighing scale Rossmax WF260 Body Fat Monitor. The respondents were requested to stood still in the middle of the scale's platform without touching anything with their body weight equally distributed on both feet. The reading was taken twice to the nearest 0.1 kg.

ii. Spatial data

The spatial data in digital form that was used in this study includes demarcations (boundaries), residential; transportation and community facilities obtained from the Malaysian Center for Geospatial Data Infrastructure (MacGDI). Google Maps was used to search and locate the home address. Google Earth and Google Map are gaining reputation as an innovative tool for community mapping (Lefer et al., 2008).

Data analysis

i. Statistical analysis

Data for the anthropometric measurement were derived using the AnthroPlus® software to classify the various categories of nutritional status namely the height-for-age (HAZ) and BMI-for-age (BAZ) z-score in order to identify the prevalence of stunting, overweight and obesity respectively, based on the WHO Child Growth standard. IBM Statistical Package for the Social Science (SPSS) version 22.0 was used for descriptive analysis and Chi-square test.

ii. Spatial analysis

Spatial data were analyzed using the ArcGIS 10.2 software. All spatial data obtained from MacGDI were specifically selected according to the objective of the study. The coordinates of households' addresses were identified using Google Maps, then the coordinates were added into the GIS database to enable mapping of the component of the study. Once geocoded, nutritional data was linked to the GIS Software to create the desired maps. Point density analysis was run to tabulate and visualize the malnutrition cases on the map.

To protect the confidentiality and anonymity of participants, the addresses were only represented on the map using dots and shapes allowing observation of the item distribution in the study area, but no cadaster layer or individualized information were used.

Results:

Nutritional status of schoolchildren

Seven hundred and sixty school children aged 7, 8, 9, 10 and 11 years old were assessed. These included 356 males (46.8%) and 404 (53.2%) females and most of them were Malay (99.2%, n=754). Majority of the children (88.9%, n= 676) were staying with their parents.

The nutritional status of the school children is presented in Table 1. The present study found a high proportion of overweight and obesity among the primary school children in Kuantan. Based on the anthropometric measurements, findings showed that 16.1% (n=122) of primary school children were overweight, 12% (n=91) were obese, 6.1% (n=46) of the respondents were moderately thin and 1.7% (n=13) were classified as severely thin while others were normal (64.2%, n=488). For the height-for-age, 90% (n=684) of the respondents fell into normal category, 9.5% (n=72) were moderately stunted and only 0.5% (n=4) were found to be severely stunted.

Table 1: Nutritional status of school children in Kuantan

Variables	No. of Respondents (%)	
BMI-for-age		
	Normal	488 (64.2)
	Overweight	122 (16.1)
	Obese	91 (12.0)
	Moderately thin	46 (6.1)
	Severely thin	13 (1.7)
Height-for-age		
	Normal	684 (90)
	Moderately stunted	72 (9.5)
	Severely stunted	4 (0.5)

Development of Map using GIS

The development of map using GIS was done in phase two of the study. The digital map of Kuantan was produced through manipulation, standardization, updating, storing and integration using GIS.

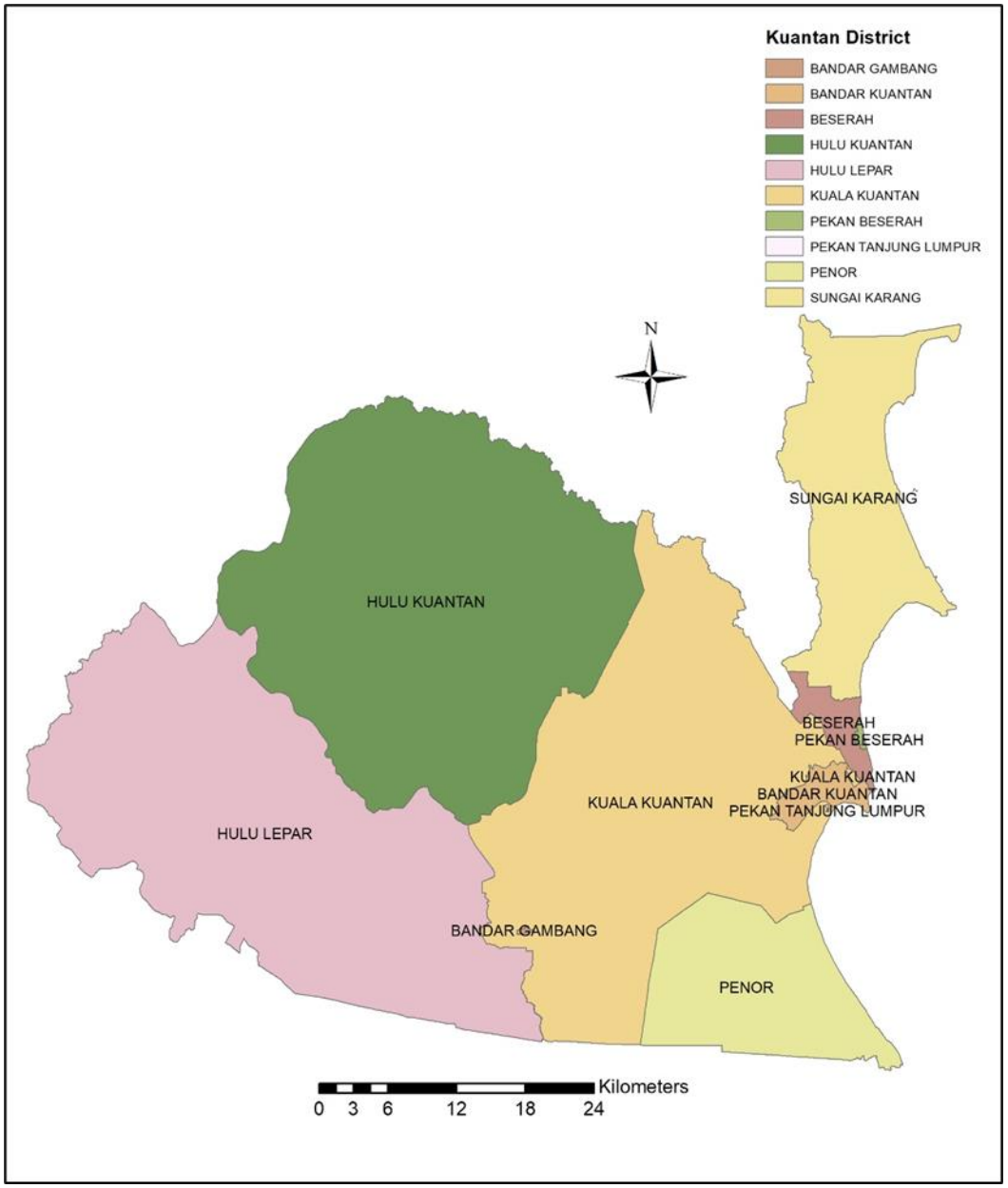

Figure 1: Digital map of Kuantan and its representative areas

The following figures visually presented the distribution of school children according to the BMI-for-age status and height-for-age status. The distribution of school children who were overweight and obese were clustered in the urban region of Kuantan which is Kuala Kuantan while the distribution of underweight was dispersed in Kuala Kuantan and Beserah area (Figure 2). Figure 3 illustrated the distribution of school children based on their height for age status. Both rural and urban area consisted of normal and stunted children. Meanwhile, Figure 4 demonstrated the distribution of obese/overweight and the stunted cases. The distribution of stunting was noted to be overlapping with the distribution of overweight/obesity.

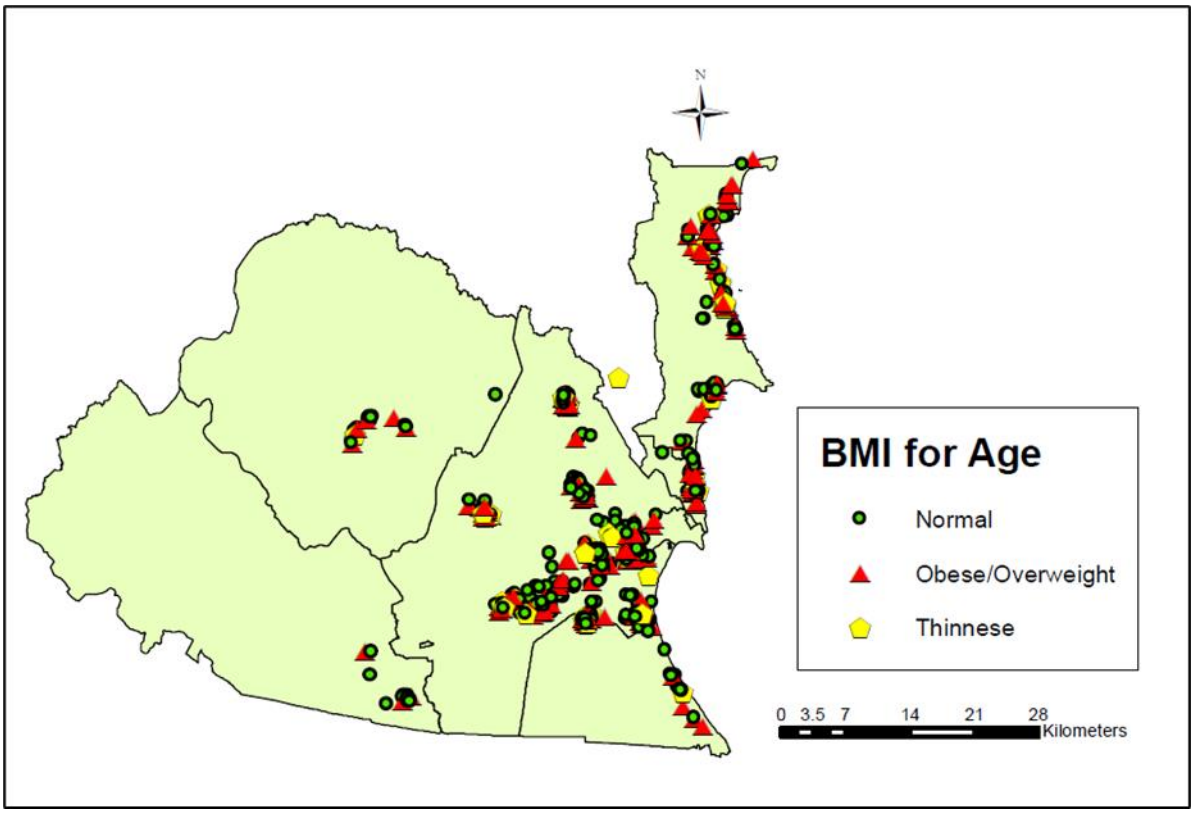

Figure 2: Distribution of school children according to BMI status.

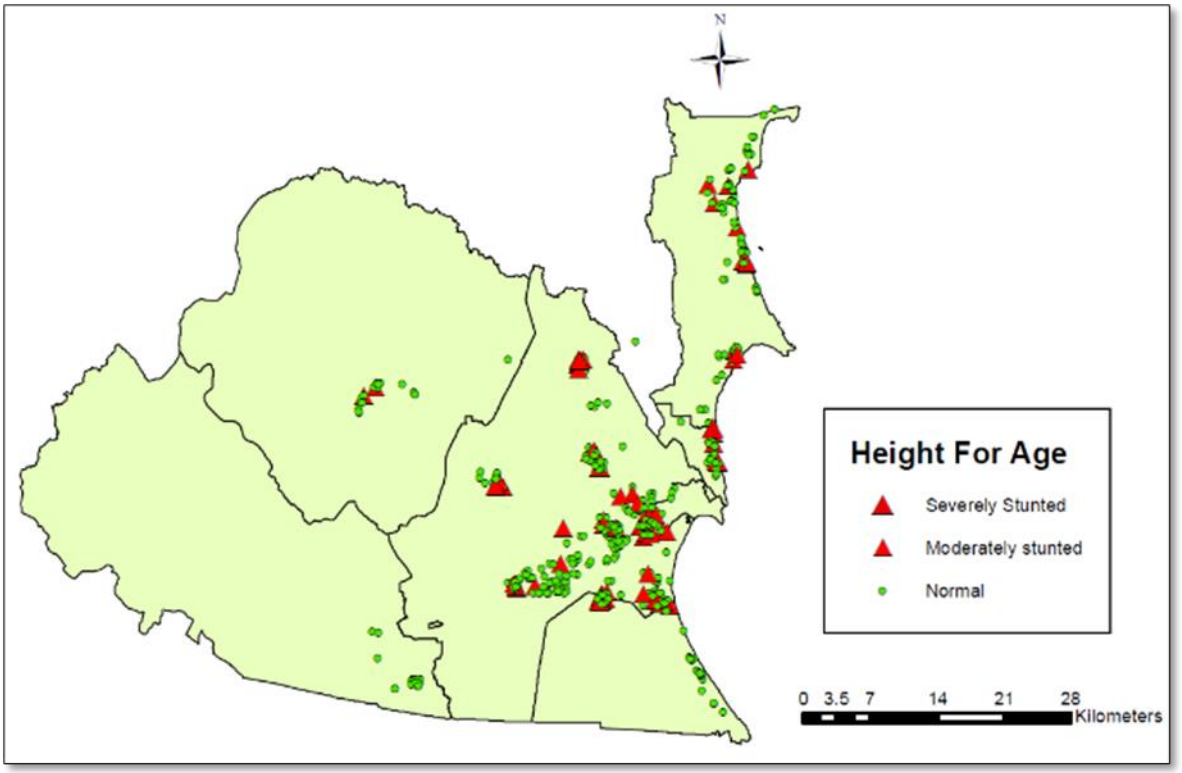

Figure 3: Distribution of schoolchildren according to height-for-age.

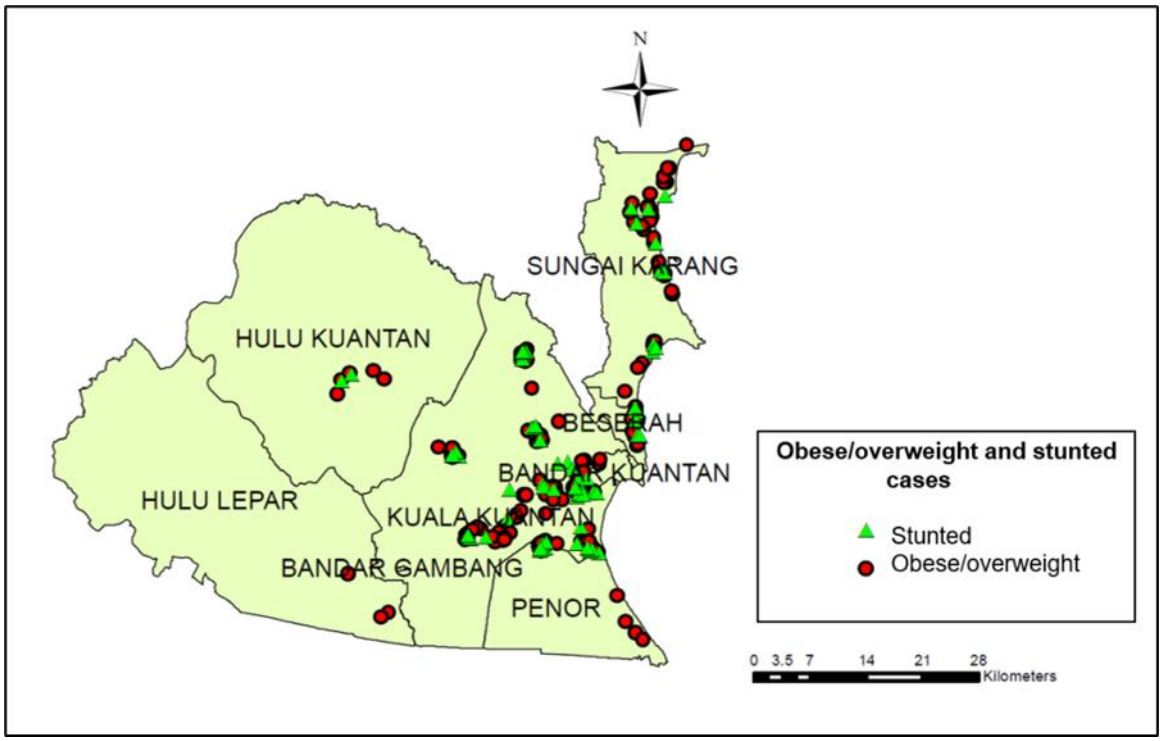

Figure 4: Distribution of stunted and obese/overweight cases.

Discussion:

Nutritional status of school children

From this study, the coexistence of under and over-nutrition has been postulated in a result acquired from the school children nutritional status data. The prevalence of obesity and overweight school children aged 7 to 11 years was 12.0% (n=91) and 16.1% (n=122) respectively. A significant association was found for gender (p=0.004, χ^2=15.426), where the proportion of obesity was found to be higher in male students (62.0%, n=75) compared to female (38.0%, n=46) whereas the proportion of overweight was higher in female (59.3%, n=54) in contrast to male students (37%, n=40.7).

The obesity prevalence among the school children in this present study is comparable to the national prevalence of obesity (11.9%) reported by the National and Health Morbidity Survey 2015.The inclining trend of obesity has been observed in Malaysia. The NHMS 2006, NHMS 2011 and NHMS 2015 have reported that the prevalence of obesity had escalated from 5.4%, 6.1% to 11.9% respectively (Institute for Public Health, 2015).

This study also found contrast findings with the NHMS 2015 which reported that the prevalence of obesity was slightly higher in females than males inferencing that body composition varies based on gender. Significant evidence from previous study demonstrated that males and females are different in terms of the body fat patterns, fat level that impact health, resisting energy expenditure, energy consumption and ability to exercise (Sweeting, 2008). Another study also highlighted similar findings that males and females certainly have different pattern of weight gain, body composition, hormone biology and particularly in certain environmental, genetic, ethnic and social factors (Wisniewski & Chernausek, 2009).

Distribution of school children according to the BMI status

The finding showed that obese cases were distributed throughout Kuantan. Point density analysis was undertaken to evaluate the density of obesity and overweight cases and the cases were found to be densely distributed in Kuala Kuantan. The higher number of obese school children in Kuala Kuantan may be due to the fact that Kuala Kuantan is the center of Kuantan, where most people choose to reside and work. Kuala Kuantan consists of two sub boundaries which are Kuantan City and Bandar Indera Mahkota. Both Kuantan City and Bandar Indera Mahkota are considered as urban area (Rancangan Tempatan Daerah Kuantan, 2015). The high prevalence of overweight and obesity in urban area was parallel to the findings in NHMS 2015.

Kuantan City is the center of services, business, recreation, commercial and trading whereas Bandar Indera Mahkota is known as the administration center with many government office, schools, clinics and other facilities. Moreover, Majlis Bandaraya Kuantan (MBK) is planning to build Bandar Indera Mahkota 2 as the transport hub and technology city in the near future (Rancangan Tempatan Daerah Kuantan, 2015). The rapid development has transformed and modernized Kuala Kuantan. Recently, the introduction of the Malaysia's First Special Economic Zone (SEZ) in Kuantan is designed to boost the regional economy, tourist and growth (Rancangan Tempatan Daerah Kuantan, 2015). This means Kuantan will have a great deal of development projects.

Urbanization leads to inadequate social environment and buildings that are not suitable for walking around causing children and adolescent to be physically inactive (Ahmed, Shah, & Kshirsagar, 2016; Pirgon & Aslan, 2015). As for now, Kuala Kuantan is rapidly developing and occupied with shopping malls and restaurants including fast food outlets, supermarkets and convenience stores that may contribute to obesity (Mehboob, Safdar & Zaheer, 2016, Malik, Willet & Hu, 2013). Bridevaux-Peytremann et al. (2006) claimed that people living in urban area are more prone to be overweight than those living in rural area. Diminished access to sporting activities and other means of physical exercise due to improper urban planning reduces suitable pathways for walking and play areas for children. This undoubtedly will force families living in inner city areas to have their children staying indoors and practice sedentary lifestyle such as playing on a computer or watching television (Pirgon & Aslan, 2015). Physical inactivity if not prevented early, will become a habit that eventually may lead to obesity.

Distribution of school children according to height-for-age

The distribution of stunting was seen to be overlapping with the overweight/obesity distribution. The reason why these school children might be overweight or obese is not because of the excess in body weight, but probably the condition is confounded by low height for age. Zalilah et al. (2016) reported that higher dietary energy intake was associated with stunting instead of overweight among urban children. Interestingly, the distribution of stunting is more prominent in the urban area but still few cases were seen to be dispersed in rural area. The United Nation Children's fund (UNICEF) stated that although children living in poor urban area has close proximity to amenities, they are found to have less access to nutritious foods, live in unsafe areas and have less opportunity to play and be active (UNICEF, 2018).

Conclusion:

The creation of map to visualize the distribution of children nutritional status has the potential to clearly demonstrate the pattern and areas of malnutrition. This information may be useful for the Ministry of Health together with the Ministry of Education to monitor malnutrition cases among children in Malaysia. Based on these findings, further research is needed to investigate the complex interaction between the children's nutritional status and geographical factors. Intervention programs such as nutrition education and promotion should be designed to streamline with the targeted areas.

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