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Review Article

Association between body mass index and major cancers with a focus on breast in South and Southeast Asia: A regional systematic review and meta-analysis

Rokshana Parvin[1], Aliza K C Bhandari[2], Richa Shah[3], Mutsumi Murakami[4], Giulia Collatuzzo[5], Paolo Boffetta[6], Sarah K Abe[1]

Departments of [1]Prevention, National Cancer Center Japan, [2]Graduate School of Public Health, St. Luke's International University, Chuo City, Tokyo, Japan, [3]Cancer Surveillance Branch, International Agency for Research on Cancer, 25 Avenue Tony Garnier, Lyon 69366, France, [4]Cancer Epidemiology Division of Social Medicine, Graduate School of Medicine, Bunkyo City, Tokyo, Japan, [5]Department of Biomedical and Clinical Sciences (DIBIC), Università degli Studi di Milano, Milano, [6]Medical and Surgical Sciences, University of Bologna, Bologna, Italy

ABSTRACT

Objectives: We investigated the association between body mass index (BMI) and cancer at different sites among adults in South and Southeast Asia in a systematic review.

Material and Methods: We conducted an electronic database search on PubMed, Embase, CINAHL, and Web of Science, in accordance with the PROSPERO protocol (registration No. CRD42023427644). Studies that reported the association of BMI and cancer incidence in South and Southeast Asian countries were included. We assessed the quality of the studies using the Newcastle-Ottawa Scale. Potential differences in the definition of BMI categories were considered. We performed random-effects meta-analysis to estimate the pooled effect size using Stata 17.

Findings: Of the 1,361 records identified, in the final analysis, 46 studies from 19 countries met the pre-specified inclusion criteria. The meta-analysis focused on 26 studies on breast cancer. Out of 46 studies, 95% were of high or moderate quality. We found an association between breast cancer and overweight (odds ratio (OR), 1.29; 95% CI: 1.02-1.64, I^2=87.31%; 19 studies) and obesity (OR, 1.82; 95% CI:1.21-2.75, I^2=87.68%; 14 studies). Results for other cancers were too sparse for a meta-analysis. A positive association was observed between BMI and other cancers like colorectal, lung, oral, endometrial, cervical, esophageal, and gastric cancer; data were insufficient to perform a meta-analysis.

Conclusion: Our findings suggest that obesity is associated with breast cancer in South and Southeast Asia. More high-quality research is needed to confirm this relationship and to support future public health efforts to promote a healthy BMI in the region.

Keywords: Body mass index, Breast cancer, Colorectal cancer, Meta-analysis, Overweight, Obesity, South and Southeast Asia

INTRODUCTION

Globally, the prevalence of obesity has nearly doubled since 1990.(1) According to the WHO, worldwide, 43% of adults aged 18 years and over were overweight, and 16% were obese in 2022.[1] The prevalence of obesity is a growing concern across Asia, with projections indicating a significant increase in its incidence. According to the World Obesity Atlas of 2022, South and Southeast Asia are expected to see a doubling in the prevalence of obesity from 2010 to 2030.[2] This trend highlights a serious public health challenge, as obesity is associated with various health risks such as diabetes, cardiovascular diseases, and certain cancers.

In 2020, the International Agency for Research on Cancer (IARC) published a report indicating a strong association between obesity and several types of cancer, including colon,[3-5] breast, endometrial, kidney, and oesophageal cancer.[6] A large population-based study involving 5.24 million adults in the UK and 166,955 new cases of 22 types

***Corresponding author:** Sarah K Abe, Prevention, National Cancer Centre Japan, 5-1-1 Tsukiji, Chuo City, 104-0045, Tokyo, Japan.
sarah.k.abe@gmail.com

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of cancer demonstrated a strong association between BMI and several common cancers.[7] Previous studies from different geographical regions have evaluated the association between overweight, obesity, and body mass index (BMI, kg/m²) as a measure of body weight and the risk of developing different types of cancer, including colorectal, endometrial, oesophageal, gallbladder, liver, and pancreatic cancers.[8-11] In 2022, GLOBOCAN reported that lung (15.9%), breast cancer (10.0%), and colorectal cancers (9.8%) were the top three cancers in the Asia region.[12] Several studies conducted in India, Bangladesh, and Indonesia have demonstrated a significant correlation between overweight and obesity and the incidence of breast cancer.[13-18] An Asia Cohort Consortium (ACC) pooled study conducted in 2022 revealed a significant gender-specific association between BMI and thyroid cancer.[19] A Japanese cohort study demonstrated a correlation between overweight and oesophageal cancer, but no clear association was found with BMI and non-cardia gastric cancer.[20]

Previous systematic reviews and meta-analyses assessed the potential association between overweight and obesity and total as well as site-specific cancer.[21-28] Some studies included obesity as a factor in determining survival outcomes of cancer patients.[27,28] However, the definition of obesity is often heterogeneous, and results for Asian populations are lacking. In addition, a systematic review and meta-analysis of 221 datasets (141 articles) comprising 282,137 incident cases from multiple regions reported that in the Asia-Pacific region, increased BMI was positively associated with both premenopausal and postmenopausal breast cancer.[29] A weaker positive association was observed for men and women in the correlations between BMI and malignant melanoma, multiple myeloma, rectal cancer, leukaemia, non-Hodgkin lymphoma, thyroid, pancreas, and colon cancer.[29] In 2017, another meta-analysis in Southeast Asia reported that BMI was positively correlated with survival outcomes in patients with breast cancer.[30] Cancer incidence patterns in South and Southeast Asia differ from those observed in high-income regions due to variations in body composition, environmental exposure, and healthcare system capacity. Several epidemiological studies have examined the link between body mass index (BMI) and cancer risk in Asian populations. However, the results are inconsistent and often limited to one type of cancer or one country. Furthermore, inconsistent BMI classification and study design make it difficult to interpret and compare results from different studies. Despite the region's distinguishing epidemiological profile, few systematic reviews have focused specifically on South and Southeast Asia.

Despite these findings, a significant research gap remains: few studies have comprehensively examined how BMI influences cancer risk across South and Southeast Asia. However, the specific relationship between BMI and site-specific cancer incidence in this region remains inadequately investigated. To address this gap, we conducted a comprehensive literature review and meta-analysis to evaluate the association between BMI (overweight, obesity, and underweight) and site-specific cancer incidence in South and Southeast Asia.

MATERIALS AND METHODS

Data sources and search strategy

We conducted a computerised systematic search in four databases, including PubMed, Embase, Cumulated Index to Nursing and Allied Health Literature (CINAHL), and Web of Science from 2000 to April 2023. The essential concept of the data search for the systematic review and meta-analysis was as follows: (Cancer OR oncology OR malignancy OR neoplasms) and (Overweight OR obese OR obesity OR body weight OR body mass index) and (South Asia) and (Southeast Asia). The full search strategy and results from each database search are described in Supplementary Tables 1-8. We limited our search to adult cancer and excluded case reports, systematic reviews, meta-analyses, animal studies, childhood cancer, skin cancer, melanoma, laboratory studies, and pediatric cancer. This study followed the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) reporting guideline [Figure 1]. The study protocol was registered with the International Prospective Register of Systematic Reviews PROSPERO (registration No: CRD42023427644).

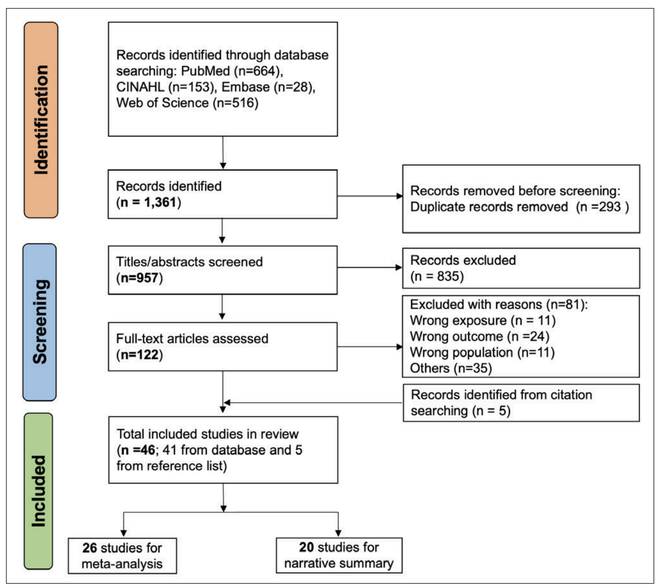

Figure 1: PRISMA flowchart for selection of studies. PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-analysis

Study area

According to the Global Initiative for Cancer Registry development (GICR), we included 20 countries from South Asia (Afghanistan, Bangladesh, Bhutan, India, Iran, Maldives, Nepal, Pakistan and Sri-Lanka) and Southeast Asia (Brunei, Cambodia, Indonesia, Lao, Malaysia, Myanmar, Philippines, Singapore, Thailand, Timor-Leste and Viet Nam).[31]

Study selection

Two independent reviewers screened the studies included. In case of contradiction between two reviewers, the decision was made by a third reviewer. We used a two-step selection process to identify all eligible studies. First, we screened the titles and abstracts of all included articles. The full-text screening was conducted based on the following inclusion and exclusion criteria. We summarized eligibility criteria using the PECOS (population, exposure, comparator, outcome, and study type) framework. All retrieved papers were checked for eligibility by the team and studies meeting following criteria were included: 1) population: subjects who participated in the studies on cancer; 2) exposure: BMI was defined both WHO (underweight: BMI <18.5, overweight: BMI 25-29.9, obesity: BMI 30) and Asian (underweight: BMI <18.5, overweight: BMI 23-24.9, obesity: BMI 25) cut off point; 3) comparator: normal weight subjects WHO (BMI 18.5-24.9); Asian (BMI 18.5-22.9); 4) outcome: all types of incident cancer; 5) study design: case-control study, cohort study and cross-sectional study; 6) we did not have any language restriction. All irrelevant articles were excluded based on the following exclusion criteria: 1) animal study; 2) protocol papers, literature review papers, reports, editorials; 3) childhood cancer, skin cancer, melanoma, pediatric cancer; 3) studies from other regions except South and Southeast Asia.

Data extraction and quality assessment

We used a standardized Excel data extraction sheet to collect information and to minimize errors in the data extraction. From each relevant study, extracted data included the following information: the first author's name, published year, study design, sample size, study period, study population, age group, exposure, outcome, confounder adjustment, and effect size. Two reviewers independently completed the data extraction. Additionally, the other two authors cross-checked the data extraction and assessed the methodological quality. We applied the Newcastle-Ottawa Scale for all observational studies and risk of bias based on the study selection (four questions), comparability (two questions), and outcome or exposure assessment (three questions). All observational studies received a score based on the nine criteria from three main domains. Studies are graded one point each for all items. The total score ranged from 0 to 9, while scores less than 3, less than 6 and between 7 to 9 were considered as low, moderate, and high-quality studies, respectively. To enhance the quality of the analysis, low-quality studies were excluded from the meta-analysis and included in the narrative review.

Statistical analysis

For meta-analysis, we performed fixed or random effects meta-analyses depending on the degree of heterogeneity to summarize the effect size. Exposure and outcome-specific pooled estimates of individual studies were reported as odds ratios (OR) with 95% confidence interval (CI) using fixed-effect meta-analysis if between-study heterogeneity was low ($I^2 < 25\%$), or random-effects meta-analysis was used otherwise. Funnel plots and the Egger test were used to assess publication bias. We conducted subgroup analyses based on study region, country, design, BMI definition, and quality. P values were 2-sided, and statistical significance was set at $P < 0.05$. In addition, we completed a narrative synthesis for studies with continuous BMI and different cut-off points of BMI. Data analyses were performed using Stata software version 17 MP (Stata Corp).

RESULTS

Figure 1 presents a flow diagram of the literature search conducted in accordance with the PRISMA guidelines. A total of 1,361 studies were identified through an electronic search on PubMed, Embase, CINAHL, and Web of Science. Of these, 293 duplicates were excluded, leaving 957 studies for title and abstract screening. Furthermore, 122 additional irrelevant articles were excluded based on the established inclusion criteria. Subsequently, 81 articles were excluded for the following reasons: a lack of exposure data (n=11), an incorrect outcome (n=24), an inappropriate population (n=11), and other reasons (n=35). A further five articles were identified through citation searching. Finally, 46 studies were selected for our systematic review and meta-analysis. Out of 46 studies, 26 studies were selected for meta-analysis, and 20 studies were included only in the narrative summary.

Tables 1 and 2 shows the background characteristics of all 46 included studies. The selected studies were published between 2000 to 2023.[3-5, 13-18, 32-68] We included six cohort studies and 34 case-control studies in the analysis. Additionally, six cross-sectional studies, excluded from the meta-analysis, were reported only in the narrative summary. Most studies evaluated overweight (32 studies [70%]), obesity (20 studies [43%]), and BMI (six studies [14%]). We identified 30 studies for breast cancer, four studies for colorectal cancer, while studies for the remaining cancer sites (cervical cancer, prostate cancer, oral cancer, esophageal cancer, gallbladder cancer, lung cancer, colon cancer, endometrial cancer) were too scarce for the meta-analysis. The selected studies covered 11 different countries. The highest number of studies was from India (16 studies, 35%) followed by Pakistan (six studies, 13%). According to the Newcastle-Ottawa scale, 95% of the included studies were of high or moderate quality (score of at least 6). [Supplementary Tables 7 and 8]

A total of 19 studies were included in the meta-analysis investigating the association between overweight and breast cancer [Figure 2]. The pooled OR for the association between overweight and breast cancer was 1.29 (95% CI: 1.02-1.64), with considerable eterogeneity (I^2 = 87.31%).

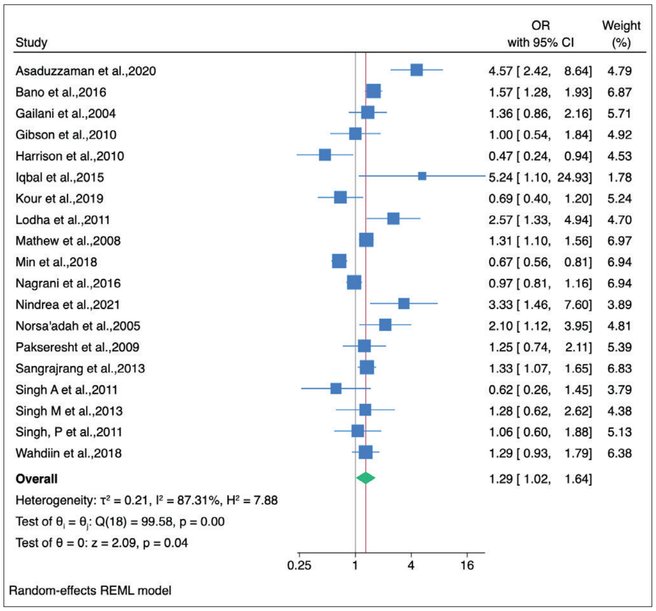

Figure 2: Association of overweight and breast cancer Note: Overweight include all definition WHO (25-29.9) and Asia (23-24.9). OR: Odds ratio, CI: Confidence interval

Figure 3 depicts the association between obesity and breast cancer. The pooled OR for obesity and breast cancer was 1.82 (95% CI: 1.21-2.75), with considerable heterogeneity (I^2=87.68%). To address potential bias and verify our results, we performed sensitivity analyses excluding highly influential studies with small effect sizes. By omitting individual studies and recalculating the pooled ORs for the remaining studies, we found no changes in the direction of the effect when any single study was excluded. [see Supplemental Figures 1 and 2]. The funnel plots and Egger test were indicated that there was no evidence of publication bias for overweight and breast cancer (p-value for Egger test=0.13), but the publication bias was present among the studies investigating the association between obesity and breast cancer (p-value for Egger test=0.02) [Figures 4]. The association of underweight (BMI<18.5 kg/m^2) and breast cancer is presented in [Supplemental Figures 3-5]. We found no significant association between underweight and breast cancer. The pooled OR was 0.65 (95% CI: 0.18-2.25) with high heterogeneity (I^2=83.66%). Results for other cancer sites were too sparse to justify a meta-analysis.

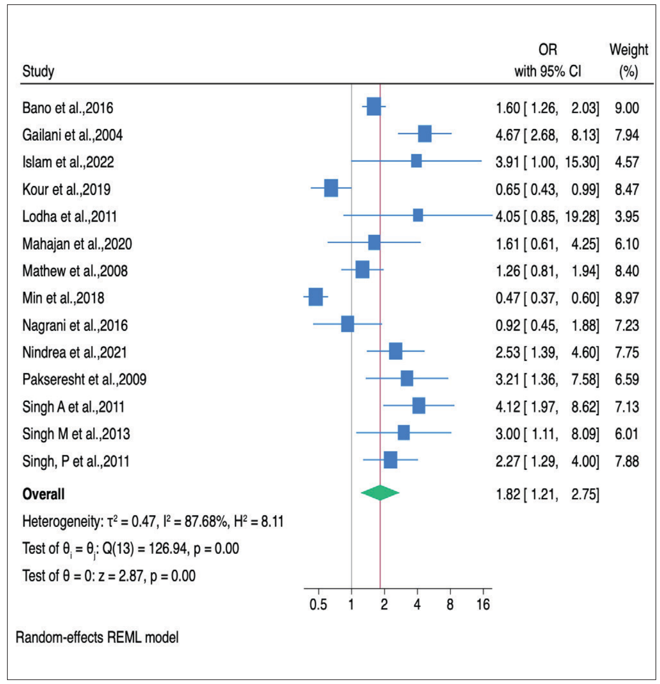

Figure 3: Association of obesity and breast cancer Note: Obesity include all definition WHO (>=30) and Asia (>=25). OR: Odds ratio, CI: Confidence interval

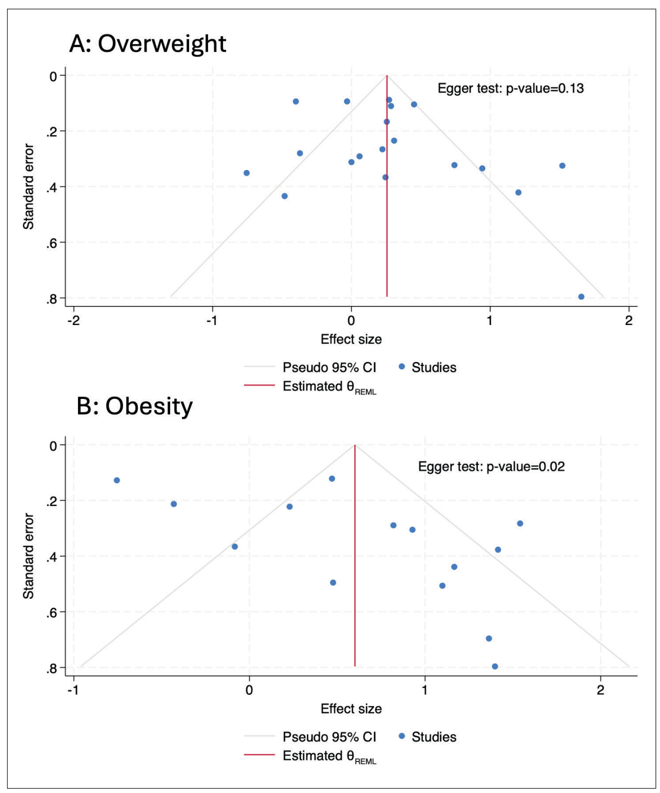

Figure 4: Funnel plot for breast cancer (A) Overweight and (B) Obesity. CI: Confidence interval

Table 1: Background characteristics of the study population for breast cancer

Country	Study period	Study design	Sample size	Gender	Age (years)	Exposure (Kg/m^2)	Study quality	Score	Author
Afghanistan	2018-2019	Case control	402	Women	>=30	BMI (Continous)	High	6	Baset *et al.*, 2021[32]
Bangladesh	2014-2015	Case control	182	Women	20-70	>=25 Obesity	Moderate	4	Asaduzzaman *et al.*, 2020[33]
Bangladesh	2018-2019	Cross-sectional	100	Women	18+	(≥23 over-weight or obese), (18.5 and 22.9) normal weight	High	7	Chowdhury *et al.*, 2021[15]
Bangladesh	2007-2010	Case control	258	Women	25-51	<18.50 underweight, (18.50- 24.99) normal-weight, ≥25 overweight, ≥30 obese	High	8	Iqbal *et al.*, 2015[16]
Bangladesh	2021-2022	Case control	111	Women	25-70	<30 Over-weight and ≥30 Obese	High	7	Islam *et al.*, 2022[34]
India	2002-2005	Case control	1785	Women	18-24	BMI (1st tertile 21.4, 2nd tertile>21.4 to 25.1 and 3rd tertile>25.1)	Moderate	4	Dey *et al.*, 2009[35]
India	2008	Case control	315	Women	25-54	BMI >25	High	6	Harrison *et al.*, 2010[36]
India	2016-2019	Cross-sectional	8352	All	18-49	>=25 (overweight/ Obese)	High	7	Kedar *et al.*, 2019[37]
India	NA	Case control	542	Women	25-70	(18.5-22.9) normal, (23-24.9) over-weight, >=25 obese	High	9	Kour *et al.*, 2019[38]
India	2008-2009	Case control	430	Women	28-78	25 lean weight, 25<BMI<30 over-weight and 30 obese	High	8	Lodha *et al.*, 2011[39]
India	2019	Case control	130	Women	40-80	>=30, <30	Moderate	5	Mahajan *et al.*, 2020[17]
India	2002-2005	Case control	3739	Women	NA	BMI<=25 lean weight, (25<BMI<30) overweight and BMI>=30 obese	High	8	Mathew *et al.*, 2008[40]
India	2009-2013	Case control	3137	Women	20-69	BMI <18.5 underweight, (18.5-24.9) normal weight, >=30 obese	High	9	Nagrani *et al.*, 2016[41]
India	2006	Case control	332	Women	24-80	<18.5 underweight, (18.5-24.99) normal weight, (25-29.99) overweight, >=30 obese	High	6	Pakseresht *et al.*, 2009[42]
India	NA	Case control	240	Women	34-70	BMI	High	7	Shetty *et al.*, 2021[43]
India	2006-2008	Cohort	358	Women	NA	<18.5 underweight, (18.5-24.9) normal weight, BMI>=25.0 overweight, (30.0-34.9) obese I, (35.0-39.9) obese II, BMI>=40 obese III	High	7	Singh A *et al.*, 2011[44]

Table 1: *Contd.*

India	2009-2010	Case control	256	Female	24-79	<18.5 underweight, (18.5-23) normal weight, (23-25) , (25-30) and >30	High	7	Singh M *et al.*, 2013[13]
India	2001-2003	Case control	640	Women	NA	<25.0 normal weight, (25.0-29.9) overweight, >=30.0 obese	High	7	Singh P *et al.*, 2011[14]
Indonesia	2020	Case control	400	Women	NA	(18.5-23.49) normal, (23.5-24.99) overweight, >=25 obese	Moderate	5	Nindrea *et al.*, 2021[18]
Indonesia	2013	Case control	762	Women	15+	>=25 obese	High	7	Wahdiin *et al.*, 2018[45]
Malaysia	2002-2016	Case control	7663	Women	40-74	<23.0 normal weight, (23.0-27.4) overweight, >=27 obese	High	9	Min Tan *et al.*, 2018[46]
Malaysia	1991-2000	Case control	294	Women	26-70	<18.5 underweight, (18.5-24.9) normal weight, >=25 overweight/obese	High	7	Norsa'adah *et al.*, 2005 [47]
Pakistan	NA	Case control	2246	Women	NA	<18.5 under-weight, 18.5-25 normal weight and >30 obese	Moderate	4	Bano *et al.*, 2016[48]
Pakistan	1997-1998	Case control	1494	All	20-44	<25 normal-weight, (25–29.9) over-weight and 30 obese	Moderate	5	Gailani *et al.*, 2004[49]
Pakistan	2019-2020	Cross-sectional	100	Women	40-70	<18.5 underweight, (18.5-22.9) normal weight, (23.0-24.9) overweight, (25.0-29.99) obese 1,>=30 obese 2	Moderate	4	Noureen *et al.*, 2023[50]
Philippine	1995-1997	Case control	1101	Women	35-64	<25, >=25 overweight	High	7	Gibson *et al.*, 2010[51]
Thailand	2011-2012	Cross-sectional	15718	Women	18+	<=23 normal-weight, 24-26 over-weight, and >=27 obesity	High	8	Anothais-intawee *et al.*, 2014[52]
Thailand	2013-2014	Case control	514	Women	<=45	<18.5 underweight, (18.5-22.9) normal weight, (23-24.9) overweight, (25-29.9) overweight, >=30 obese	High	8	Chaveepo-jnkamjorn *et al.*, 2017[53]
Thailand	2002-2006	Case control	2272	Women	NA	<18.5 underweight, (18.5-24.9) normal weight, >=25 overweight	Moderate	4	Sangrajrang *et al.*, 2013[54]
Vietnam	2007-2013	Case control	588	Women	25-75	<18 normal weight, (18-20) overweight, >20 obese	Moderate	5	Nguyen *et al.*, 2016[55]
Vietnam	1993-1999	Case control	1331	Women	24-57	Body mass index quartile	High	9	Nichols *et al.*, 2005[56]

Note: [a]Study quality was conducted based on Newcastle-Ottawa scale (NOS). Studies are graded one point each for all items and studies are rated from 0-9, with those studies rating 03 (poor quality), 4-5 (moderate quality) and 6-9 (high quality) NA: Not applicable

Table 2: Background characteristics of the study population for other cancer sites

Country	Study period	Study design	Sample size	Gender	Age (years)	Exposure (Kg/m^2)	Outcome	Study quality[a]	Score	Author
India	1998-1999	Case control	418	Women	NA	BMI (>=23, (21.5-23.3), <21.5	Cervical cancer	High	7	Rajkumar *et al.*, 2003[57]
Pakistan	2015-2020	Cohort	236	All	20-85	Underweight, (23.1-27.5) Normal weight,BMI>27.5) Overweight	Colon Cancer	High	9	Saleem *et al.*, 2022[58]
India	2014-2016	Case control	220	All	NA	Underweight, Normal weight, Overweight, Obese	Colorectal cancer	High	6	Ferreira *et al.*, 2021[3]
Thailand	2016-2017	Cross-sectional	338	All	50-75	≥23 over-weight, <23 normal weight	Colorectal cancer	Moderate	5	Jangsirikul *et al.*, 2019[4]
Singapore	1993-1998	Cohort	51251	All	45-74	<18.5 underweight, (18.5-21.4) normal weight, (21.5-24.4) and ((24.4-27.4) overweight, >=27.5 obese	Colorectal cancer	High	8	Odegaard *et al.*, 2011[59]
Indonesia	2021	Cross-sectional	221	All	45+	Abnormal (over obese) and Normal	Colorectal cancer	Moderate	4	Purnomo *et al.*, 2023[5]
Thailand	2002-2006	Case control	506	All	39-70	BMI<25 and BMI >=25	Colorectal cancer	High	8	Sriamporn *et al.*, 2007[60]
Sri Lanka	2016-2017	Case control	415	Women	<=55 and >55	>=25 obese	Endometrial cancer	High	6	Jayawickcrama *et al.*, 2019[61]
Singapore	1993-1998	Cohort	30,404	Women	45-74	<18.5 underweight, 18.5–22.9 normal weight, 23.0–27.4 overweight, and ≥27.5 obesity	Endometrial cancer	High	8	Lei *et al.*, 2022[62]
Afghanistan	2019	Case control	264	All	45-64	Underweight, Normal weight, Overweight, Obese	Esophageal cancer	High	6	Saadaat *et al.*, 2022[63]
Pakistan	1988-2007	Case control	180	All	18-75	BMI <=23 and BMI>23,	Gallbladder cancer	Moderate	5	Alvi *et al.*, 2011[64]
Singapore	1993-1998	Cohort	63257	All	45-74	<27.5 and >=27.5 (obese)	Gastric cancer	High	7	Wang *et al.*, 2017[65]
Singapore	1993-2006	Cohort	1042	All	45-74	<20, (20-<24), (24-<28),>=28	Lung cancer	Moderate	5	Koh *et al.*, 2010[66]
India	2016-2019	Cross-sectional	8352	All	18-49	>=25 (overweight/ Obese)	Oral cancer, Breast cancer and cervical cancer	High	7	Kedar *et al.*, 2019[37]
Pakistan	2012-2013	Case control	420	All	<55 and >55	Obesity >25	Prostate cancer	High	6	Bashir *et al.*, 2015[67]
India	1999-2001	Case control	290	All	45-64	>=25 and <25	Prostate cancer	High	7	Ganesh *et al.*, 2011[68]

Note: [a]Study quality was conducted based on Newcastle-Ottawa scale (NOS). Studies are graded one point each for all items and studies are rated from 0-9, with those studies rating 03 (poor quality), 4-5 (moderate quality) and 6-9 (high quality). NA: Not applicable, BMI: Body mass index

Table 3: Stratified analysis of pooled odds ratio of BMI for breast cancer women

Variables	No. of study	Pooled OR (95% CI)	Heterogeneity: Q statistic (P-value)
Overweight			
Region			
South Asia	13	1.29 (0.94-1.76)	0.95
Southeast Asia	7	1.30 (0.87-1.97)	
Country			
Bangladesh	2	4.66 (2.58-8.40)	0.001
India	9	1.04 (0.79-1.30)	
Indonesia	2	1.92 (0.76-4.79)	
Malaysia	2	1.14 (0.37-3.47)	
Pakistan	2	1.53 (1.27-1.85)	
Philippine	1	1.00 (0.54-1.84)	
Thailand	1	1.33 (1.07-1.65)	
BMI definition			
Asian	4	1.14 (0.55-2.36)	0.56
WHO	12	1.40 (1.16-1.72)	
Study design			
Case control	18	1.33 (1.04-1.70)	0.09
Cohort study	2	0.62 (0.26-1.45)	
Sample size			
<500	10	1.65 (1.04-2.62)	0.10
>=500	9	1.29 (1.01-1.64)	
Quality			
Low	3	2.00 (1.00-4.01)	0.32
Moderate	4	1.25 (0.61-2.59)	
High	12	1.13 (0.89-1.45)	
Obesity			
Region			
South Asia	12	2.01 (1.36-2.99)	0.46
Southeast Asia	2	1.07 (0.20-5.54)	
Country			
Bangladesh	1	3.91 (1.0-15.3)	0.00
India	9	1.79 (1.13-2.83)	
Indonesia	1	2.53 (1.39-4.6)	
Malaysia	1	0.47 (0.37-0.6)	
Pakistan	2	2.65 (0.93-7.56)	
BMI definition			
Asian	4	2.02 (0.86-4.75)	0.97
WHO	9	2.06 (1.41-3.02)	

Table 3: *Contd.*

Study design			
Case control	13	1.71 (1.12-2.6)	0.04
Cohort study	1	4.12 (1.97-8.62)	
Sample size			
<500	8	2.44 (1.66-3.6)	0.11
>=500	6	1.28 (0.65-2.53)	
Quality			
Low	1	1.60 (1.26-2.03)	0.03
Moderate	4	3.04 (1.98-4.67)	
High	9	1.57 (0.87-2.70)	

P-value<0.05. NA, not applicable

A subgroup analysis was conducted to investigate the relationship between overweight and obesity and breast cancer, with respect to region, country, study design, sample size, and study quality [Table 3]. A subgroup analysis by geographic region revealed a higher risk of breast cancer in South Asia for individuals with obesity (OR: 2.01; 95% CI: 1.36-2.99). The p-value for the Q-statistic was greater than 0.05 for both overweight and obesity, indicating that the pooled OR was not significantly different between regions. Due to the limited number of studies conducted in Bangladesh, the pooled OR for breast cancer in overweight and obese individuals was higher than in other countries (OR: 4.66; 95% CI: 2.58-8.40 for overweight and OR: 3.91; 95% CI:1.0-15.3 for obese) compared to other countries. The p-value for the Q-statistic was less than 0.05, which indicates that the pooled OR significantly differed between countries. Furthermore, the data were stratified according to the definitions of BMI proposed by the WHO and the Asian region. The pooled OR for the Asian definition was 1.14, while that for the WHO definition was 1.43. The p-value for Q statistics was 0.56 see [Supplementary Figures 4 and 5], indicating that there was no statistically significant difference between the two definitions. In the case of obesity, the p-value for Q-statistics was 0.98, indicating that there was no statistically significant difference between the two definitions. The pooled OR for obesity in cohort studies demonstrated a significantly higher OR for breast cancer compared to that observed in case-control studies.

Table 4 presents a narrative summary of the relationship between overweight/ obesity and cancer risk. In the narrative summary, we observed an association between BMI and different sites of cancer among 28 studies. Out of 12 studies, 4 studies reported a positive association with BMI and breast cancer, and 3 of 5 studies for colorectal cancer. The result of two studies indicated an insignificant association between overweight and cancers of the colon and cervix. A positive correlation was observed between obesity and endometrial cancer. The findings of studies conducted on esophageal and gastric cancers have indicated an evident non-association with BMI.

Table 4: Narrative summary of BMI and different cancer sites

Country	Findings	Conclusion	Study
Breast cancer			
Afghanistan	BMI was not statistically significant with female breast cancer.	-	Baset *et al.*, 2021[32]
Bangladesh	High BMI (AOR 53.65, 95% CI 5.70–504.73) was found to be independent risk factors for breast cancer.	↑	Chowdhury *et al.*, 2021[15]
India	No association was found between breast cancer and overweight and obesity.	-	Kedar *et al.*, 2019[37]
India	An association between high BMI and breast cancer is statistically significant.	↑	Shetty *et al.*, 2021[43]
Pakistan	Significant link between obesity and breast cancer (p-0.002), with higher BMI carrying a higher risk of advanced breast cancer.	↑	Noureen *et al.*, 2023[50]
Thailand	Higher BMI was significantly associated with increased risk of breast cancer.	↑	Chaveepojnkamjorn *et al.*, 2017[53]
Thailand	Obesity, but not overweight, was a significant predictor of breast cancer with OR of 2.02 (95% CI: 1.26, 3.24).	↑	Anothaisintawee *et al.*, 2014[52]
Vietnam	BMI was positively associated with breast cancer risk.	↑	Nguyen *et al.*, 2016[55]
Vietnam	BMI was not significantly associated with increased risk of breast cancer.	-	Nichols *et al.*, 2005[56]
Colorectal cancer			
India	BMI was significantly associated with colorectal cancer (P = 0.003).	↑	Ferreira *et al.*, 2021[3]
Indonesia	BMI may be associated with cancerous lesion in histology examination.	↑	Purnomo *et al.*, 2023[5]
Singapore	BMI's ≥27.5 were associated with an increased risk of colorectal cancer. This association was driven by colon cancer, which had a strong, positive association with BMI's≥27.5. There was no association between BMI and rectal cancer.	↑	Odegaard *et al.*, 2012[59]
Thailand	There was statistically significant association between overweight and the CRN detection (OR, 2.57; 95% CI, 1.57-4.20).	↑	Jangsirikul *et al.*, 2019[4]
Cervical cancer			
India	No association was found between metabolic risk factors and cervical cancer and cervical precancer.	-	Kedar *et al.*, 2019[37]
India	The associations between ICC and paan chewing, BMI and overall vegetable and fruit intake according to the fully adjusted model in three different types of comparisons.	-	Rajkumar *et al.*, 2023[57]
Colon cancer			
Pakistan	Kaplan–Meier survival analysis for the BMI groups. Colon cancer patients with normal weight have a better chance of survival than overweight patients.	-	Saleem. *et al.*, 2022[58]
Endometrial cancer			
Sri Lanka	Generalized obesity was found to be associated with an increased risk of endometrial cancer.	↑	Jayawickcrama *et al.*, 2019[61]
Singapore	Overweight (HR: 2.00, 95% CI 1.32–3.03) and obesity (HR: 2.22, 95% CI 1.26–3.92) were associated with increased EC risk in the entire cohort.	↑	Lei *et al.*, 2022[62]
Esophageal cancer			
Afghanistan	BMI showed no association between esophageal cancer.	-	Saadaat *et al.*, 2022[63]
Gastric cancer			
Singapore	BMI was associated with a significant increased risk of gastric cancer.	↑	Wang *et al.*, 2017[65]
Oral cancer			
India	Risk of oral cancer is higher among overweight/obese than normal weight people and is statistically significant.	↑	Kedar *et al.*, 2019[37]
Lung cancer			
Singapore	Low BMI was associated with a statistically significant increased risk of lung cancer (P for trend=0.0004).	↑	Koh *et al.*, 2009[66]

BMI: Body mass index, AOR : Adjusted odds ratio, ICC: Invasive cervical, cancer, HR: Hazard ratio, EC: Endometrial cancer, CI: Confidence interval

DISCUSSION

This is one of the first studies to systematically explore the association between overweight and obesity and multiple cancer sites in South and Southeast Asian countries. The present systematic review and meta-analysis include 45 studies on BMI and different sites of cancer incidence, and results showed that being overweight and obesity are significantly associated with an increase of breast cancer in South and Southeast Asia. Based on the results, overweight women had a 1.29 times risk of developing breast cancer compared to normal BMI women, and obese women had a 1.82 times risk of developing breast cancer. The result indicated that obese women had a higher chance of developing breast cancer than overweight women. Additionally, our findings indicate that there is no significant difference between the two regions, sample sizes, or study quality regarding overweight and obesity. Most importantly, we observed no difference by WHO and the Asian definition of BMI categories. However, we did identify notable differences between countries, notably Bangladesh showing the highest OR for both overweight and obesity, possibly due to difference in lifestyle, sample characteristics, or genetic factors.[34] Furthermore, our narrative summary identified positive associations between overweight and obesity and other forms of cancer, for example, colorectal, endometrial, and cervical cancer. No relationship was found between BMI and esophageal and gastric cancer.

The results of this study are in line with previous studies, which showed an association of overweight and obesity with breast cancer during the menopausal period in Asian countries.[69,70] Other studies from Europe and North America found an inverse association between high BMI and the risk of breast cancer in premenopausal women.[71-73] Furthermore, an additional study from the Philippines found no correlation between BMI and breast cancer.[51] Additionally, when stratified by menopausal status, no statistically significant association was observed.[51] However, some research indicates that women who are overweight or obese in the premenopausal period may have a reduced risk of developing breast cancer.[73, 74] Interestingly, two studies from India and Malaysia reported contradictory findings with high BMI being associated with a lower risk of breast cancer.[36, 46] It seems probable that the current BMI estimates were used, but the weight subsequently decreased. Studies in India, Thailand, and Vietnam have identified an association between BMI and an increased risk of breast cancer.[13,54,55] Our systematic review and meta-analysis confirmed that breast cancer in South and Southeast Asia is significantly correlated being overweight and obesity. Stratified analyses by sub-regions suggested no difference between them. The findings emphasize the need for targeted public health interventions to address obesity and promote healthy lifestyles in these regions.

The results of our study indicate a correlation between BMI and not only breast cancer but also other cancer sites. As with our present findings, a meta-analysis of studies conducted in high- and middle-income countries demonstrated that individuals with a higher BMI are at an elevated risk of developing colorectal cancer in comparison to those with a normal weight.[75] Additionally, a cohort study and a meta-analysis in an Asian country also identified a positive correlation between BMI and the risk of developing colorectal cancer incidence and mortality.[8,76] Another meta-analysis provided strong support for the association between excess body weight, overweight, and obesity and endometrial cancer risk.[77] Similar to our narrative findings, a meta-analysis result indicated that obesity was associated with the risk of gastric cancer.[78] A 2020 meta-analysis hypothesized that overweight might be a protective factor in gastric cancer risk in Asian adults.[79] The present study underscores a substantial evidence gap regarding the association between BMI and site-specific cancer risk in South and Southeast Asia. The majority of available studies focus on breast cancer, with limited data on other common cancers such as colorectal, prostate, and lung cancer. Most studies used a case–control design, with only a few being long-term cohort studies. Because of this, we cannot be sure about cause and effect, so the link between BMI and cancer risk should be interpreted with caution. It is imperative that future research prioritizes prospective studies with standardized BMI measurement, stratification by menopausal status, and evaluation of other risk modifiers such as diet, physical activity, and metabolic health.

To our best knowledge, this is the first comprehensive systematic review and meta-analysis on BMI to include multiple cancer sites from South and Southeast Asia. The main strength is that we included all types of observational studies, including case-control, cohort and cross-sectional studies. The large sample size provides a more precise result and a narrower confidence interval than obtained from previous meta-analyses. The study has a few limitations. While the search strategy included a comprehensive 20 countries from South and Southeast Asia, we only identified articles from 11 countries (Afghanistan, Bangladesh, India, Pakistan, Philippine, Singapore, Sri Lanka, Thailand, and Vietnam). Due to a lack of comparable data on multiple cancer sites, we only conducted the meta-analysis for breast cancer. We were not able to conduct a stratified analysis by pre- and post-menopausal women. Additionally, cancer incidence data are not available for all Asian countries due to limited high-quality cancer registries in the region.

CONCLUSION

In conclusion, being overweight or obese raises the risk of breast cancer and other cancers in South and Southeast Asia. This review provides a comprehensive synthesis of the available evidence, but the predominance of case-control studies limits causal inference. To improve the quality of the evidence base and clarify the relationship between BMI and cancer risk, future large-scale prospective cohort studies are needed in South and Southeast Asia. The implications of our results are profound, emphasizing the need for targeted public health interventions to address obesity and its related health risks. Strategies should include promoting healthy dietary practices, increasing physical activity, and implementing policies that foster environments conducive to healthy living. Furthermore, this review underscores the importance of culturally tailored cancer prevention programs that consider regional dietary habits, socioeconomic factors, and healthcare access. Further research is needed to explore the underlying mechanisms and develop region-specific guidelines.

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