



## **Trends and associated factors of intergenerational obesity mother-child pairs in low-income households in Malaysia: Evidence from the National Health and Morbidity Survey.**

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### **Abstract**

The transmission in intergenerational overweight and obesity (OW/OB) from mothers to their offspring has been widely explored in numerous studies. This phenomenon of OW/OB is a greater concern globally in particular among low-income households. However, studies conducted to determine the factors associated with OW/OB among mother-child pairs in low-income families are very scarce especially in Malaysia. Therefore, this study aimed to determine the prevalence trend and associated factors of overweight mothers and children in low-income households using the National Health and Morbidity Survey data between the years 2006 to 2015. In each low-income household, mother and child were identified and grouped as mother-child pairs based on their body mass index categories. Multivariable logistic regression was conducted to determine the factors associated with overweight mother/overweight child pairs (OWM/OWC) in low-income households. The reference group determined in the analysis was normal weight mother/normal weight child pairs (NWM/NWC). Within a decade, the transmission of OWM/OWC mother-child pairs in the



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low-income households has increased by 9.0%, while the prevalence of NWM/NWC decreased by 6.9%. In low-income households, older mothers and children aged between 10 to 14 years were significantly associated with OWM/OWC, while a larger household size and being as Chinese were less likely to become OWM/OWC. In conclusion, intergenerational obesity in mothers and their offspring are showing an alarming trend among the lowest socio-economic group in Malaysia.

### Introduction

The epidemic of overweight and obesity (OW/OB) is a worrying public health issue that affects adults and children across the globe.<sup>1-7</sup> A recent estimate indicated that 39% of adults worldwide were overweight or obese.<sup>8</sup> Among children aged between 5 to 19 years, there was a four-fold increase in the worldwide prevalence of OW/OB over the past four decades.<sup>9</sup> OW/OB phenomenon is a major concern because OW/OB occurrence is linked to numerous unfavourable health implications such as cardiovascular diseases, diabetes mellitus and certain cancers.<sup>10-12</sup> It was also attributed to 7.1% mortality and 4.9% disability cases globally in the year 2015.<sup>6</sup>

Researchers have demonstrated that the global OW/OB prevalence was higher among women.<sup>13</sup> Along with this problem, women who were OW/OB had a higher risk of having children with OW/OB.<sup>14,15</sup> Later, overweight or obese child tend to grow up as an adult with OW/OB.<sup>16,17</sup> These findings implied that undesirable intergenerational OW/OB existed in one generation to the other next generation. Hence, in recent years, researches on intergenerational OW/OB have drawn the attention of many researchers.<sup>18-21</sup> Researchers have proposed that intergenerational OW/OB may occur through genetic inheritance or a shared environment.<sup>19,20</sup> Moreover, few researchers hypothesised that intergenerational OW/OB might begin in the womb,<sup>22</sup> while other researchers theorised that it might occur due to social and environmental influences.<sup>23,24</sup> Nonetheless, genetic influence alone is unconvincing in explaining the dramatic increase in OW/OB prevalence globally.<sup>25,26</sup> The developmental origins of health and disease (DOHaD) hypothesis posits that epigenetic modification of genes in response to environmental influences also involve in intergenerational OW/OB.<sup>27</sup>

Available studies on the association between parental and child OW/OB disclosed that maternal influence on childhood OW/OB is stronger than paternal influence.<sup>28-30</sup> In other study, researchers have demonstrated that the body mass index (BMI) of children with obesity was strongly determined by their mothers compared to the fathers.<sup>19</sup> Also, Yoon and colleagues identified maternal OW/OB was associated with obese sons and daughters, while paternal OW/OB was merely associated with obesity among sons.<sup>31</sup>

A growing body of literature reported that the association between maternal and child OW/OB was influenced by socio-economic status. Previously, the OW/OB was prevalent among individuals from high socioeconomic status in high-income countries, while people from low socio-economic status were struggling with undernutrition.<sup>32</sup> To date, the rate of OW/OB prevalence has reached a plateau in some high-income countries while it continues to arise in low- and middle-income countries (LMICs).<sup>13,33</sup> Surprisingly, the trends of OW/OB in the LMICs are shifting from high to low socio-economic groups.<sup>34</sup> The researchers have projected that the prevalence of OW/OB among poor people in the LMICs will be elevated in the next decade.<sup>35</sup> A recent study showed that intergenerational OW/OB between mother and child was stronger in disadvantaged households.<sup>15</sup>

There was an increasing number of studies of parent-child pairs reported the prevalence of OW/OB among parents and children living in the same household.<sup>36-41</sup> Based on the single health survey conducted in a small district in Johor, Malaysia, the researchers disclosed that the prevalence of overweight or obese children living with overweight mothers was 14.2%, higher than those living with overweight fathers.<sup>37</sup> However, this study did not specifically investigate

the prevalence and factors associated with OW/OB in low-income groups.

Even though the growing obesity epidemic in Malaysia has been well documented in many studies, there is a lack of knowledge regarding the prevalence trends and factors associated with overweight mothers and their overweight offspring in low-income households. An attempt by Mariapun and colleagues in year 2018 found that OW/OB had become a burden among Malaysian women in low socio-economic groups.<sup>42</sup> Moreover, a recent report from a national survey in Malaysia demonstrated that the prevalence of overweight children was highest among children from low-income households,<sup>43</sup> which may support the phenomenon of intergenerational obesity. To our knowledge, no prior study has been conducted to demonstrate the prevalence of overweight mother-child pairs in low-income households. There have been limited studies that reported the prevalence of co-existence between obese mother and obese child in a household, specifically at national level in Malaysia. Hence, this study aimed to determine the prevalence trends and factors associated with overweight and obesity among mother-child pairs in low-income households in Malaysia, using population-based data for the years 2006, 2011, and 2015.

### Materials and Methods

This study utilised the secondary data from the Malaysian National Health and Morbidity Survey (NHMS) for 2006, 2011, and 2015. It is a repeated cross-sectional survey conducted to assess Malaysian health status and other health-related topics at household levels. A two-stage stratified random sampling was applied. Detailed procedures have been described elsewhere.<sup>44-46</sup>

### Study Population

The study populations were the mothers and children from low-income households who participated in the Malaysian NHMS in 2006, 2011, and 2015. Mothers and children were identified manually from the anonymised data based on the relationship to the head of households, gender, and age. As for now Malaysia is still considered a patriarchal society, the head of the household is commonly a man or a father. Therefore, a woman who is the wife to the head of the household and has at least a child

was recorded as a mother. Couples living together with a family unit but without legal marriage were not included in this analysis. The head of the household may consist of a woman in a single-headed family.

A child was referred to an individual aged less than 18 years.<sup>47</sup> In this study, only children aged between 5 to 17 years were chosen to be paired with their mothers. If there were more than one child within the age group in the family, the youngest was selected.<sup>48-50</sup> The children aged less than five years were excluded owing to the different definitions of World Health Organization categories for underweight, overweight, and obesity.<sup>51</sup>

Currently, the Malaysian Government has categorised the household income into three groups based on new categories; 1) the bottom 40% (B40), the middle 40% (M40), and the top 20% (T20).<sup>52</sup> The B40 group indicates the impoverished household, while the T20 group denotes the wealthy household. In the Malaysian NHMS data, there was no variable on the household income based on this current category. Hence, the household income was intentionally ranked into five quintiles, equivalent to the current income category for each survey year. The bottom two quintiles (quintiles 1 and 2) were the B40 or low-income group, the middle two quintiles (quintiles 3 and 4) were M40 or middle-income households, while the quintile 5 refers to the T20, the high-income household accordingly to the defined category.

The exclusion criteria of the households were: 1) no data on child and mother in the household; 2) living with friends or alone; 3) the youngest child aged above 17 years; 4) single father in the family, as our interest is the mother only; 5) the relationship to the head of the household could not be determined; 6) no data available on height and weight; 7) no data available on household income or household income in the M40 and T20 groups. After excluding the participants based on the exclusion criteria, 2,057 pairs were acquired for the year 2006, 994 pairs for the year 2011, and 952 mother-child pairs from low-income households were obtained in year 2015.

### Ethical Approval

The ethical approval to conduct this study was acquired from the Medical Research Ethics Committee, Ministry of Health Malaysia (NMRR-

17-2714-38075) and the Human Research Ethics Committee of Universiti Sains Malaysia (USM/JEPeM/17110579).

### Categories of Mother-Child Pairs

In the Malaysian NHMS, the body weight was assessed using a Tanita Personal Scale HD 319 (Tanita Corporation, Tokyo, Japan). At the same time, height was measured using a SECA 206 Body Meter (Seca Nihon, Chiba, Japan) by trained health professionals, such as nurses.<sup>44-46</sup> Body mass index (BMI) was calculated using the index of height and weight [weight in kg/(height in meter)<sup>2</sup>]. The BMI classification for mothers was based on the World Health Organization classification.<sup>53</sup> They were divided into three groups; underweight (BMI less than 18.5 kg/m<sup>2</sup>), normal weight (BMI between 18.5 to 24.9 kg/m<sup>2</sup>) and overweight (BMI of 25 kg/m<sup>2</sup> and above). Among children, the classification was based upon the World Health Organization Growth Reference, using BMI-for-age z-scores.<sup>51</sup> They were grouped into underweight (BMI z-score < -2SD), normal weight (BMI z-score between -2SD to +1SD) and overweight (BMI z-score > +1SD).

The mothers were paired with their children according to their BMI categories. Nine categories of BMI for mother-child pairs were obtained after the matching. They were; 1) underweight mother/underweight child (UWM/UWC); 2) underweight mother/normal weight child (UWM/NWC); 3) underweight mother/overweight child (UWM/OWC); 4) normal weight mother/underweight child (NWM/UWC); 5) normal weight mother/normal weight child (NWM/NWC); 6) normal weight mother/overweight child (NWM/OWC); 7) overweight mother/underweight child (OWM/UWC); 8) overweight mother/normal weight child (OWM/NWC); and 9) overweight mother/overweight child (OWM/OWC).

### Statistical Analyses

Data analyses were performed using IBM Statistical Package for the Social Sciences (SPSS) Statistics software, version 26 (IBM Corporation, New York, USA). Sociodemographic data of the mothers and children were demonstrated as frequencies (n) and percentage (%), except for continuous variables such as maternal age, child age, and household size was presented in mean and standard deviation (SD).

Household size, which was the number of individuals living in the house, was categorised as small (less than five people), medium (5 to 7 people) and large (more than seven people).<sup>54</sup> The ethnic group was divided into four (Malay, Chinese, Indian and Other), based on the major ethnic groups in Malaysia. Other refers to the other three major ethnic groups in Malaysia, including Bumiputras in Sabah and Sarawak. Maternal education was categorised into no education, primary, secondary, and tertiary education.<sup>55</sup> Family structure was categorised as single-parent (single mother in the family) or dual-parent (have both a father and a mother) households. The residential area was categorised as urban and rural.<sup>44,45</sup>

Univariable logistic regression was performed for each independent variable. The independent variables included in the statistical analysis were maternal and child age, child gender, household size, ethnicity, maternal education level, family structure, and residential area. The variables with a p-value <0.25 were retained in the multivariable logistic regression analysis to determine the odds of OWM/OWC in low-income households. The NWM/NWC was used as the reference group during the analysis.<sup>40</sup> Multicollinearity was evaluated by a variance inflation factor (VIF). The VIF value above 10 denotes that multicollinearity was present between the independent variables. Two-way interaction terms were tested by checking the interaction of the independent variables such as maternal age with education level. Model fitness was checked by performing the Hosmer-Lemeshow goodness-of-fit test and a classification table.<sup>56</sup> The findings from multivariable logistic regression were presented as adjusted odds ratio (AOR), 95% confidence intervals (CI), and p-values. Variables with a p-value <0.05 were considered statistically significant.

## Results

### Characteristics of Mother-Child Pairs

The characteristics of mother-child pairs from low-income households selected for this study are demonstrated in Table 1. The average maternal age was 40.97 (SD 8.38) years in 2006, 41.07 (SD 7.91) years in 2011, and 41.28 (SD 8.29) years in 2015. In all survey years, most of the mothers were Malay (2006=63.4%; 2011=62.1%; 2015=63.6%) and resided in the rural area (2006=64.8%;

2011=57.8%; 2015=57.7%). In 2006, the majority of the mothers from low-income households had completed primary education level (42.2%), while in the 2011 and 2015 surveys, more than half of the mothers had completed a secondary education level (2011=54.9%; 2015=59.5%).

Throughout the survey years, most of the children aged 5 to 9 years (2006=60.7%; 2011=56.2%;

2015=57.2%) and living in a dual-parent family (2006=90.9%; 2011=90.3%; 2015=88.6%). In 2006 and 2011, most of the mother-child pairs lived in a medium household size (2006=47.6%; 2011=49.5%), while in 2015, more than half of the mother-child pairs were living in small households (55.1%). The proportion of boys and girls was almost similar in each year of study.

**Table 1: Characteristics of mother-child pairs from low-income households in the National Health and Morbidity Survey of Malaysia in 2006, 2011 and 2015**

Characteristics of mother-child pairs	2006 (n=2,057)		2011 (n=994)		2015 (n=952)	
	n	%	n	%	n	%
Maternal age in years, mean (SD)	40.97 (8.38)		41.07 (7.91)		41.28 (8.29)	
< 30	241	11.7	92	9.3	94	9.9
31 – 40	749	36.4	392	39.4	370	38.9
41 – 50	781	38.0	384	38.6	346	36.3
51 and above	286	13.9	126	12.7	142	14.9
Child age in years, mean (SD)	9.15 (3.53)		9.56 (3.69)		9.49 (3.65)	
5 – 9	1249	60.7	559	56.2	545	57.2
10 – 14	581	28.2	285	28.7	273	28.7
15 – 17	227	11.0	150	15.1	134	14.1
Gender of child						
Girl	971	47.2	500	50.3	480	50.4
Boy	1086	52.8	494	49.7	472	49.6
Maternal education level						
Tertiary	10	0.5	48	4.8	68	7.2
Secondary	834	40.7	544	54.9	563	59.5
Primary	865	42.2	308	31.1	262	27.7
None	340	16.6	90	9.1	54	5.7
Ethnicity						
Malay	1304	63.4	617	62.1	605	63.6
Chinese	119	5.8	76	7.6	80	8.4
Indian	115	5.6	58	5.8	54	5.7
Other <sup>a</sup>	519	25.2	243	24.4	213	22.4
Household size, mean (SD)	5.09 (1.87)		4.99 (1.64)		4.47 (1.56)	
Small (< 5 persons)	868	42.2	430	43.3	525	55.1
Medium (5 – 7 persons)	980	47.6	492	49.5	394	41.4
Large (> 7 persons)	209	10.2	72	7.2	33	3.5
Family structure						
Dual-parent family	1869	90.9	898	90.3	843	88.6
Single-parent family	188	9.1	96	9.7	109	11.4
Residential area						
Rural	1332	64.8	575	57.8	549	57.7
Urban	725	35.2	419	42.2	403	42.3

SD=standard deviation

<sup>a</sup>Other=Other three major ethnic groups in Malaysia, including Bumiputras in Sabah and Sarawak

### The Prevalence of Different BMI Categories by Mother-Child Pairs in Low-Income Households

Table 2 presents the trends of prevalence of low-income mother-child pairs by different BMI categories. In all survey years, after considering exclusion criteria, the highest prevalence of mother-child pairs was among OWM/NWC (2006=39.4%; 2011=43.3%; 2015=39.7). Surprisingly, the prevalence of NWM/NWC from low-income households has decreased from 30.1% in 2006 to 23.2% in 2015 while the prevalence of low-income OWM/OWC has increased from 11.7% in 2006

to 20.7% in 2015. The result also indicates that there was a slight decrease in the prevalence of UWM/UWC (2006=0.9%; 2011=0.9%; 2015=0.6%), UWM/NWC (2006=2.9%; 2011=2.2%; 2015=2.6%), UWM/OWC (2006=0.5%; 2011=0.3%; 2015=0.2%), and NWM/UWC (2006 =6.0%; 2011=4.6%; 2015=3.6%). Additionally, the prevalence of NWM/OWC (2006=5.0%; 2011=5.4%; 2015=5.5%) and OWM/UWC (2006=3.5%; 2011=4.8%; 2015=3.9%) had increased slightly across the survey years.

**Table 2: Prevalence of different BMI categories for mother-child pairs in low-income households**

Mother-child pairs	2006 (n=2,057)		2011 (n=994)		2015 (n=952)	
	n	%	n	%	n	%
UWM/UWC	18	0.9	9	0.9	6	0.6
UWM/NWC	60	2.9	22	2.2	25	2.6
UWM/OWC	10	0.5	3	0.3	2	0.2
NWM/UWC	123	6.0	46	4.6	34	3.6
NWM/NWC	620	30.1	232	23.3	221	23.2
NWM/OWC	102	5.0	54	5.4	52	5.5
OWM/UWC	73	3.5	48	4.8	37	3.9
OWM/NWC	811	39.4	430	43.3	378	39.7
OWM/OWC	240	11.7	150	15.1	197	20.7

UWM/UWM=underweight mother/underweight child; UWM/NWC=underweight mother/normal weight child; UWM/OWC=underweight mother/overweight child;NWM/UWC=normal weight mother/underweight child;NWM/NWC=normal weight mother/normal weight child; NWM/OWC=normal weight mother/overweight child; OWM/UWC=overweight mother/underweight child; OWM/NWC=overweight mother/normal weight child; OWM/OWC=overweight mother/overweight child

### Factors Associated with OWM/OWC in Low-Income Households

Table 3 demonstrates the univariable logistic regression analysis of the factors associated with OWM/OWC in low-income households in Malaysia. In the unadjusted model, maternal age above 50 years (OR=4.91, 95% CI=2.45–9.85,  $p<0.001$ ) and child age between 10 to 14 years (OR=3.31, 95% CI=2.37–4.63,  $p<0.001$ ) had the highest risk of being OWM/OWC in low-income households for the year 2006. However, the other

ethnicities (OR=0.41, 95% CI=0.28–0.61,  $p<0.001$ ) and large household size (OR=0.44, 95% CI=0.25–0.77,  $p=0.004$ ) were less likely to be associated with OWM/OWC in low-income households.

In 2011, children aged 10 to 14 years from low-income households had two times higher risk of OWM/OWC than children aged less than ten years (OR=2.06, 95% CI=1.31–3.24,  $p=0.002$ ). Meanwhile, mother-child pairs from medium-sized households were less likely to be OWM/OWC than

in small households (OR=0.60, 95% CI=0.39–0.91, p=0.017). Similar to the 2006 survey, the other ethnicities were less likely to be associated with OWM/OWC in low-income households (OR=0.39, 95% CI=0.23–0.68, p=0.001).

**Table 3: Univariable logistic regression for the factors associated with OWM/OWC from low-income households in Malaysia for years 2006, 2011 and 2015**

Risk factors	2006 (n=860)			2011 (n=384)			2015 (n=418)		
	OR	95% CI	p-value	OR	95% CI	p-value	OR`	95% CI`	p-value
Maternal age									
≤ 30	1.00			1.00			1.00		
31 – 40	<b>2.11</b>	<b>1.12, 3.98</b>	<b>0.021</b>	1.10	0.49, 2.45	0.818	1.48	0.71, 3.09	0.301
41 – 50	<b>3.99</b>	<b>2.13, 7.45</b>	<b>&lt;0.001</b>	1.35	0.62, 2.98	0.452	1.95	0.94, 4.06	0.074
51 and above	<b>4.91</b>	<b>2.45, 9.85</b>	<b>&lt;0.001</b>	2.26	0.91, 5.65	0.081	<b>3.17</b>	<b>1.37, 7.33</b>	<b>0.007</b>
Child age									
5 – 9	1.00			1.00			1.00		
10 – 14	<b>3.31</b>	<b>2.37, 4.63</b>	<b>&lt;0.001</b>	<b>2.06</b>	<b>1.31, 3.24</b>	<b>0.002</b>	<b>1.79</b>	<b>1.15, 2.79</b>	<b>0.010</b>
15 – 17	<b>2.62</b>	<b>1.62, 4.23</b>	<b>&lt;0.001</b>	1.33	0.70, 2.54	0.388	1.00	0.58, 1.72	0.993
Child gender									
Girl	1.00			1.00			1.00		
Boy	0.88	0.66, 1.19	0.416	0.93	0.62, 1.40	0.594	1.27	0.86, 1.86	0.231
Household size <sup>a</sup>									
Small	1.00			1.00			1.00		
Medium	<b>0.60</b>	<b>0.44, 0.83</b>	<b>0.002</b>	<b>0.60</b>	<b>0.39, 0.91</b>	<b>0.017</b>	0.92	0.62, 1.37	0.691
Large	<b>0.44</b>	<b>0.25, 0.77</b>	<b>0.004</b>	0.45	0.18, 1.12	0.085	<b>0.19</b>	0.04, 0.87	0.033
Ethnicity									
Malay		1.00		1.00			1.00		
Chinese	0.54	0.28, 1.05	0.067	0.47	0.22, 1.03	0.058	0.39	0.20, 0.77	0.006
Indian	1.58	0.80, 3.10	0.186	2.19	0.93, 5.15	0.073	1.11	0.53, 2.33	0.790
Other <sup>b</sup>	<b>0.41</b>	<b>0.28, 0.61</b>	<b>&lt;0.001</b>	<b>0.39</b>	<b>0.23, 0.68</b>	<b>0.001</b>	<b>0.48</b>	<b>0.30, 0.77</b>	<b>0.002</b>
Maternal education									
Tertiary	1.00			1.00			1.00		
Secondary	0.71	0.06, 7.86	0.776	0.70	0.28, 1.76	0.452	1.48	0.71, 3.10	0.296
Primary	1.08	0.10, 12.02	0.951	0.57	0.22, 1.50	0.257	1.42	0.65, 3.08	0.380
None	0.37	0.03, 4.19	0.419	0.50	0.17, 1.50	0.217	1.85	0.68, 5.00	0.228
Family structure									
Dual-parent	1.00			1.00			1.00		
Single-parent	0.80	0.47, 1.38	0.423	1.44	0.74, 2.77	0.281	<b>2.11</b>	<b>1.14, 3.90</b>	<b>0.018</b>
Residential area									
Rural	1.00			1.00			1.00		
Urban	1.12	0.82, 1.52	0.480	1.03	0.69, 1.56	0.879	0.78	0.53, 1.14	0.198

Note. CI=confidence interval; OR=odds ratio

Statistically significant (p-value<0.05) are highlighted in bold

<sup>a</sup>Small=less than five persons; medium=5 to 7 persons; large=more than seven persons in the household

<sup>b</sup>Other=Other three major ethnic groups in Malaysia, including Bumiputras in Sabah and Sarawak

In the 2015 survey, mothers aged more than 50 years (OR=3.17, 95% CI=1.37–7.33, p=0.007) and children aged between 10 to 14 years (OR=1.79, 95% CI=1.15–2.79, p=0.010) from low-income

households had higher odds of being OWM/OWC. Moreover, mother-child pairs from single-parent families had 2.1 times more likely to become OWM/OWC in low-income households (OR=2.11, 95% CI=1.14–3.90, p=0.018). Conversely, the Chinese (OR=0.39, 95% CI=0.20–0.77, p=0.006) and large household size (OR=0.19, 95% CI=0.04–0.87, p=0.033) were found to have lower odds of being OWM/OWC in low-income households.

Table 4 demonstrates the final multiple logistic regression model for the factors associated with OWM/OWC from low-income households in 2006, 2011, and 2015. In 2006, the odds of OWM/OWC were the highest among mothers aged between 41 to 50 years (AOR=2.35, 95% CI=1.21–4.60, p=0.012) and followed by the mothers who were above 50 years (AOR=2.29, 95% CI=1.06–

4.98, p=0.036). Additionally, children aged 10 to 14 years were positively associated with OWM/OWC (95% CI=1.63–3.47, p<0.001). However, Chinese (AOR=0.46, 95% CI=0.23–0.92, p=0.027) and other ethnicities (AOR=0.49, 95% CI=0.32–0.73, p=0.001) were less likely of being OWM/OWC than Malay in low-income households.

In the NHMS 2011, only child age and ethnicity were significantly associated with OWM/OWC in low-income families. Similar to the findings in 2006, children aged between 10 to 14 years had a 1.76 times higher risk of OWM/OWC (AOR=1.76, 95% CI=1.05–2.96, p=0.032). Meanwhile, the odds of being OWM/OWC were lower among other ethnicities when compared to the Malay (AOR=0.46, 95% CI=0.25–0.83, p=0.010).

**Table 4: Multivariable logistic regression for the factors associated with OWM/OWC from low-income households in Malaysia for years 2006, 2011 and 2015**

Risk factors	2006 (n=860)			2011 (n=384)			2015 (n=418)		
	AOR	95% CI	p-value	AOR	95% CI	p-value	AOR	95% CI	p-value
Maternal age									
≤ 30	1.00			1.00			1.00		
31 – 40	1.66	0.86, 3.18	0.130	0.91	0.39, 2.11	0.819	1.40	0.65, 3.04	0.395
41 – 50	<b>2.35</b>	<b>1.21, 4.60</b>	<b>0.012</b>	1.04	0.44, 2.49	0.929	1.70	0.74, 3.89	0.194
51 and above	<b>2.29</b>	<b>1.06, 4.98</b>	<b>0.036</b>	2.06	0.68, 6.25	0.201	<b>3.23</b>	<b>1.14, 9.13</b>	<b>0.025</b>
Child age									
5 – 9	1.00			1.00			1.00		
10 – 14	<b>2.38</b>	<b>1.63, 3.47</b>	<b>&lt;0.001</b>	<b>1.76</b>	<b>1.05, 2.96</b>	<b>0.032</b>	1.45	0.85, 2.49	0.174
15 – 17	1.76	0.99, 3.10	0.052	0.81	0.36, 1.84	0.612	0.59	0.28, 1.23	0.158
Household size <sup>a</sup>									
Small	1.00			1.00			1.00		
Medium	0.75	0.53, 1.06	0.106	0.68	0.42, 1.09	0.106	1.01	0.64, 1.60	0.963
Large	0.60	0.33, 1.10	0.096	0.55	0.21, 1.47	0.234	0.19	0.04, 0.94	0.041
Ethnicity									
Malay	1.00			1.00			1.00		
Chinese	<b>0.46</b>	<b>0.23, 0.92</b>	<b>0.027</b>	0.46	0.21, 1.03	0.058	<b>0.40</b>	<b>0.19, 0.83</b>	<b>0.014</b>
Indian	1.51	0.74, 3.08	0.259	2.29	0.94, 5.55	0.068	1.24	0.56, 2.73	0.596
Other <sup>b</sup>	<b>0.49</b>	<b>0.32, 0.73</b>	<b>0.001</b>	<b>0.46</b>	<b>0.25, 0.83</b>	<b>0.010</b>	<b>0.53</b>	<b>0.31, 0.91</b>	<b>0.020</b>

Note. CI=confidence interval; AOR=adjusted odds ratio  
 Statistically significant (p-value<0.05) are highlighted in bold  
 Multicollinearity and interaction were not detected

Hosmer-Lemeshow test (2006: p=0.160; 2011: p=0.644; 2015: p=0.561)

<sup>a</sup>Small=less than five persons; medium=5 to 7 persons; large=more than seven persons in the household

<sup>b</sup>Other=Other three major ethnic groups in Malaysia, including Bumiputras in Sabah and Sarawak



In 2015, mothers from low-income households with ages above 50 years were 3.23 times more likely to be OWM/OWC than mothers aged less than 31 years (95% CI=1.14–9.13,  $p=0.025$ ). The odds of OWM/OWC were the lowest among Chinese (AOR=0.40, 95% CI=0.19–0.83,  $p=0.014$ ), followed by other ethnicities (AOR=0.53, 95% CI=0.31–0.91,  $p=0.020$ ). In addition, mother-child pairs living in large household sizes were inversely associated with OWM/OWC in low-income households (AOR=0.19, 95% CI=0.04–0.94,  $p=0.041$ ).

### Discussions

This study demonstrated an alarming trend in the prevalence of intergenerational overweight and obesity from mother to offspring in low-income households in Malaysia. Our findings suggested that 1 in 5 low-income households in Malaysia revealed both mother and child OW/OB. The prevalence trends of OWM/OWC in low-income households had increased by 9.0%, while the prevalence of NWM/NWC decreased by 6.9% within a decade. Even though OWM/NWC was the highest in low-income households, the prevalence only increased by 0.3% across three survey years. Our finding was higher than a single local study that found the prevalence of overweight mother-child pairs in the year 2015 (20.7%) was also higher<sup>37</sup> than other LMICs such as China (13.4%) and Columbia (12.4%) but lower than South Africa (22.4%), Brazil (28.4%), and Mexico (40.0%).<sup>36,40</sup>

The presence of an overweight mother and overweight child in a household indicates that this country is undergoing a nutrition transition.<sup>40</sup> A greater increase in the prevalence of OW/OB among mothers and children in low-income households was similar to the trends in other LMICs.<sup>34</sup> It has been suggested that this phenomenon is influenced by rapid economic development in the LMICs, which lead to weight gain due to changes in dietary and lifestyle behaviour.<sup>57</sup> The World Health Organization<sup>58</sup> has reported that Malaysia experienced a dietary shift from fresh local foods to highly ultra-processed foods with high in sugar and fat. Besides, overweight mother-child pairs in low-income households may be driven by the unaffordability to purchase healthy foods but expensive, such as fruits and vegetables. As reported earlier,<sup>59</sup> low-income adults in this

country were unaffordable to buy fruits and vegetables because of the high cost.

The age of our Malaysian mothers plays a big role in low-income groups in this mother-child transmission. The current study exhibits that the risk of intergenerational OW/OB increases among maternal aged above 40 years. This finding is consistent with those existing studies that found that older age was significantly associated with a high risk of being OW/OB.<sup>60,61</sup> A possible explanation for this association could be the increase in physical inactivity with age, which has been observed in several studies in this country.<sup>43,62,63</sup> Moreover, the risk of becoming obese among women was higher as increasing age owing to the reduction in basal metabolic rate<sup>64</sup> and hormonal changes during the menopausal transition.<sup>65</sup> Besides that, the risk of OW/OB among children was higher among older mothers in low-income households, probably because of late marriage. In Malaysia, it has been reported that one of the reasons for marriage postponement among men and women is due to financial hardship.<sup>66</sup> The women from low-income households might experience limited financial resources, causing them to postpone their marriage and become pregnant at an older age. Therefore, advanced maternal age or being pregnant at an older age can increase the risk of foetal macrosomia,<sup>67,68</sup> which can also elevate the risk of childhood obesity.<sup>69</sup>

We also found a significant association between child age and intergenerational OW/OB. In earlier studies,<sup>70,71</sup> researchers have reported that the risk of OW/OB was higher among children aged between 10 to 14 years which is similar to our finding. One of the assumptions that can be made is that older children may be less active than younger children. In Malaysia, the Adolescent Nutrition Survey revealed that physical inactivity was higher among older children.<sup>72</sup> Additionally, a higher risk of OW/OB among early adolescent years (10 to 14 years) may be related to puberty, which usually occurs within this age group and is associated with adipose tissue accumulation.<sup>73</sup>

In the present study, we found that mother-child pairs in low-income households with higher family members were protective against OW/OB. This finding agrees with Cauch-Viñas *et al.*,<sup>40</sup>

who demonstrated an inverse association between household size and the co-existence of obesity among mother and child. This finding might be explained by the limited financial resources to consume enough food when the number of households increases. According to the previous studies,<sup>74,75</sup> individuals living in large households tend to experience food insecurity compared to those living in small households. Also, a significant decrease in energy intake from carbohydrates and protein was reported as household size increased.<sup>76,77</sup> Another possible reason the mothers from large family sizes were protective against OW/OB is that they might spend more time on household chores and taking care of the family, increasing their physical activity. In the previous study, the researchers have shown that living in a larger household size was positively associated with domestic physical activity.<sup>78</sup> Meanwhile, the children from large households possibly indicated that they have many siblings. Evidence has shown that the children with many siblings tend to spend more time in physical activity with their siblings,<sup>79</sup> and decrease the risk of being OW/OB.

Our result also indicated that being Chinese was protective against the risk of intergenerational obesity compared to Malay, similar to other studies.<sup>42,80,81</sup> This finding could be ascribed to the healthy dietary and lifestyle behaviours adopted by the Chinese. As disclosed in the previous studies,<sup>82,83</sup> the dietary pattern of the Chinese was healthier than Malay. It has been shown that the Chinese had better diet quality<sup>84</sup> apart from spending more time on physical activity than Malay.<sup>85</sup> These findings may explain why the Chinese were less likely to become overweight or obese than Malay.

We also discovered that maternal education level was not significantly associated with the risk of OW/OB among mother-child pairs in low-income families. However, our finding contradicts the previous works by Cauch-Viñas and team,<sup>40</sup> who observed that mother and child were protective against OW/OB when the mothers had more years of education. The discrepancy in these findings could be attributed to the specific study population of low-income mother-child pairs.

The main strength of this study was the use of nationally representative data from the Malaysian

NHMS for the years 2006, 2011, and 2015. These data enable us to determine the prevalence trends of intergenerational obesity in low-income households in Malaysia over a decade. Nevertheless, several limitations need to be acknowledged. First, this study did not infer the causality of the association because the Malaysian NHMS is a cross-sectional study and reacted as an annual general health screening. Since this study utilised repeated cross-sectional data, weight changes could not be assessed because different mother-child pairs were included as participants in every survey year. Apart from that, the data was not adjusted for participants' dietary and physical activity. Moreover, a complex analysis could not be done due to the smaller sample size. Although the sample is small, the number of samples derived for low-income households in this survey is still beneficial to reflect the scenario of intergenerational obesity transmission issue in Malaysia at the national level. Future studies may be required to emphasise in proper sampling method getting low-income groups as the respondents. Besides, the factors associated with intergenerational OW/OB in this study is limited on the sociodemographic factors of the mothers and their offspring. A further study is needed to explore how behavioural and environmental factors such as food price, food industries, and policies involve in intergenerational OW/OB in low-income households.

### Conclusion

In conclusion, there was a shocking trend in the prevalence of OW/OB among mothers and their children in low-income households in this country. The prevalence has increased from 11.7% to 21.7% in ten years. This study also demonstrated that mothers from the older age group (above 50 years) and early adolescent age group (10 to 14 years) were at a high risk of intergenerational OW/OB. Meanwhile, mothers and children from large household sizes, being Chinese and other ethnicities, were protective against OW/OB compared to Malay as a predominant ethnicity in Malaysia. Our findings indicate a need to address the OW/OB problem in low-income households. Any strategy for weight management should be targeted at mothers and their children, particularly from low-income households.

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**Conflict of Interest**

The authors declare no conflict of interest.

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