

## Review Article

# The double burden of malnutrition in Association of South East Asian Nations (ASEAN) countries: a comprehensive review of the literature

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**Background and Objectives:** The double burden of malnutrition (DBM) – a combination of undernutrition and overnutrition – is a problem faced by many countries. This study aimed to comprehensively review the DBM in ASEAN (Association of South East Asian Nations) countries, including levels (population [including country, city, or any community], household, or individual), types (the type of undernutrition and overweight), and prevalence. **Methods and Study Design:** Data were sourced from four electronic databases, Medline via OvidSP, Scopus, Global Health via OvidSP and Web of Science, from January 1990 until May 2017. We only included studies that reported prevalence of DBM, were published in English language peer-reviewed journals and were available in full text. Studies were formally assessed against a published critical appraisal tool to produce a robust narrative review. **Results:** We included 48 studies in the review from eight countries. No study was found from Singapore or Brunei Darussalam. Most studies were from Indonesia and there was only one study from Lao PDR. There were a range of criteria for anthropometry used in these studies, hence comparison is impossible. DBM happened at community, household, and individual levels, with different types of undernutrition (stunting/underweight/wasting/thinness) in combination with overweight/obesity. At the household level, DBM ranged from 5.0% in Vietnam to 30.6% in Indonesia. **Conclusions:** ASEAN countries may need to strengthen surveillance using WHO standards to improve the comparability of data, further develop strategies to address under- or overweight issues and investigate potential “double-duty actions” as suggested by the World Health Organization.

**Key Words:** double burden malnutrition, ASEAN, undernutrition, overnutrition

## INTRODUCTION

The double burden of malnutrition (DBM) occurs when there is a combination of overweight/ obesity with a form of undernutrition, such as underweight, wasting, stunting, or any micronutrient deficiencies.<sup>1-4</sup> Previous studies have found that DBM can occur at the level of the country, city, household or individual.<sup>5-15</sup> Many country-level representative surveys also provide solid evidence of this phenomenon of the combination of underweight children and overweight mothers.<sup>5,7,8,10,16</sup> The 2014 report from the International Food Policy Research Institute has called DBM “the new normal” for less-developed and developing countries.<sup>3</sup>

DBM also occurs in countries in southeast Asia. Southeast Asian countries can be classified in a number of ways. One such classification is the Association of South East Asian Nations (ASEAN), a political and economic alliance aimed at promoting regional peace, stability and economic growth.<sup>17</sup> In this paper, we use the ASEAN grouping because this comprises countries with similar characteristics who may thus share similar issues around nutrition. The ten ASEAN countries are Brunei Darus-

salam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam.

In this paper we aim to provide a comprehensive review of the prevalence of DBM in ASEAN countries in all age groups, in order to facilitate comparison between countries and to identify gaps in current knowledge in order to inform future research. Specifically, we review DBM at different levels (population [including country-, city-, or any community-level studies], household, or even individual), the types of DBM (the type of undernutrition associated with overweight), and the prevalence by age, housing area (urban/ rural) or education of the participants. As the currently available information is scattered,

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this review will provide a consolidated overview of DBM in these countries, including identifying similarities and differences in patterns and highlighting potential strategies/ interventions.

## METHODS

### *Inclusion and exclusion criteria*

The inclusion criteria of studies were: 1) studies that reported prevalence data of the double burden of malnutrition (overweight/ obesity with either stunting, or underweight, or wasting) in one or more of the ASEAN countries, including multi-country studies that included any ASEAN country; 2) studies published in peer-reviewed journals; 3) studies available in full text written in English; and 4) sample size >300. The exclusion criteria were editorials or commentaries, qualitative studies, studies focusing on clinical features and intervention studies.

We did not include micronutrient deficiency studies in this review, because previous searches only identified one study that included micronutrient deficiency and overweight/ obesity and met the other inclusion criteria.

### *Literature search process*

We conducted a literature search using four electronic databases for English language papers: Medline via OvidSP, Scopus, Global Health via OvidSP and Web of Science, from January 1990 until May 2017. The search in Medline used the following key words/ MeSH terms: 1) overnutrition (overnutrition OR overweight OR obes\* OR weight OR body weight OR fat), 2) undernutrition (undernutrition OR stunt\* OR wasting OR thin\* OR underweight), 3) malnutrition, 4) double burden (dual OR double OR burden), 5) prevalence (prevalence OR number\* OR case\*, incidence OR survey), 6) adults (adult\* OR mother OR father OR parent\* OR caretaker OR elder\*), 7) children and adolescents (child\* OR adolescen\* OR school-age OR preschool OR under five ), 8) countries (ASEAN OR South East Asia OR Asia OR LMIC\* OR developing countr\* OR Brunei Darussalam OR Cambodia OR Indonesia OR Lao PDR OR Malaysia OR Myanmar OR Philippines OR Singapore OR Thailand OR Vietnam). We combined the results from 1) to 7) with AND and then combined the results with each of the countries item in number 8) with AND. We also limited the search to the English language and journal articles. Searches in three other electronic databases used similar search strategies and key words.

Furthermore, we identified papers through hand searching of the reference lists of journals and contacted several South East Asian public health researchers to seek full publications of conference abstracts.

### *Document screening process*

We screened publications identified from the literature and hand search process. The first step was to remove duplicates and ensure the relevance of the articles. We excluded non-English language articles. Titles and abstracts were then screened by CNR. After further exclusion of records according to our criteria, relevant full texts were then ready to be assessed to ensure quality.

### *Critical appraisal to ensure quality*

For the purposes of this review, we assessed full text articles against a tool established by Loney et al which was specifically developed for critically appraising prevalence or incidence studies.<sup>18</sup> This tool includes three quality assessment criteria: 1) validity of the study methods (6 questions); 2) interpretation of results (1 question); and 3) applicability of results (1 question). The critical appraisal tool is available in Supplementary table 1. In this review we included articles that scored 5 or more and fulfilled at least two of three assessment criteria. Afterwards, we grouped the data in each country based on the level of DBM: 1) population level (includes DBM that happened within the same country, city, or smaller population), 2) household level, or 3) individual level.

### *Definitions and cut off points for malnutrition*

There were many different criteria and cut-off points for malnutrition used in the included studies, which are summarised in Supplementary table 2. Several studies used a combination/ modification of criteria, as listed in the table.

## RESULTS

### *Characteristics of included studies*

Figure 1 shows the results of the literature search. Of the 45 identified studies from our literature search identification and screening process, 44 scored 5 or more on the critical appraisal score (6 scored 8, 29 scored 7, and 9 scored 6); these 44 studies are included in the review. The results of the critical appraisal process are available in Supplementary table 3. Four of the included studies were multi-country studies, and 40 were single country studies. The country with the most studies of DBM was Indonesia and that with the fewest was Lao PDR. We found no study on DBM from Singapore or Brunei Darussalam, resulting in studies from 8 countries to be further analysed. The earliest study was from 2000 and latest ones were from 2017.

### *Level of double burden of malnutrition*

We analysed the studies at three levels: studies that were conducted at the population level (country-, city-, or any community-level), those that were conducted at the household level, and those conducted to investigate whether DBM occurred within the same individual. From this point onwards, we calculated studies based on the country.

### *Population level*

All eight countries had studies that described the presence of DBM at the population level, with the number of studies from each country as follows: Vietnam (13 studies), Indonesia (nine studies) and Malaysia (nine studies), Cambodia (four studies), Thailand (four studies), Myanmar (two studies), Philippines (two studies) and Lao PDR (one study). From 44 studies at the population level, 27 were nationally representative samples while the other 17 studies were conducted in a limited number of provinces, cities or communities. The 27 national studies were: 4/4 studies from Cambodia, 6/9 studies from Indonesia, 4/9 studies from Malaysia, 1/2 studies from Myanmar, 1/1

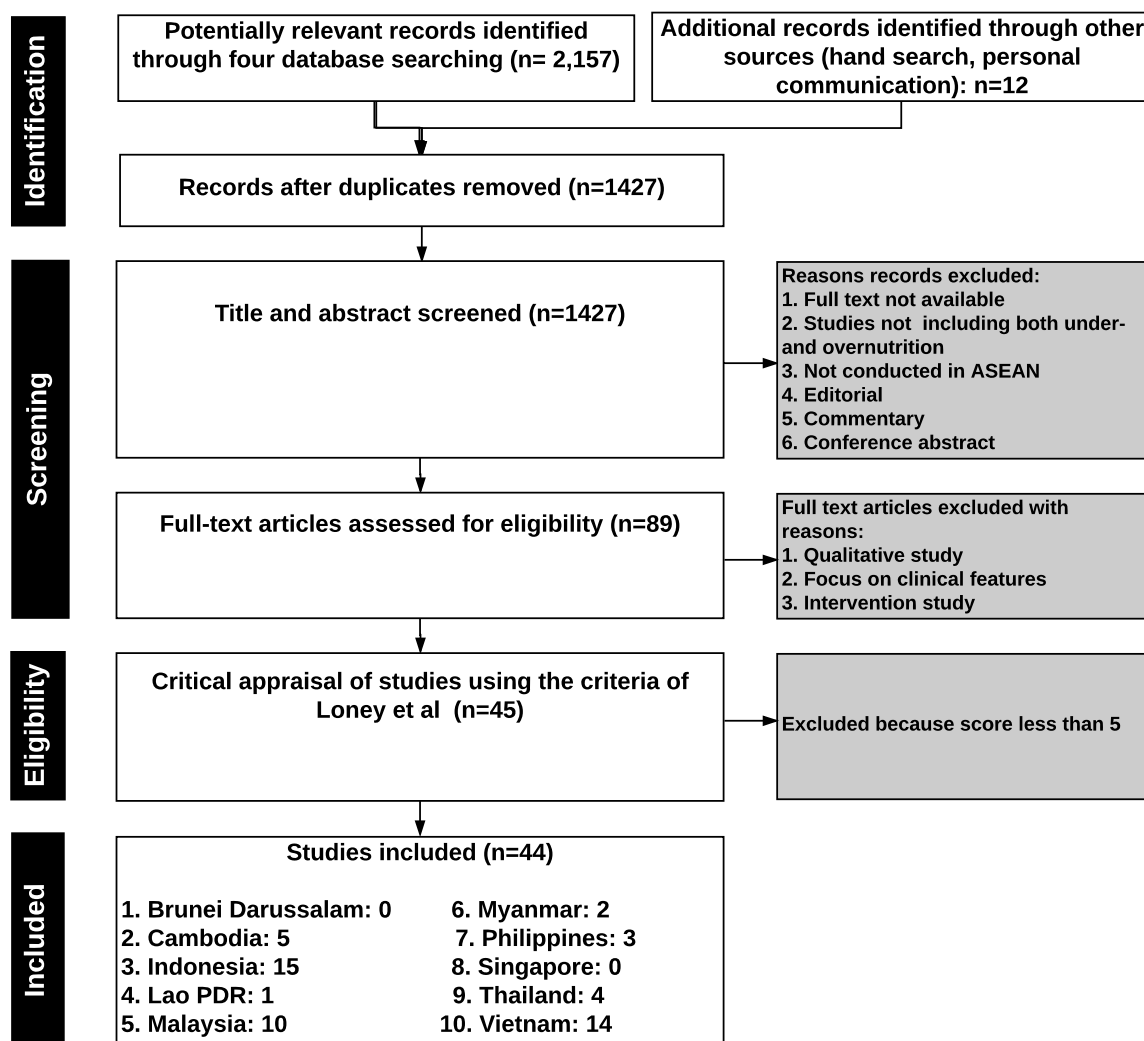


Figure 1. A flow diagram showing the flow of citations reviewed in this study.

study from Lao PDR, 1/2 studies from Philippines, 2/4 studies from Thailand, and 8/13 studies from Vietnam.

### Household level

Studies looking at the occurrence of DBM within the same household, most of which were the combination of overweight mother and underweight child, were from 4 countries. Most studies were from Indonesia (five studies), followed by Malaysia, Philippines, and Vietnam (each with one study). Five of these 8 studies (4 from Indonesia and one from Vietnam) were nationally representative.

### Individual

Two studies, one each from Cambodia and Indonesia, reported DBM in the same individual using nationally representative data. Both studies were conducted in children and found concurrent stunting and overweight/ obesity. Both studies were published in 2016, with one conducted in under five children, and one in children aged 2.0-4.9 years. The complete list of studies according to the three levels of DBM is available in Figure 2.

### The double burden of malnutrition in each country

The included studies used different criteria and cut off points, which makes direct comparisons impossible. However, we highlight the characteristics of studies in

each country in more detail. Details of the included studies are shown in Tables 1-3 in alphabetical order.

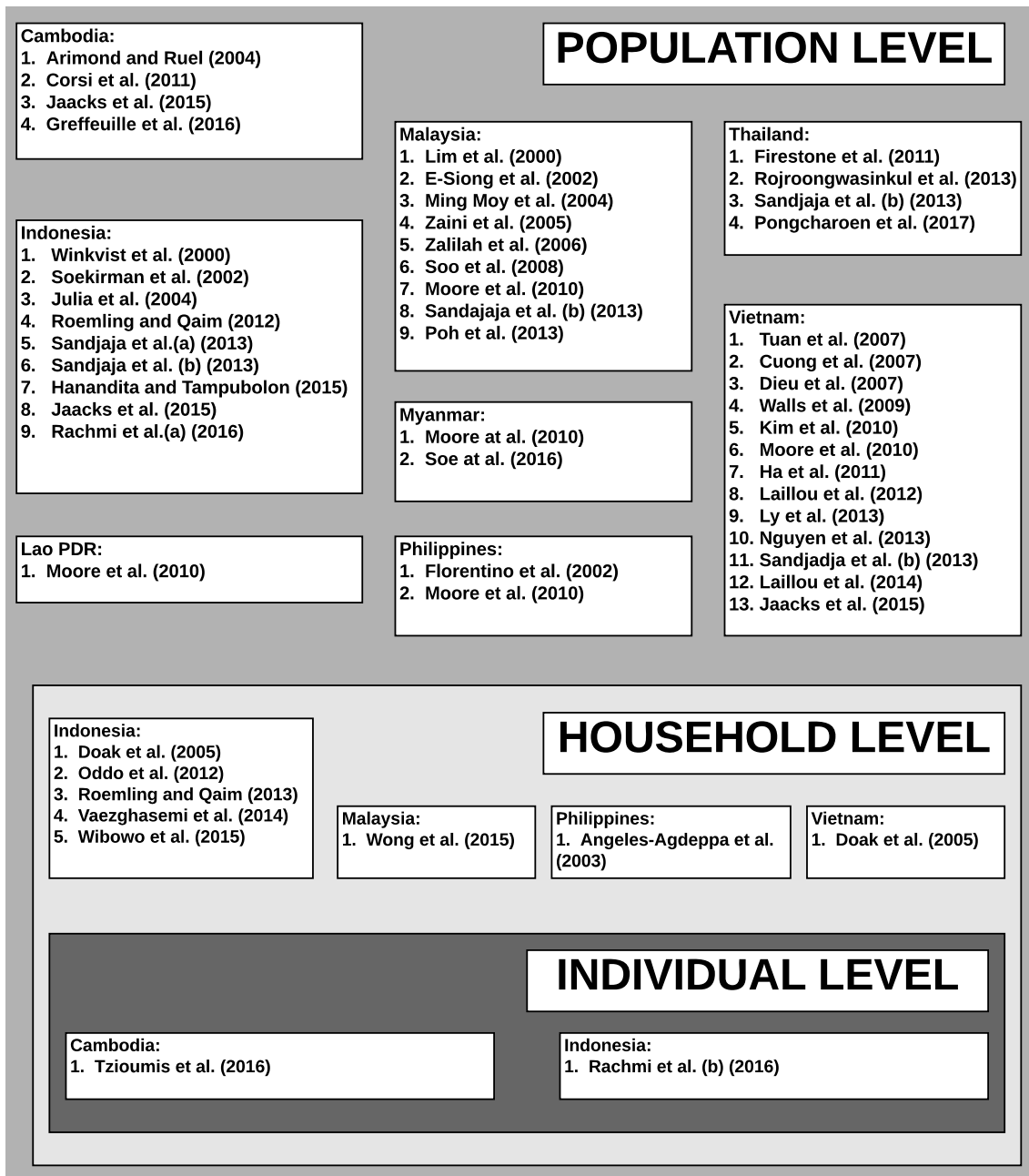
### Cambodia

Five studies were from Cambodia, four of which were conducted at the population level and one at the individual level. Of the population level studies, two were in adults and adolescent to adult women, one in female adolescents, and the other one in children. The two studies in women showed a decreased prevalence of underweight and increased prevalence of overweight/ obesity from 2000 to 2005 and 2000 to 2014.<sup>19,20</sup> The study in female adolescents showed an increase of both underweight and overweight/ obesity prevalence over a five-year period (2000 to 2005).<sup>21</sup> The other study involving children aged 6-23 months showed that stunting, wasting and overweight/ obesity were present at the population level, with a high prevalence of stunting and wasting.<sup>22</sup>

The individual level study in children aged 0-5 years showed an increased prevalence of concurrent stunting and overweight between 2000 to 2010.<sup>23</sup>

### Indonesia

Of the 15 studies from Indonesia, 9 were at the population level, 5 at the household level and one at the individual level.<sup>7,10,21,24-35</sup> Six out of 9 studies at the population level



**Figure 2.** Different levels of the double burden of malnutrition in 8 ASEAN countries; Country order alphabetically, study order by year of publication.

studies were conducted in children and adolescents, one involving adolescent and adult participants and two involving adult participants. One country-level study of repeated cross-sectional analyses showed that from 1993 to 2007 the prevalence of underweight in adults decreased while the prevalence of overweight/ obesity increased.<sup>24</sup> In children and adolescent similar trends were found in two country-level studies (both repeated cross-sectional analyses).<sup>21,25</sup>

At the household level, one study found that underweight and overweight were present in different individuals (children or adults) in 22.0% of households in 1993 while a similar study found this occurred in 19.0% of households in 2007, both using the Indonesian Family Life Survey (IFLS) dataset.<sup>7,26</sup> One study that performed repeated cross-sectional analyses in different years within the same household, also using IFLS dataset, showed an increasing prevalence of DBM (one overweight and one

underweight household member) between 1993 (11.1%) and 2007 (16.1%).<sup>27</sup> Another study using the Basic Health Survey (Riskesdas) dataset reported that the prevalence of one type (or any combination) of undernutrition (stunting, underweight, or wasting) in a child aged 2-5 years with an overweight mother was 29.8% of DBM in the households in 2015.<sup>28</sup> A further study conducted in eight provinces documented the prevalence of overweight mother and stunted child aged 6-59 months to be 5.8% in 2012.<sup>10</sup>

A study conducted at the individual level with children aged 2.0-4.9 years in four different years (1993, 1997, 2000 and 2007) showed an increased prevalence of concurrent stunting and overweight over the 14 year time period.<sup>29</sup>

#### **Lao PDR**

The nationally representative multi-country study of DBM in adults >18 years that included Lao PDR as one

**Table 1.** The double burden of malnutrition in Cambodia and Indonesia<sup>†</sup>

Authors (year of publication)	Participants		Criteria and cut-off points used Stunting, Underweight, Wasting, Thinness, Overweight, Obesity	Combination of DBM Stunting, Underweight, Wasting, Thinness, Overweight	Prevalence (%)		
	Total	Sex and age range			DBM	Overweight, Obesity, or Overweight/ Obesity	Stunting, Underweight, Wasting, Thinness
<b>CAMBODIA</b>							
Population level							
Arimond and Ruel (2004) <sup>22</sup>	2,049	Both sexes: 6-23 m	Adult: WHO 1995 [O] BMI ≥25 Children: WHO 1995 [S] HAZ <-2 [W] WHZ <-2	[S] and [U] in children, and [O] in mothers	N/A	[O/OB]: 4.0%	[S]: 36.0 [W]: 19.0
Corsi et al (2011) <sup>19</sup>	2000: 5,292 2005: 6,147	Female: 20-49 y	WHO 2000 [U] BMI <18.5 [O] BMI ≥25	[U] and [O] in adult	N/A	[O/OB] 2000: 7.3 2005: 11.3	[U] 2000: 19.1 2005: 17.8
Jaacks et al (2015) <sup>21</sup>	2005: 1,447 2010: 1,582	Female: 15-18.9 y	IOTF 2000 [U] BMI <18.5 [O] BMI ≥25	[U] and [O] in adolescent	N/A	[O/OB] 2005 Urban: 4.0 Rural: 1.0 2010 Urban: 4.0 Rural: 2.0	[U] 2005 Urban: 24.0 Rural: 21.0 2010 Urban: 25.0 Rural: 21.0
Greffeuille et al (2016) <sup>20</sup>	2000: 15,351 2005: 16,823 2010: 18,754 2014: 17,577	Female: 15-49 y	WHO 2000 [U] (BMI <18.5) [O] BMI ≥25	[U] and [O] in adult	N/A	[O/OB] 2000: 6.4 2005: 9.5 2010: 10.9 2014: 18.3	[U] 2000: 20.7 2005: 20.3 2010: 19.1 2014: 13.9
Individual level							
Tzioumis et al (2016) <sup>23</sup>	2000: 1,753 2005: 1,557 2010: 1,449	Both sexes: 0-5 y	WHO Growth Standards 2006 [S] HAZ<-2 [O] WHZ>+2	[S] and [O] concurrently in a child	2000: 2.7 2005: 0.8 2010: 1.2	N/A	N/A
<b>INDONESIA</b>							
Population level							
Winkvist et al (2000) <sup>30</sup>	4,132	Female: 15-49 y	WHO 2000 [U] BMI<18.5 [O] BMI ≥25	[U] and [O] in adults	N/A	[O/OB] 1996: 11.6 1997: 14.3	[U] 1996: 16.2 1997: 14.4
Soekirman et al (2002) <sup>31</sup>	1,367	Both sexes: 8-10 y	WHO 1995 [S] HAZ <-2 [U] WAZ <-2 [O] BMI >85th percentile [OB] BMI>95th percentile	[S], [U], and [O] in children	N/A	[O/OB] Male: 17.76 Female: 15.29	[S] Male: 11.79 Female: 8.97 [U] Male: 12.95 Female: 7.35
Julia et al (2004) <sup>32</sup>	3,010	Female: 6-7.9 y Male: 6-8.9y	WHO 1995 [S] HAZ <-2 [W] WHZ <-2 IOTF 2000 [O] BMI ≥25	[S], [W], and [O] in children	N/A	[O/OB] 2.7	[S]: 19.3 [W]: 5

S: stunting; U: underweight; W: wasting; T: thinness; O: overweight; OB: obesity; DBM: double burden of malnutrition.

<sup>†</sup>Country order alphabetically, study order by year of publication.

**Table 1.** The double burden of malnutrition in Cambodia and Indonesia<sup>†</sup> (cont.)

Authors (year of publication)	Participants		Criteria and cut-off points used Stunting, Underweight, Wasting, Thinness, Overweight, Obesity	Combination of DBM Stunting, Underweight, Wasting, Thinness, Overweight	Prevalence (%)		
	Total	Sex and age range			DBM	Overweight, Obesity, or Overweight/ Obesity	Stunting, Underweight, Wasting, Thinness
Roemling and Qaim (2012) <sup>24</sup>	1993: 10,227 2000:17,041 2007: 20,475	Both sexes: 20-75 y	WHO 2004 and Gurruci 1998 [U] BMI <18.5 [O] BMI ≥23	[U] and [O] in adults	N/A	[O/OB] 1993 Male: 20.84 Female: 32.0 2000 Male: 24.56 Female: 39.62 2007 Male: 31.38 Female: 48.75	[U] 1993 Male: 16.71 Female: 17.29 2000 Male: 16.66 Female: 14.47 2007 Male: 13.67 Female: 10.95
Sandjaja et al (2013) <sup>33</sup>	7,211	Both sexes: 0.5-12 y	WHO Growth Standard (2006) and Reference (2007) [S] HAZ <-2 [U] WAZ <-2 [W] WHZ <-2 [O] BMIZ >+2 (less than 5 years) and >+1 (≥5 years)	[S], [U], [W], and [O] in chil- dren	N/A	[O] Urban: 5.6 Rural: 3.2 [OB]Urban: 5.1 Rural: 1.8	[S] Urban: 25.1 Rural: 39.2 [U]Urban: 19.2 Rural: 28.9 [W]Urban: 5.8 Rural: 6.0
Sandjaja et al (2013) <sup>34</sup>	2,396	Both sexes: 6-12 y	WHO Growth Reference 2007 [S] HAZ <-2 [U] WAZ <-2 [T] BMIZ <-2 [O] BMIZ >+1	[S], [U], [T], and [O] in children	N/A	[O]: 5.9 [OB]: 5.6	[S]: 29.0 [U]: 25.2 [T]: 9.7
Hanandita and Tam- pulong (2015) <sup>35</sup>	645,032	Both sexes: ≥15 y	WHO 2004 and Gurruci 1998 [U] BMI <18.5 [O] BMI ≥25	[U] and [O] in adolescent and adults	N/A	[O/OB]: 17.9	[U]: 14.4
Jaacks et al (2015) <sup>21</sup>	2000: 1,336 2007: 1,069	Female: 15-18.9 y	IOTF 2000 [U] BMI <18.5 [O] BMI ≥25	[U] and [O] in adolescent	N/A	[O/OB] 2000 Urban: 7.0 Rural: 6.0 2007 Urban: 10.0 Rural: 10.0	[U] 2000 Urban: 23.0 Rural: 28.0 2007 Urban: 28.0 Rural: 25.0
Rachmi et al (2016) <sup>25</sup>	4,101	Both sexes: 2.0-4.9 y	WHO Growth Standards 2006 [S] HAZ <-2 [U] WAZ <-2 [O] BMIZ >+1	[S], [U], and [O] in children	N/A	[O/OB] 1993: 10.3 1997: 10.6 2000: 11.7 2007: 16.5	[S] 1993: 50.8 1997: 48.6 2000: 44.8 2007: 36.7 [U] 1993: 34.5 1997: 34.6 2000: 27.1 2007: 21.4

S: stunting; U: underweight; W: wasting; T: thinness; O: overweight; OB: obesity; DBM: double burden of malnutrition.

<sup>†</sup>Country order alphabetically, study order by year of publication.

**Table 1.** The double burden of malnutrition in Cambodia and Indonesia<sup>†</sup> (cont.)

Authors (year of publication)	Participants		Criteria and cut-off points used Stunting, Underweight, Wasting, Thinness, Overweight, Obesity	Combination of DBM Stunting, Underweight, Wasting, Thinness, Overweight	Prevalence (%)		
	Total	Sex and age range			DBM	Overweight, Obesity, or Overweight/Obesity	Stunting, Underweight, Wasting, Thinness
Household level							
Doak et al (2005) <sup>7</sup>	6,461 households	Both sexes: ≥2 y	Adults WHO 2000 [U] BMI <18.5 [O] BMI ≥25 Children IOTF 2000 [U] BMI <18.5 [O] BMI ≥25	[U] and [O] in children and adults	22	[O/OB] Children: 5.1 Adults: 14.6	[U] Children: 32.2 Adults: 19.2
Oddo et al (2012) <sup>10</sup>	247,126 households	Female: mean 28y Both sexes: 6-59 m	Adults WHO 2004 [O] BMI ≥23 Children WHO Growth Standards 2006 [S] HAZ <-2	[S] in children and [O] in mother	5.80	[O/OB]: 32	[S]: 37
Roemling and Qaim (2013) <sup>27</sup>	27,237 households	Both sexes: ≥2 y	Adult: WHO 2004 [U] BMI <18.5 [O] BMI ≥25 Children: WHO Growth Standard (2006) and Reference (2007) [U] BMIZ <-2 [O] BMIZ >+1	Dual burden household: one [O] and one [U] member.	1993: 11.1 1997: 16.3 2000: 16.8 2007: 16.1	N/A	N/A
Vaezghasemi et al (2014) <sup>26</sup>	9,743 households (38,237 individuals)	Both sexes: ≥2 y	Adults WHO 2000 [U] BMI <18.5 [O] BMI ≥25 Children IOTF 2000 [U] BMI <18.5 [O] BMI ≥25	[U] and [O] in children and adults	19	[O/OB] Urban: 25 Rural: 17	[U] Urban: 18 Rural: 20
Wibowo et al (2015) <sup>28</sup>	1,899 households	Female: 18-40 y Both sexes: 2-5 y	Adults WHO 2000 [O] BMI ≥25 Children WHO Growth Standards 2006 [S] HAZ <-2 [U] WAZ <-2 [W] WHZ <-2	[S], [U], [W] and any combi- nation in the child and [O] mother	29.80	N/A	N/A
Individual level							
Rachmi et al (2016) <sup>29</sup>	4,101	Both sexes: 2.0-4.9 y	WHO Growth Standards 2006 [S] HAZ <-2 [O] BMIZ >+1	[S] and [O] concurrently in a child	1993: 6.4 1997: 6.8 2000: 5.2 2007: 7.2	N/A	N/A

S: stunting; U: underweight; W: wasting; T: thinness; O: overweight; OB: obesity; DBM: double burden of malnutrition.

<sup>†</sup>Country order alphabetically, study order by year of publication.

**Table 2.** The double burden of malnutrition in Lao PDR, Malaysia, Myanmar, and Philippines†

Authors (year of publication)	Participants		Criteria used		Combination of DBM Stunting, Underweight, Thinness, Overweight	Prevalence (%)		
	Total	Sex and age range	Stunting, Overweight, Obesity	Underweight, Thinness, Overweight, Obesity		DBM	Overweight, Obesity, or Overweight Obesity	Stunting, Underweight, Thinness
LAO PDR								
Population level Moore et al (2010) <sup>36</sup>	3,536	Both sexes: ≥18 y	WHO 2000 [U] BMI <18.5	[O] BMI ≥25	[U] and [O] in adults	N/A	[O] Male: 9.1 Female: 11.9 [OB] Male:0.7 Female:1.7	[U] Male: 9.3 Female: 9.0
MALAYSIA								
Population level Lim et al (2000) <sup>37</sup>	28,737	Both sexes: ≥20 y	WHO 1995 [U] BMI <18.5	[O] BMI >25	[U] and [O] in adults	N/A	[O/OB]: 26.5	[U]: 12.7
E-Siong et al (2002) <sup>39</sup>	1,208	Both sexes: 8-10 y	WHO 1995 [S] HAZ <-2 [O] BMI >85th percentile [OB] BMI >95th percentile	[U] WAZ <-2	[S], [U], and [O] in children	N/A	[O/OB]: 17.8 Male: 19.2 Female: 16.5	[S]: 6.7 [U]: 7.1
Ming Moy et al (2004) <sup>40</sup>	3,620	Both sexes: Primary 5 (11 y) Secondary 2 (14 y) and Secondary 4 (16 y)	WHO 1995 [U] BMI <5th percentile [O] BMI >95th percentile		[U] and [O] in children	N/A	[O/OB]: 7.3	[U]: 14.8
Zaini et al (2005) <sup>41</sup>	1,405	Both sexes: 9-10 y	WHO 1995 [U] BMI <3rd percentile [O] BMI >85th percentile [OB] BMI >95th percentile		[U] and [O] in children	N/A	[O]: 16.3 [OB]: 6.3	[U]: 1.2
Zalilah et al (2006) <sup>42</sup>	6,555	Both sexes: 11-15 y	WHO 1995 [U] BMI <5th percentile [O] BMI >85th percentile		[U] and [O] in adolescent	N/A	[O/OB] Male:19.5 Female: 16.7	[U] Male: 14.9 Female: 7.8
Soo et al (2008) <sup>43</sup>	489	Both sexes: 15-17 y	WHO 1995 [U] BMI <5th percentile At risk [O] BMI >85th percentile [O] BMI >95th percentile		[U] and (at risk of) [O] in adolescent	N/A	At risk [O]: 9.8 [O]: 8.6	[U]: 3.1
Moore et al (2010) <sup>36</sup>	4,546	Both sexes: ≥18 y	WHO 2000 [U] BMI <18.5	[O] BMI ≥25	[U] and [O] in adults	N/A	[O] Male: 21.8 Female: 25.0 [OB] Male: 8.4 Female: 9.2	[U] Male: 10.1 Female: 6.4
Sandjaja et al (2013) <sup>34</sup>	2,262	Both sexes: 6-12 y	WHO Growth Reference 2007 [S] HAZ <-2 [T] BMIZ <-2	[U] WAZ <-2 [O] BMIZ >+1	[S], [U], [T] and [O/OB] in children	N/A	[O]: 14.0 [OB]: 21.8	[S]: 5.8 [U]: 9.9 [T]: 7.0

S: stunting; U: underweight; T: thinness; O: overweight; OB: obesity; DBM: double burden of malnutrition.

†Country order alphabetically, study order by year of publication.



**Table 2.** The double burden of malnutrition in Lao PDR, Malaysia, Myanmar, and Philippines<sup>†</sup> (cont.)

Authors (year of publication)	Participants		Criteria used Stunting, Underweight, Thinness, Overweight, Obesity	Combination of DBM Stunting, Underweight, Thinness, Overweight	Prevalence (%)		
	Total	Sex and age range			DBM	Overweight, Obesity, or Overweight Obesity	Stunting, Underweight, Thinness
Poh et al (2013) <sup>44</sup>	3,542 individuals	Both sexes: 0.5-12.9 y	WHO Growth Standards 2006 and WHO Growth Reference 2007 [S] HAZ <-2 [T] BMIZ <-2 [O] BMIZ >+1 (>5 y) and ≥+2 (<5 y)	[S], [T] and [O] in chil- dren	N/A	[O] Urban: 9.7 Rural: 9.9 [OB] Urban: 12.7 Rural: 8.2	[S] Urban: 8.3 Rural: 8.8 [T] Urban: 5.2 Rural: 6.0
Household level Wong et al (2015) <sup>38</sup>	438 households (931 mothers and 304 children)	Female: 15-55 y Both sexes: 3-59 m	Adult WHO 2000 [O] BMI ≥ 25 Children WHO Growth Standards 2006 [S] HAZ <-2 [U] WAZ <-2 [O] BMIZ >+2	[O] mother and mal- nourished children	Stunted child overweight mother: 19.4 Underweight child overweight mother: 12.5	[O/OB] Adult: 26.0 Children: 5.2	Children [S]: 64.2 [U]: 48.7
MYANMAR							
Population level Moore et al (2010) <sup>36</sup>	5,539	Both sexes: ≥18 y	WHO 2000 [U] BMI <18.5 [O] BMI ≥25	[U] and [O] in adults	N/A	[O] Male: 5.1 Female: 8.8 [OB] Male: 0.7 Female: 1.1	[U] Male: 14.6 Female: 13.3
Soe et al (2016) <sup>45</sup>	385	Both sexes: 6-24 m	WHO Child Growth Standards 2006 [U] WAZ <-2 SD [O] WAZ >+1.5 SD	[U] and [O] in children	N/A	[O/OB]: 1.5	[U]: 28.4
PHILIPPINES							
Population level Florentino et al (2002) <sup>46</sup>	1,208 individuals	Both sexes: 8-10 y	WHO 1995 [S] HAZ <-2 [U] WAZ <-2 [O] BMI >85th percentile [OB] BMI >95th percentile	[S], [U], and [O] in children	N/A	[O] Public school: 5.8 Private school: 24.9 [OB] Public school: 3.3 Private school: 12.0	[S] Public school: 26.5 Private school: 6.6 [U] Public school: 18.2 Private school: 4.3
Moore et al (2010) <sup>36</sup>	7,557 individuals	Both sexes; ≥18 y	WHO 2000 [U] BMI <18.5 [O] BMI ≥25	[U] and [O] in adults	N/A	[O] Male: 11.2 Female: 12.4 [OB] Male: 2.3 Female: 4.6	[U] Male: 16.5 Female: 9.2
Household level Angeles-Agdeppa et al (2003) <sup>47</sup>	378 child-mother pairs	Female: >20y Both sexes: 33-83 m	Adults WHO 2000 [O] BMI ≥ 25 Children [U] WAZ <-2	[U] child and [O] mother	8.20	N/A	N/A

S: stunting; U: underweight; T: thinness; O: overweight; OB: obesity; DBM: double burden of malnutrition.

<sup>†</sup>Country order alphabetically, study order by year of publication

**Table 3.** The double burden of malnutrition in Thailand, and Vietnam†

Authors (year of publication)	Participants		Criteria used Stunting, Underweight, Thinness, Overweight, Obesity	Combination of DBM Stunting, Underweight, Thinness, Overweight, Obesity	Prevalence (%)		
	Total	Sex and age range			DBM	Overweight, Obesity, or overweight/ Obesity	Stunting, Underweight, Wasting, Thinness
<b>THAILAND</b>							
Population level							
Firestone et al (2011) <sup>49</sup>	4,610	Both sexes: 2-10 y	CDC 2000 [S] <-2 SD Height for age [U] BMI for age <5th percentile [O] BMI for age >95th percentile	[S], [U] and [O] in children	N/A	[O/OB]: 8.26	[S]: 19.85 [U]: 27.79
Rojroongwasinkul et al (2013) <sup>48</sup>	3,119	Both sexes: 0.5-12.9 y	WHO Growth Standards 2006 and WHO Growth Reference 2007 [S] HAZ <-2 [U] WAZ <-2 [T] BMIZ <-2 [O] BMIZ ≥+1 and ≤+2 [OB] BMIZ >+2	[S], [U], [T], [O] and [OB] in children	N/A	[O] Urban: 6.9 Rural: 8.0 [OB] Urban: 11.8 Rural: 5.9	[S] Urban: 4.1 Rural: 8.4 [U] Urban: 6.4 Rural: 10.2 [T] Urban: 6.2 Rural: 6.4
Sandjaja et al (2013) <sup>34</sup>	1,580 individuals	Both sexes: 6-12 y	WHO Growth Reference 2007 [S] HAZ <-2 [U] WAZ <-2 [T] BMIZ <-2 [O] BMIZ >+1	[S], [U], [T], and [O] in children	N/A	[O]: 9.7 [OB]: 14.0	[S]: 7.0 [U]: 13.2 [T]: 8.1
Pongcharoen et al (2017) <sup>50</sup>	845 individuals	Both sexes: 3-5 y	WHO Growth Standards 2006 [S] HAZ <-2 [T] BMIZ <-2 [O] BMIZ >+2	[S], [T] and [O] in children	N/A	[O/OB]: 14.0	[S]: 5.0 [T]: 3.0
<b>VIETNAM</b>							
Population level							
Tuan et al (2007) <sup>51</sup>	1992: 24,068 2002: 158,019	Both sexes: 2-17 y and 18-65 y	Adults: WHO 1995 [U] BMI <18.5 [O] BM ≥25 Children: CDC 2000 [U] BMI <5th percentile [O] BMI >85th percentile	[U] and [O] in children and adult	N/A	[O] Children 1992: 1.4 2002: 1.8 [O] Adults 1992: 2.0 2002: 5.2	[U] Children 1992: 32.1 2002: 33.5 [U] Adults 1992: 32.6 2002: 24.8%
Cuong et al (2007) <sup>52</sup>	1,488	Both sexes: 20-60 y	WHO 2004 [U] BMI <18.5 [O] BM ≥23	[U] and [O] in adults	N/A	[O/OB] Male: 31.6 Female: 33.6	[U] Male: 22.6 Female: 18.9
Dieu et al (2007) <sup>53</sup>	670	Both sexes: 48-65 m	CDC 2000 [S] Height for age <5th percentile [U] Weight for age <5th percentile [W] BMI for age <5th percentile IOTF 2000 [O] BMI ≥25	[S], [U], [W] and [O] in children	N/A	[O] 20.5 [OB] 16.3	[S] 2.3 [U] 2.7 [W] 2.6

S: stunting; U: underweight; W: wasting; T: thinness; O: overweight; OB: obesity; DBM: double burden of malnutrition.

†Country order alphabetically, study order by year of publication.

**Table 3.** The double burden of malnutrition in Thailand, and Vietnam<sup>†</sup> (cont.)

Authors (year of publication)	Participants		Criteria used Stunting, Underweight, Thinness, Overweight, Obesity	Combination of DBM Stunting, Underweight, Thinness, Overweight, Obesity	Prevalence (%)		
	Total	Sex and age range			DBM	Overweight, Obesity, or overweight/ Obesity	Stunting, Underweight, Wasting, Thinness
Walls et al (2009) <sup>54</sup>	978	Both sexes: 25-74 y	WHO 2000 and WHO 2004 [U] BMI <18.5 [O] BMI ≥25 [O] BMI ≥23	[U] and [O] in adults	N/A	[O/OB] BMI ≥25 Male: 14.0 Female: 12.7 [O/OB] BMI ≥23 Male: 29.7 Female: 31.5	[U] Male: 14.5 Female: 12.6
Kim et al (2010) <sup>55</sup>	497 individuals	Both sexes: 19-60 y	WHO 2004 [U] BMI <18.5 [O] BMI ≥23	[U] and [O] in adults	N/A	[O/OB] Male: 21.6 Female: 20.4	[U] Male: 14.2 Female: 18.8
Moore et al (2010) <sup>36</sup>	2,995 individuals	Both sexes: ≥18 y	WHO 2000 [U] BMI <18.5 [O] BMI ≥25	[U] and [O] in adults	N/A	[O] Male: 2.7 Female: 7.2 [OB] Male: - Female: 0.6	[U] Male: 22.8 Female: 12.1
Ha et al (2011) <sup>56</sup>	2000: 14,452 2005: 17,213	Both sexes: 25-64 y	WHO 2000 and WHO 2004 [U] BMI <18.5 [O] BMI ≥25 [O] BMI ≥23	[U] and [O] in adults	N/A	[O/OB] BMI ≥25 2000: 3.5 2005: 6.6 [O/OB] BMI ≥23 2000: 16.3 2005: 11.7	[U] 2000: 25.0 2005: 20.9
Lailou et al (2012) <sup>57</sup>	2,112 (1,526 women and 586 children)	Female: >18y Both sexes: 0.5-6 y	Adult WHO 2000 [U] BMI <18.5 [O] BMI ≥25 Children WHO Growth Standards 2006 [S] HAZ <-2 [U] WAZ <-2 [W] WHZ <-1	[U] and [O] in children and adult	N/A	Adult [O/OB] 8.0	Children [S] 23.2 [U] 18.1 [W] 6.3 Adult [U] 20.5
Ly et al (2013) <sup>58</sup>	1,621	Both sexes: ≥35 y	WHO 2000 and WHO 2004 [U] BMI <18.5 [O] BMI ≥25 [O] BMI ≥23	[U] and [O] in adults	N/A	[O/OB] BMI ≥25: 16.0 [O/OB] BMI ≥23: 33.7	[U] 12.4
Nguyen et al (2013) <sup>59</sup>	952	Both sexes: 0.5-4.9 y	WHO Growth Standards 2006 [S] HAZ <-2 [U] WAZ <-2 [O] BMIZ >+2	[S], [U], and [O] in children	N/A	[O/OB] 6.5	[S] 14 [U] 8.6
Sandjaja et al (2013) <sup>34</sup>	1,920	Both sexes: 6-12 y	WHO Growth Reference 2007 [S] HAZ <-2 [U] WAZ <-2 [T] BMIZ <-2 [O] BMIZ >+1	[S], [U], [T], and [O] in children	N/A	[O] 7.0 [O/OB] 6.7	[S] 15.8 [U] 22.0 [T] 12.7

S: stunting; U: underweight; W: wasting; T: thinness; O: overweight; OB: obesity; DBM: double burden of malnutrition.

<sup>†</sup>Country order alphabetically, study order by year of publication.

**Table 3.** The double burden of malnutrition in Thailand, and Vietnam<sup>†</sup> (cont.)

Authors (year of publication)	Participants		Criteria used Stunting, Underweight, Thinness, Overweight, Obesity	Combination of DBM Stunting, Underweight, Thinness, Overweight, Obesity	Prevalence (%)		
	Total	Sex and age range			DBM	Overweight, Obesity, or overweight/ Obesity	Stunting, Underweight, Wasting, Thinness
Lailou et al (2014) <sup>60</sup>	1,526	Female: 15-49 y	WHO 2004 [U] BMI <18.5 [O] BMI ≥23	[U] and [O] in women		[O/OB] 20	[U] 20.5
Jaacks et al (2015) <sup>21</sup>	6,581	Female: 15-18.9 y	IOTF 2000 [U] BMI <18.5 [O] BMI ≥25	[U] and [O] in adolescents	N/A	[O/OB] Urban: 1.0 Rural: 1.0	[U] Urban: 36.0 Rural: 33.0
Household level Doak et al (2005) <sup>7</sup>	4,600 households	Both sexes: ≥2 y	Adults WHO 2000 [U] BMI <18.5 [O] BMI ≥25 Children IOTF 2000 [U] BMI <18.5 [O] BMI ≥25	[U] and [O] in children and adults	5.00	[O/OB] Children 1.2 Adults 2.0	[U] Children 43.7 Adults 34.4

S: stunting; U: underweight; W: wasting; T: thinness; O: overweight; OB: obesity; DBM: double burden of malnutrition.

<sup>†</sup>Country order alphabetically, study order by year of publication.

of the sites showed that DBM was present in adults 18 years and older in 2010. There was a higher prevalence of overweight/ obesity in females compared to males, but a higher prevalence of underweight in males compared to females.<sup>36</sup>

### Malaysia

There were 10 studies of DBM in Malaysia, nine at the population level (seven involving children and adolescents, two involving adults) and one at the household level.<sup>34,36-44</sup> The two country-level studies in adults used the same criteria and cut off points for both underweight and overweight.<sup>36,37</sup> Both showed an increased prevalence of overweight/ obesity and a decreased prevalence of underweight between 2000 and 2010, although Lim et al involved adults aged 20 years and older while Moore et al involved those aged 18 years and older.<sup>36,37</sup> Those studies in children and adolescents involved participants of different ages and used different criteria and cut off points so we were not able to make a comparison or identify prevalence trends.

The one household level study showed a 19.4% prevalence of a combination of a stunted child and overweight mother and a 12.5% prevalence of a combination of underweight child and overweight mother.<sup>38</sup>

### Myanmar

We found two studies of DBM in Myanmar. One, a multi-country study conducted in adults in 2010, showed a higher prevalence of underweight in male compared to female, but a higher prevalence of overweight/ obesity in female compared to male.<sup>36</sup> The other study, conducted at the city-level involving young children aged 6-24 months, showed a high prevalence of underweight (28.4%) and a low prevalence (1.5%) of overweight/ obesity.<sup>45</sup>

### Philippines

There were two population level studies conducted in the Philippines. One city-level study in children aged 8-10 years showed a significantly higher (more than 4 times) prevalence of stunting and underweight in children from public schools compared to those from private schools.<sup>46</sup> In contrast, there was a significantly higher prevalence of overweight/ obesity in children from private schools compared to those in public schools.<sup>46</sup> The only study that was conducted at the household level revealed that 8.2% of households had an overweight mother and a underweight child.<sup>47</sup>

### Thailand

There were four studies of DBM in Thai children.<sup>34,48-50</sup> We are not able to show trends in prevalence because of differences in criteria and cut off points as well as the age of participants. One study showed a higher prevalence of stunting, underweight, and thinness in rural areas compared to urban areas whereas a higher prevalence of overweight/ obesity in urban areas.<sup>48</sup>

### Vietnam

There were 14 studies of DBM in Vietnam, 13 at the population level (seven in adults, four in adolescents, two in children through to adults) and only one at the house-

hold level.<sup>7,21,34,36,51-60</sup> Of the adult studies, three city- and country-level studies using similar criteria found a higher prevalence of overweight/ obesity in females and a higher prevalence of underweight in males.<sup>36,52,54</sup> One country-level study showing decreasing trends of prevalence of underweight from 2000 to 2005 and increasing trends of overweight prevalence in adults.<sup>56</sup> One study conducted at the household level showed that 5% of 4,600 households had a combination of underweight/ overweight in children and adults.<sup>7</sup>

## DISCUSSION

This study is the first comprehensive review of high-quality publications on the double burden of malnutrition (a combination of undernutrition and overweight/obesity) in ASEAN countries. Four multi-country studies were included. Indonesia had the most studies on this issue, with only one study that met the quality criteria from Lao PDR, and no study from Singapore or Brunei Darussalam. Eight of the ASEAN countries reported 35 prevalence studies at the population level, seven at the household level and only two at the individual level. Our review also highlighted the range of criteria and cut-off points for anthropometry used in studies between and within countries, making it difficult to compare the prevalence rates; hence we depend on those studies with repeated cross-sectional analyses to provide data on prevalence trends.

At the population level, we found an increasing prevalence of overweight/ obesity and decreasing prevalence of underweight in Cambodia, Indonesia, and Vietnam. Synthesising our findings from all countries, there was a higher prevalence of overweight/ obesity in urban areas and in females, while underweight was more prevalent in rural areas and in males. At the household level, the prevalence of DBM ranged from 5.0% in Vietnam to as high as 29.8% in Indonesia with varying combinations of DBM. The two studies at the individual level showed an increased prevalence of concurrent stunting and overweight in under five children between 1993 to 2007 and 2000 to 2010.

At the population-level we found a higher prevalence of overweight compared to underweight in adults from six out of seven countries. This finding is in line with the changing face of malnutrition affecting all regions in the world. For example, in 2014, 1.9 billion adults aged 18 years or older were overweight and 462 million adults underweight.<sup>61,62</sup>

Most of the studies in this review focussed on DBM at the population level, while recent studies from Latin American countries (e.g. Mexico, Guatemala, Colombia and Ecuador) have had a greater focus on the household- and individual level.<sup>6,63-65</sup> These studies have investigated the combination of stunted children and overweight mother at the household level and concurrent stunting and overweight/ obesity in children at the individual level.<sup>6,63-65</sup>

The most common household-level combination of DBM found in this review was an underweight child with an overweight mother. Given that the largest number of children living with stunting and underweight is in Asia,<sup>2,66</sup> it is clear that ASEAN countries should have a major focus of their policies, program implementation

and monitoring and evaluation systems on the combination of underweight/stunting with overweight/ obesity, both at the household, as well as the individual level.

One of the possible reasons behind the varying prevalence rates of DBM in different ASEAN countries is that the nutrition transition is at different stages in these countries. Other studies have suggested possible explanations behind the occurrence of DBM, especially at the household level. One study in Guatemala found that the socio-economic status of dual burden households (i.e. stunted children with overweight mothers) was lower than those non-stunted households. The associated risk factors for dual burden households were short statured mothers, a higher number of births, mother currently working, and being indigenous.<sup>67</sup> Another study that analysed demographic health survey data from 18 low- and middle-income countries stated that factors associated with dual burden households (overweight mother and stunted/ underweight children) were higher maternal age (>30 years), lower level of maternal education, having more than two siblings under the age of 5 years living in the same house and living in urban areas.<sup>68</sup> However, they also concluded that the paradox in dual burden households could be best defined as a “rapid secular increase” in the weight of the mothers.<sup>68</sup>

Several studies demonstrated a social patterning to DBM. For example, one study from the Philippines found a much higher prevalence of undernutrition (stunting and underweight) in children from public schools compared to those from private schools, but a higher prevalence of overweight/ obesity in children in private schools.<sup>46</sup> Such findings are similar to those in a study from Burkina Faso where overweight was more prevalent in children from private schools and stunting more prevalent in children from public schools.<sup>69</sup> Several studies found the ‘classic’ phenomenon of higher undernutrition in rural areas and higher overweight/ obesity in urban areas in Thailand, Malaysia, and Indonesia.<sup>26,33,44,48</sup> This is in keeping with observations that undernutrition in low and middle income countries occurs more commonly in the poor, the urban poor and those living in rural areas, while overweight/ obesity affects people in higher socioeconomic status groups.<sup>15,70,71</sup> This phenomenon might be shifting as overweight prevalence can be found in both urban and rural areas as well as in the poorest to richest quintiles in many low and middle income countries.<sup>8,21</sup>

We did not find any study from Singapore and Brunei Darussalam. According to the 2014 and 2015 Global Nutrition Reports, there is no available information on under five stunting, wasting, or overweight, although 6.2% of adults were documented as having obesity in Singapore.<sup>3,4</sup> The prevalence of under-five stunting, wasting, and overweight in 2009 in Brunei Darussalam was 19.7%, 2.9%, and 8.3%, respectively, however, Brunei Darussalam has been listed as one of the countries with insufficient data to make a formal assessment.<sup>4</sup>

The main strength of the review is that we conducted a comprehensive literature search of studies published in English on DBM from the ASEAN countries. Secondly, we only included papers of high quality, supported by the use of a valid critical appraisal tool which also reduced subjectivity and reporting bias. Thirdly, this review pro-

vides the first collated summary of DBM in ASEAN countries. One limitation is there might be incompletely identified studies in other national languages.

In this review of DBM, the use of different criteria and cut-off points of both under- and overnutrition within and between different countries highlights the need for harmonisation of definitions to make comparisons possible.<sup>72-76</sup> While many country-level surveys are available, the need to facilitate the documentation of trends in prevalence is of great importance.

The World Health Organization recommends several strategies to address DBM. One of them is to create supportive environments for nutrition at all ages, including home, school and workplace settings, as well as the city context.<sup>61</sup> Regular monitoring of weight and height as well as supporting diet quality are crucial and should not be limited only to children and adolescents, as good maternal nutrition can prevent both under- and overnutrition in their offspring.<sup>61,62</sup>

The information on the prevalence of DBM should be useful to health care practitioners and policy makers, providing country-level guidance for development and implementation of specific preventions/ interventions across the lifespan in the respective country. For example, Cambodia is experiencing a decreased prevalence of underweight and an increased prevalence of overweight in adult women, while there is an increased prevalence of both underweight and overweight in adolescent females.<sup>19-21</sup> Such findings highlight the need for specific policies to address the environmental and social determinants of malnutrition within schools, communities and work contexts.<sup>61</sup> Different approaches might be needed to decrease the prevalence of both under- and overnutrition and prevent future malnutrition.

Future research should have a strong focus at the individual level of DBM, the only work at this level in the ASEAN region having been conducted in Cambodia and Indonesia.<sup>23,29</sup> Research should also aim to better understand the shared drivers of both under- and overnutrition, including biology (poor adolescent and maternal nutrition, early-life nutrition), environmental factors (food, health, social, living and working environments), and socioeconomic influences (poverty, inequality, food insecurity).<sup>37</sup> By identifying these shared drivers, governments may be able to create shared platforms to address the different types of malnutrition in one action, for example through modification of national dietary guidelines or other national-level policies.<sup>62</sup>

To date most countries have had separate policies to address under- and overnutrition, but there has been no framework to address both conditions simultaneously.<sup>2</sup> The World Health Organization released two policy briefs in 2017 to set out the potential for “double-duty actions” to eliminate both ends of the malnutrition spectrum.<sup>61,62</sup> These actions are not necessarily new actions. However, actions previously aimed to overcome one form of malnutrition, may have potential to overcome several forms concurrently.<sup>62</sup> These include exclusive breastfeeding initiatives, optimising early nutrition, programs involving maternal nutrition and antenatal care, school food policies and regulations on food marketing.<sup>62</sup> ASEAN countries will benefit from revisiting existing actions currently in

place to address under- or overnutrition issues and search for potential “double-duty actions”.

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#### AUTHOR DISCLOSURES

The authors declare no conflict of interest.

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**Supplementary table 1.** Guidelines for critically appraising studies of prevalence or incidence of a health problem by Loney et al<sup>18</sup> – previously published in Rachmi et al (2017)<sup>77</sup>

Criteria	Scoring system
A. ARE THE STUDY METHODS VALID?	
Are the study designs and sampling method appropriate for the research question?	1 point
Is the sampling frame appropriate?	1 point
Is the sample size adequate?	1 point
Are objectives, suitable and standard criteria used for measurement of the health outcome?	1 point
Is the health outcome measured in an unbiased fashion?	1 point
Is the response rate adequate? Are the refusers described?	1 point
B. WHAT IS THE INTERPRETATION OF THE RESULTS? <sup>[11]</sup> <sub>[SEP]</sub>	
Are the estimates of prevalence or incidence given with confidence intervals and in detail by subgroup, if appropriate?	1 point
C. WHAT IS THE APPLICABILITY OF THE RESULTS?	
Are the study subjects and the setting described in detail and similar to those of interest to you?	1 point
Total	8 points

**Supplementary table 2.** Criteria and cut-off points used in this literature review

No	Name of criteria (abbreviations)	Age in years	Cut off points		
			Overweight/Obesity	Stunting	Underweight/Wasting/Thinness
Children and adolescents					
1	World Health Organization (WHO 1995)	6-19	[O]: BMI $\geq$ 85% percentile [OB]: BMI $\geq$ 95% percentile	HAZ $<$ -2 or $<$ 3 <sup>rd</sup> percentile	[W]: WHZ $<$ -2 or $<$ 3 <sup>rd</sup> percentile ( $<$ 10 years) BMI for age $<$ 5 <sup>th</sup> percentile ( $\geq$ 10 years)
2	International Obesity Task Force (IOTF 2000)	2-18	[O]: BMI-for-age-and sex $\geq$ BMI of 25 at age 18 [OB]: BMI-for-age-and sex $\geq$ BMI of 30 at age 18		[T]: BMI-for-age-and sex $<$ BMI of 18.5 at age 18
3	United States Centers for Disease Control and Prevention growth charts (CDC 2000)	2-20	[O]: BMI $\geq$ 85 <sup>th</sup> percentile [OB]: BMI $\geq$ 95 <sup>th</sup> percentile	Stature for age $<$ 5 <sup>th</sup> percentile	[U]: BMI for age $<$ 5 <sup>th</sup> percentile
4	World Health Organization Child Growth Standards 0-5 years (WHO Growth Standards 2006)	0-5	[O]: BMIZ $\geq$ +2 SD [OB]: BMIZ $\geq$ +3 SD	HAZ $<$ -2	[U]: WAZ $<$ -2 [W]: WHZ $<$ -2
5	World Health Organization Child Growth Reference Data for 5-19 years (WHO Growth Reference 2007)	5-19	[O]: BMIZ $\geq$ +1 SD [OB]: BMIZ $\geq$ +2 SD		[T]: BMIZ $<$ -2SD
Adults					
1	World Health Organization (WHO 1995)	$\geq$ 18	[O]: BMI $>$ 25 [OB]: BMI $\geq$ 30		
2	Gurruci cut-off values for obesity for Indonesians (Gurruci 1998)	$\geq$ 18	[OB]: BMI $>$ 27		
3	World Health Organization; the international classification of adult underweight, overweight and obesity according to BMI (WHO 2000)	$\geq$ 18	[O]: BMI $\geq$ 25 [OB]: BMI $\geq$ 30		[U]: BMI $<$ 18.5
4	World Health Organization; Appropriate body-mass index for Asian populations (WHO 2004)	$\geq$ 18	[O]: BMI $\geq$ 23 [OB]: BMI $\geq$ 27.5		[U]: BMI $<$ 18.5

O: overweight; OB: obesity; S: stunting; U: underweight; W: wasting; T: Thinness; WAZ: Weight-for-age z score; BMI: Body Mass Index; HAZ: Height-for-age z score; WHZ: Weight-for-height z score; BMIZ: BMI-for-age z score; SD: Standard deviation.

**Supplementary table 3.** Critical appraisal process using Loney et al<sup>18†</sup>

No	Authors and year of publication	Random sample or whole population	Unbiased sampling frame	Adequate sample size	Measures were the standards	Outcome measured in an unbiased fashion	Adequate response rate, refusers described	Confidence intervals, subgroup analysis	Study subjects described	Score
CAMBODIA										
1	Arimond and Ruel (2004) <sup>22</sup>	Y	Y	Y	Y	Y	N/A	Y	Y	7
2	Corsi et al (2011) <sup>19</sup>	Y	Y	Y	Y	Y	N/A	Y	Y	7
3	Jaacks et al (2015) <sup>21</sup>	Y	Y	Y	Y	Y	N/A	Y	Y	7
4	Tzioumis et al (2016) <sup>23</sup>	Y	Y	Y	Y	Y	N/A	Y	Y	7
5	Greffeuille et al (2016) <sup>20</sup>	Y	Y	Y	Y	Y	N/A	Y	Y	7
INDONESIA										
1	Winkvist et al (2000) <sup>30</sup>	Y	Y	Y	Y	Y	Y	N	Y	7
2	Soekirman et al (2002) <sup>31</sup>	Y	Y	Y	Y	Y	N/A	Y	Y	7
3	Julia et al (2004) <sup>32</sup>	Y	N	Y	Y	Y	Y	Y	Y	7
4	Doak et al (2005) <sup>7</sup>	Y	Y	Y	Y	N/A	N/A	Y	Y	6
5	Roemling and Qaim (2012) <sup>24</sup>	Y	Y	Y	Y	Y	N/A	Y	Y	7
6	Oddo et al (2012) <sup>10</sup>	Y	Y	Y	Y	Y	N/A	N	Y	6
7	Sandjaja et al (2013) <sup>33</sup>	Y	Y	Y	Y	Y	N/A	Y	Y	7
8	Sandjaja et al (2013) <sup>34</sup>	Y	Y	Y	Y	Y	N/A	Y	Y	7
9	Roemling and Qaim (2013) <sup>27</sup>	Y	Y	Y	Y	Y	N/A	Y	Y	7
10	Vaezghasemi et al. (2014) <sup>26</sup>	Y	Y	Y	Y	Y	N/A	Y	Y	7
11	Wibowo et al (2015) <sup>28</sup>	Y	Y	Y	Y	Y	N/A	Y	Y	7
12	Hanandita and Tampubolon (2015) <sup>35</sup>	Y	Y	Y	Y	Y	N/A	N	Y	6
13	Jaacks et al (2015) <sup>21</sup>	Y	Y	Y	Y	Y	N/A	Y	Y	7
14	Rachmi et al (2016) <sup>25</sup>	Y	Y	Y	Y	Y	N/A	Y	Y	7
15	Rachmi et al (2016) <sup>29</sup>	Y	Y	Y	Y	Y	N/A	Y	Y	7
LAO PDR										
1	Moore et al (2010) <sup>36</sup>	Y	Y	Y	Y	N	N/A	Y	Y	6
MALAYSIA										
1	Lim et al (2000) <sup>37</sup>	Y	Y	Y	Y	Y	Y	Y	Y	8
2	E Siong et al (2002) <sup>39</sup>	Y	Y	Y	Y	Y	N/A	Y	Y	7
3	Ming Moy et al (2004) <sup>40</sup>	Y	Y	Y	Y	Y	Y	N	Y	7
4	Zaini et al (2005) <sup>41</sup>	Y	Y	Y	Y	Y	N/A	Y	Y	7
5	Zalilah et al (2006) <sup>42</sup>	Y	Y	Y	Y	Y	N/A	Y	Y	7
6	Soo et al (2008) <sup>43</sup>	Y	Y	Y	Y	Y	Y	N	Y	7
7	Muhammad et al (2008) <sup>78</sup>	N	N	Y	Y	Y	N/A	N	Y	4

†Country order alphabetically, study order by year of publication.

**Supplementary table 3.** Critical appraisal process using Loney et al<sup>18†</sup> (cont.)

No	Authors and year of publication	Random sample or whole population	Unbiased sampling frame	Adequate sample size	Measures were the standards	Outcome measured in an unbiased fashion	Adequate response rate, refusers described	Confidence intervals, subgroup analysis	Study subjects described	Score
MALAYSIA										
8	Moore et al (2010) <sup>36</sup>	Y	Y	Y	Y	N	N/A	Y	Y	6
9	Sandjaja et al (2013) <sup>34</sup>	Y	Y	Y	Y	Y	N/A	Y	Y	7
10	Poh et al (2013) <sup>44</sup>	Y	Y	Y	Y	Y	N/A	Y	Y	7
11	Wong et al (2015) <sup>38</sup>	Y	Y	Y	Y	Y	Y	Y	Y	8
MYANMAR										
1	Moore et al (2010) <sup>36</sup>	Y	Y	Y	Y	N	N/A	Y	Y	6
2	Soe et al (2016) <sup>45</sup>	Y	Y	Y	Y	Y	N/A	N	Y	6
PHILIPPINES										
1	Florentino et al (2002) <sup>46</sup>	Y	Y	Y	Y	Y	N/A	Y	Y	7
2	Angeles-Agdeppa et al (2003) <sup>47</sup>	Y	Y	Y	Y	Y	Y	N	Y	7
3	Moore et al (2010) <sup>36</sup>	Y	Y	Y	Y	N	N/A	Y	Y	6
THAILAND										
1	Firestone et al (2011) <sup>49</sup>	Y	Y	Y	Y	Y	N/A	N	Y	6
2	Rojroongwasinkul et al (2013) <sup>48</sup>	Y	Y	Y	Y	Y	N/A	Y	Y	7
3	Sandjaja et al (2013) <sup>34</sup>	Y	Y	Y	Y	Y	N/A	Y	Y	7
4	Pongcharoen et al (2017) <sup>50</sup>	Y	Y	Y	Y	Y	N/A	N	Y	6
VIETNAM										
1	Doak et al (2005) <sup>7</sup>	Y	Y	Y	Y	N/A	N/A	Y	Y	6
2	Tuan et al (2007) <sup>51</sup>	Y	Y	Y	Y	Y	Y	Y	Y	8
3	Cuong et al (2007) <sup>52</sup>	Y	Y	Y	Y	Y	N/A	Y	Y	7
4	Dieu et al (2007) <sup>53</sup>	Y	Y	Y	Y	Y	N/A	Y	Y	7
5	Walls et al (2009) <sup>54</sup>	Y	Y	Y	Y	Y	Y	Y	Y	8
6	Kim et al (2010) <sup>55</sup>	Y	Y	Y	Y	Y	N/A	Y	Y	7
7	Moore et al (2010) <sup>36</sup>	Y	Y	Y	Y	N	N/A	Y	Y	6
8	Ha et al (2011) <sup>56</sup>	Y	Y	Y	Y	Y	N/A	Y	Y	7
9	Laillou et al (2012) <sup>57</sup>	Y	Y	Y	Y	Y	Y	Y	Y	8
10	Ly et al (2013) <sup>58</sup>	Y	Y	Y	Y	Y	Y	N	Y	7
11	Nguyen et al (2013) <sup>69</sup>	Y	Y	Y	Y	Y	N/A	N	Y	6
12	Sandjaja et al (2013) <sup>34</sup>	Y	Y	Y	Y	Y	N/A	Y	Y	7
13	Laillou et al (2014) <sup>60</sup>	Y	Y	Y	Y	Y	Y	Y	Y	8
14	Jaacks et al (2015) <sup>21</sup>	Y	Y	Y	Y	Y	N/A	Y	Y	7

†Country order alphabetically, study order by year of publication.