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ORIGINAL ARTICLE

Prevalence and influencing factors of obesity in preschool children in Suzhou, China

Prevalencia y predictores de obesidad en niños preescolares de Suzhou, China

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ABSTRACT

Background. The study aims to assess the prevalence of obesity among preschool children in Suzhou, China, and analyze potential risk factors to the condition.

Methods. The study included preschool children aged 3-6 from various kindergartens in Suzhou. Height and weight measurements were used to determine obesity status, while parents completed questionnaires on relevant information. The Chi-square test was applied to compare obesity rates across groups, and stepwise logistic regression analysis identified associated risk factors for obesity.

Results. Eight hundred and forty-eight preschoolers participated. The overall obesity prevalence was 14.0%, with 4.0% categorized as moderately obese (and 7.5% as mildly obese. Boys had a higher obesity prevalence than girls (15.3% vs. 12.7%), and rural children higher than urban children (17.2% vs. 13.1%), although these differences were not statistically significant. Obesity was most prevalent among 3-year-olds (16.1%) and least prevalent among 6-year-olds (11.2%). Logistic regression identified age (boys: OR=0.30; 95%CI: 0.19-0.38, girls: OR=0.24; 95%CI: 0.17-0.36), height (boys: OR=1.21; 95%CI: 1.16-1.26, girls: OR=1.25; 95%CI: 1.18-1.38), and urban location (boys: OR=0.60; 95%CI: 0.34-0.86, girls: OR=0.48; 95%CI: 0.31-0.84) as significant independent predictors for obesity in preschool children in Suzhou, China.

Conclusions. The obesity rate among preschool children in Suzhou is 14.0%. The study highlights lower age, higher height, and rural location as predictor factors of obesity in both sex.

Keywords. Preschool Children. Obesity. Risk Factors. Kindergarten.

RESUMEN

Fundamento. El objetivo es evaluar la prevalencia de obesidad entre preescolares de Suzhou (China) y analizar su relación con diferentes factores.

Métodos. En el estudio participaron niños de 3 a 6 años de edad de varios jardines de infancia de Suzhou. Se midieron la altura y el peso para determinar el estado de obesidad, y los padres rellenaron cuestionarios para obtener información relevante sobre estilos de vida. Se compararon las tasas de obesidad mediante Chi-cuadrado y el análisis de regresión logística por pasos identificó los factores de riesgo asociados.

Resultados. Participaron 848 preescolares. La prevalencia global de obesidad fue del 14,0%: 4,0% de moderada y 7,5% leve. La prevalencia de obesidad fue mayor en niños (15,3% frente a 12,7%) y en zonas rurales (17,2% frente a 13,1%), aunque con diferencias estadísticamente no significativas. La obesidad fue más prevalente a los 3 años (16,1%) y menos prevalente a los 6 (11,2%). Tanto en niños como en niñas, la edad (OR=0,30; IC95%: 0,19-0,38 y OR=0,24; IC95%: 0,17-0,36), la altura (OR=1,21; IC95%: 1,16-1,26 y OR=1,25; IC95%: 1,18-1,38) y la zona urbana/rural (OR=0,60; IC95%: 0,34-0,86 y OR=0,48; IC95%: 0,31-0,84) resultaron predictores independientes de obesidad en preescolares de Suzhou, China.

Conclusiones. La tasa de obesidad entre preescolares de Suzhou es del 14,0%. Menor edad, mayor estatura y residir en zona rural fueron identificados como predictors independientes de obesidad en ambos sexos.

Palabras clave. Niños en edad preescolar. Obesidad. Factores de riesgo. Jardín de infancia.

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INTRODUCTION

The increasing prevalence of childhood obesity has become a global public health concern[1]. Childhood obesity poses significant risks, including impaired organ function and negative impact on mental and psychological well-being, while increasing the likelihood of adult cardiovascular diseases, such as obesity, hypertension, and hyperlipidemia[2-4]. Individuals born after the turn of the 21st century are experiencing obesity at younger ages, with greater severity during key developmental stages of childhood[5]. This issue has been further exacerbated by the COVID-19 pandemic, during which lockdowns led to reduce physical activity and increased sedentary behavior among children, contributing to the rise of childhood obesity[6,7].

Recent evidence indicates that the majority of overweight in obese children occurs before the age of five and tend to persist into later childhood[8]. Preschoolers who are already overweight are particularly susceptible to becoming obese before adolescence, underscoring the importance of early intervention[9,10].

Prevention of obesity is far more effective than treatment, and there is growing global recognition of the need for early prevention efforts[11]. The preschool years are considered a critical window for preventing obesity[12], as this period is essential for forming core beliefs, behaviors, and healthy habits – such as diet and physical activity – that play a key role in obesity prevention and management[13]. To develop effective prevention strategies, it is crucial to understand the factors influencing during early childhood.

In the United States, childhood obesity rates have tripled over the past decade, with over one quarter of children aged 2-5 years classified as overweight[14]. Similarly, China has seen a marked increase in childhood obesity, particularly in certain urban areas, where prevalence rates have risen by four – to six-fold[15-17]. In 2020, the prevalence of obesity among children aged 3 to 6 in Suzhou's Wujiang District was reported at 13.2%. Nonetheless, currently the status of childhood obesity in Suzhou remains limited.

This study aims to assess the current prevalence of obesity among preschoolers in both urban and rural areas of Suzhou, China, and to thoroughly examine the various factors influencing this condition.

METHODOLOGY

This cross-sectional study assessed the prevalence of obesity among preschool children aged 3 to 6 years in Suzhou, China. Data collection took place between March 1 and May 31, 2023.

Suzhou, located in Jiangsu Province, is a major city recognized for its cultural heritage and rapid economic development. It spans approximately 8,488 square kilometers and has a population exceeding 12 million. The city comprises both urban and rural areas – urban districts feature high population density and developed infrastructure, while rural regions are more agricultural and less densely populated.

The sample size (n=848) was calculated based on the estimated obesity prevalence among preschool children in Suzhou, with a 95% confidence level and a 5% margin of error. Participants were selected using a cluster sampling method from eight kindergartens across Suzhou: two in Gusu District, one in the Industrial Park District, one in town and one village kindergarten in Wujiang District, and three in Zhangjiagang City, one in town and two in villages.

Inclusion criteria were: children aged 3 to 6 years with typical cognitive development and without serious physical illnesses. Exclusion criteria included lack of parental informed consent, with secondary obesity, or incomplete data.

Prior to participation, written informed consent was obtained from parents. An *ad-hoc* questionnaire (Appendix I for English version, Supplementary material for Chinese version) was used to collect information about family background, parental knowledge of obesity, attitudes towards childhood obesity, and obesity-related behaviors in both parents and children. Questionnaires were completed by the children's parents.

The presence of obesity in children was defined as the dependent variable. All children had their height (in centimeters) and weight (in kilograms) measured. Obesity status (excluding secondary obesity) was determined using Chinese national standards for height and weight assessments in children aged 0-6. Children were classified as: mildly obese if their weight exceeded the reference weight by 20%-30% for their for sex and height, moderately obese if the excess was 30%-50%, and severely obese if their weight was over 50% above the reference value for the same sex and height[18].

The following were included as independent variables: birth weight (in grams), region (rural/urban), picky eating habits (yes/no), beverage consumption (volume and frequency of different beverages per month), food allergies (yes/no), feeding method (exclusive breastfeeding/mixed feeding/exclusive formula feeding), breastfeeding duration (in months), and physical activity time (total hours per month). Additionally, sex (male/female) and age (in years), were recorded.

Statistical analysis

Data collected through questionnaires and physical measurements were entered into the Epidate 3.02 database for processing. Quantitative variables are presented as mean and standard deviation (SD), while qualitative as frequencies and percentages. Differences in obesity rates across groups (e.g., by sex, age, and region) were assessed using the Chi-square test. To identify factors associated to obesity, variables with a p-value <0.01 in univariate analysis were entered in a multivariate logistic regression analysis using a stepwise method. Association is presented as odds ratio (OR) and its 95% confidence interval (95%CI). Statistical analyses were performed using the SPSS software version 18.0.

RESULTS

Participants

Of the initial 950 preschool children recruited, 102 were excluded due to parental refusal (n=50, 5.3%), incomplete data (n=40, 4.2%), or secondary obesity (n=12, 1.3%). The final sample included 848 children, resulting in a response rate of 89.3%. All participants underwent physical examination and their parents completed the questionnaires.

The sample consisted of 437 boys (51.5%) and 411 girls (48.5%). The distribution by age was as follows: 87 children (10.3%) were 3 years old, 192 (22.6%) were 4 years old, 354 (41.7%) were 5 years old, and 215 (25.4%) were 6 years old.

Obesity prevalence by sex and age

Among the 848 children, 119 were classified as obese, yielding an overall prevalence of 14.0%, gradually decreasing from mild to severe cases (Table 1). Although the obesity rate was slightly higher among boys compared to girls (15.3% vs. 12.7%), this difference was not statistically significant. Additionally, this distribution of obesity levels did not differ significantly between boys and girls.

Table 1. Prevalence of obesity among preschool children, overall and by sex

Gender	n (%)	Obesity rate	Degree of obesity n (%)		
		n (%)	Mild	Moderate	Severe
Boy	437 (51.5)	67 (15.3)	36 (8.2)	17 (3.9)	14 (3.2)
Girl	411 (48.5)	52 (12.7)	28 (6.8)	17 (4.1)	7 (1.7)
Total	848	119 (14.0)	64 (7.5)	34 (4.0)	21 (2.5)
p-value		0.53	0.28	0.75	0.12

Obesity detection rates varied across age groups, with the highest rate observed in 3-year-olds (16.1%) and the lowest in 6-year-olds (11.2%). However, no statistically significant differences were found. Boys exhibited higher prevalence of obesity compared to girls across all four age groups, although these differences were not statistically significant (Table 2).

Table 2. Obesity detection rates by age group and sex

Age Group	Global		Boys		Girls		p-value
	n (%)	Obesity Rate n (%)	n	Obesity Rate n (%)	n	Obesity Rate n (%)	
3	87 (10.3)	14 (16.1)	40	8 (20.0)	47	6 (12.8)	0.15
4	192 (22.6)	26 (13.5)	93	13 (14.0)	99	13 (13.1)	0.31
5	354 (41.7)	55 (15.5)	187	30 (16.0)	167	25 (15.0)	0.76
6	215 (25.4)	24 (11.2)	117	16 (13.7)	98	8 (8.2)	0.08

Obesity prevalence in urban and rural areas

Among the 186 rural children, the obesity detection rate was 17.2% (n = 32), compared to 13.1% (n = 87) among the 662 urban children. However, this difference was not statistically significant (p=0.350).

Factors influencing childhood obesity

In the univariate logistic regression analysis, age, height, birth weight, area of residence, and food allergies were significantly associated with childhood obesity (Table 3).

Table 3 Univariate logistic analysis of the influencing factors of childhood obesity

Factors	Boys OR (95%CI)	Girls OR (95%CI)	p
Age (years)	1.25 (1.08-1.67)	1.30 (1.12-1.72)	0.005
Height (cm)	1.50 (1.03-1.40)	1.55 (1.10-1.60)	0.015
Birth weight (kg)	0.78 (0.64-0.94)	0.82 (0.68-0.98)	0.021
Regions (rural vs urban)	2.00 (1.22-3.30)	1.95 (1.18-3.20)	0.008
Food allergy	1.85 (1.05-3.25)	1.75 (0.98-3.10)	0.045

OR: odds ratio; CI: confidence interval.

In the multivariate analysis, age, height, and area of residence remained significantly associated with obesity after adjusting for other variables (Table 4). Specifically, older age and urban residence were associated with lower odds of obesity, while greater height was associated with higher odds. Children living in urban areas had 40% lower odds of obesity for boys (OR=0.60) and 52% lower odds for girls (OR=0.48) compared to those living in rural areas. Each additional year of age reduced the odds of obesity by 70% in boys (OR=0.30) and 76% in girls (OR=0.24). Each additional centimeter in height increased the odds of obesity by 21% in boys (OR=1.21) and 25% in girls (OR=1.25). Although birth weight and food allergies were significant in the univariate analysis, they were not retained in the final multivariate model due to lack of statistical significance.

Table 4. Multivariate logistic regression analysis of factors influencing childhood obesity

Factor	Sex	OR (95%CI)	p-value
Age (years)	Boys	0.30 (0.19-0.38)	<0.01
	Girls	0.24 (0.17-0.36)	<0.01
Height (cm)	Boys	1.21 (1.16-1.26)	<0.01
	Girls	1.25 (1.18-1.38)	<0.01
Regions (Urban vs. Rural)	Boys	0.60 (0.34-0.86)	0.01
	Girls	0.48 (0.31-0.84)	0.02

OR: odds ratio; CI: confidence interval.

DISCUSSION

This study focused on the prevalence of obesity and its associated factors in kindergarten children (aged 3-6 years) across urban and rural areas of Suzhou City. The results indicate that the obesity rate among preschool children in Suzhou is 14.0%, higher than the 10.4% reported in the *Report on Nutrition and Chronic Diseases of Chinese Residents* (2020). This elevated prevalence highlights the urgent need to address childhood obesity in this region.

The obesity rate is higher in boys than in girls (15.3% vs 12.7%), consistent with findings from previous studies conducted in China and other regions[19-21]. This gender disparity may be

influenced by cultural preferences for a robust physique in boys, often leading to overfeeding and reduced physical activity[22-24]. Despite the concerning prevalence, most cases were classified as mild obesity, suggesting that early interventions could effectively mitigate this condition. This finding offers optimism that appropriate measures could substantially reduce the health impact of childhood obesity in Suzhou.

Obesity detection rates vary across age groups, with the highest rate among 3-year-olds and the lowest among 6-year-olds. These differences may reflect the gradual increase in both the range and intensity of physical activities as children grow older, supported by studies showing that older children participate in more structured physical activities[12]. This result is confirmed by the decrease in the prevalence of obesity in children between 3 and 6 years. The multivariate logistic model confirmed this trend, showing that with each additional year, the odds of obesity decreases by 73% in boys and 75% in girls.

These results differ from those reported by Ye Hu et al.[25] in 2022, who found that the prevalence of obesity among children aged 3-6 years increased with age in another Chinese city, Hangzhou. This discrepancy may be attributed to regional variations in lifestyle factors or dietary habits.

As height increased, the risk of obesity rises by approximately 1.21 times in boys (OR=1.21) and 1.25 times in girls (OR=1.25). This positive association may reflect the dual role of growth and appetite in young children, suggesting that those who grow faster and have a stronger appetite may be more susceptible to obesogenic environments[26]. This aligns with previous studies indicating that rapid height growth during early childhood could be a risk factor for obesity, potentially due to increased caloric intake relative to energy expenditure[27,28].

Although birth weight showed an association with obesity risk in the univariate analysis, it was not retained in the final multivariate model, as its influence was not statistically significant after adjusting for other variables. This suggests that the association observed initially may have been confounded by other factors. However, the initial finding highlights the importance of birth weight in studies on childhood obesity. Kumar et al.[29] reported that high birth weight (>3,500 g) increases the risk of childhood obesity, while normal birth weight reduces the risk by up to five times. In our study, birth weight was treated as a continuous variable (measured in grams), differing from studies that categorized it (e.g., high vs. normal). These methodological differences, along with variations in sample characteristics, may partly explain discrepancies across studies. Further research is needed to clarify the role of birth weight in childhood obesity, accounting for potential confounders and methodological variations.

A distinctive aspect of this study is the exploration of the disparities in obesity prevalence and dietary behaviors between urban and rural children. The higher obesity prevalence observed in rural children (17.2%) compared to urban children (13.1%) contrasts with findings from other regions[30,31]. This disparity may stem from limited access to nutrition education, fewer healthy food options, and reduced availability of structured physical activity programs in rural areas[32,33]. Nutritional education activities organized in rural schools and communities aim to raise awareness among parents and children about healthy eating habits[34,35]. Additionally, encouraging schools and communities to host diverse sports activities and competitions can effectively foster children's interest in physical activity, contributing to the prevention of childhood obesity[36].

There are several limitations to this study. The use of a cluster sampling method may have introduced selection bias, as the selected kindergartens might not fully capture the socioeconomic diversity of Suzhou. Factors such as family income, parental education level, and regional disparities were not explicitly controlled during the sampling process, potentially limiting the generalizability of the findings. Moreover, some variables were self-reported by parents; for instance, picky eating habits were based on parental responses, which may introduce subjectivity and recall bias. Such biases could distort the relationships between these variables and childhood obesity, thereby affecting the reliability of the conclusions.

In conclusion, this study highlights a concerning obesity prevalence of 14.0% among preschool children aged 3-6 years in Suzhou, China, with higher rates observed among boys and in rural areas. Key factors influencing obesity include age, height, and regional differences, with older children and those living in urban areas showing lower risks of obesity.

These findings underscore the urgent need for targeted interventions, particularly in rural areas,

to address dietary habits, physical activity, and nutrition education. Early prevention strategies are critical to mitigate the long-term health impacts of childhood obesity. Future research should further investigate the role of birth weight and other potential risk factors to support the development of more comprehensive obesity prevention programs.

Conflicts of interests

The authors declare that there is no conflict of interest to disclose.

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Authors' contributions

Study conception and design: YZ, XZ;
Data collection: XW, ZW;
Analysis and interpretation of results: YW, HD;
Draft manuscript preparation: YZ.

All authors reviewed the results and approved the final version of the article.

Data availability

They are available upon request to the corresponding author.

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APPENDIX I.
Nutritional status of children aged 3 ~ 6 years in Suzhou (Gusu district, industrial park, Wujiang city, Zhangjiagang city)

Children's individual code _____ Code class _____ Investigator _____ Survey date _____

Parents' names		**Relationships with children**		**Cell phones**	
Address				**Home number**	

THE FIRST PART, GENERAL (CHILDREN PART)

Please fill in the blanks below or circle the appropriate fields.

1.1 Name: _____

1.2 Date of birth:

1.3 Gender: ① male ② female

1.4 Ethnicity: _____

1.5 Birth weight: _____ kg; present weigh: _____ cm; present height: _____ cm.

1.6 Do you think your child is Picky: ① yes ② No (jump to 1.11)

1.7 Do you think your child is picky at the age of _____ ?

1.8 Which of the following foods your child doesn't like (optional) :
① milk and its products ② beans and its products ③ cereals and its products ④ vegetables ⑤ fruits ⑥ meat ⑦ sweets ⑧ eggs ⑨ others: _____

1.9 How many times have you given your child these foods and decided that he or she shouldn't eat them?
① 1 times ② 2 times ③ 3 times ④ 4 times ⑤ more than 10 times

1.10 Which of the following foods your child loves to eat (optional)
① milk and its products ② beans and its products ③ cereals and its products ④ vegetables ⑤ fruits ⑥ meat ⑦ sweets ⑧ eggs ⑨ others: _____

1.11 You think your child's weight is:
① fat ② too fat ③ standard (jump to 1.12) ④ thin ⑤ too thin
If you think your child is overweight/underweight, will you help your child improve his weight? ① is ② no

1.12 What do you think of your child's current nutritional status?
① good, balanced (skip to 1.13) ② not so good
Please circle the areas where your child's diet is not as good (optional) :

Vegetable	fruit	meat/egg	milk and dairy produc	snack
① less than ② excess	① less than ② excess	① less than ② excess	① less than ② excess	① less than ② excess

1.13 Is your child allergic to food?

① yes ② no ③ not clear.
If allergic, the allergenic food is (optional):
① milk ② eggs ③ peanuts ④ soybeans ⑤ fish ⑥ shrimp ⑦ wheat ⑧ Oranges ⑨ others: _____

1.14 Does the child's father or mother have a history of food allergies?

① yes ② no ③ not clear
If allergic, the allergenic food is (optional):
① milk ② eggs ③ peanuts ④ soybeans ⑤ fish ⑥ shrimp ⑦ wheat ⑧ Oranges ⑨ others: _____

1.15 Does your child have any food intolerance (e.g. diarrhoea or vomiting) ?

① yes ② no ③ not clear.

1.16 How is your child fed for the first 4 months after birth?

① exclusive breast feeding ② exclusive breast feeding, mixed formula feeding ③ exclusive formula feeding.

1.17 Please circle the duration of exclusive breastfeeding after the birth of the child, e.g. after 4 months of exclusive breastfeeding to start adding complementary foods, circle 4.

0 1 2 3 4 5 6 7 8 9 10 11 12

THE SECOND PART, THE CONSUMPTION OF BEVERAGES INVESTIGATION

We would like to know if your child has had any of the following drinks in the past month and estimate how often they have been consumed Number (including beverages consumed in kindergarten). First answer yes or No? Do you drink daily, weekly or monthly? How much do you drink at the end? Please leave no space.
Example: if your child drank a can of coke and sprite once a day for the last month (about 330 ml); Fill in the form as follows: Circle each day, fill in 2, and fill in 330.

7	Carbonated drinks (cola, sprite, etc.)	0. Not eating	1.Every six months	2. Monthly	3. per week.	4.per day	2	330

	Name of beverage	**Frequency of drinking in the past month** **0. Not Eating** **1. Every six months** **2. Monthly** **3. Per week** **4. Every day**					**Times**	**Volume drunk every time (mL)**
1	Whole fat liquid milk	0	1	2	3	4		
2	Low-fat, skim liquid milk	0	1	2	3	4		
3	Yogurt	0	1	2	3	4		
4	Lactobacillus drinks (joy, etc.)	0	1	2	3	4		
5	Configuration milk beverage (nutrition fast line, unified milk tea, etc.)	0	1	2	3	4		
6	Plant protein drink (Vivi soy milk, coconut juice, almond juice, etc.)	0	1	2	3	4		
7	Carbonated drinks (cola, sprite, etc.)	0	1	2	3	4		
8	Fresh fruit and vegetable juices	0	1	2	3	4		
9	Fruit and vegetable juice drinks (apple juice, orange juice)	0	1	2	3	4		
10	Coffee drinks	0	1	2	3	4		
11	Tea drinks (such as green tea, black tea, Jasmine tea)	0	1	2	3	4		
12	Teas	0	1	2	3	4		
13	Solid drinks (such as Nescafe, Orange C, bagged coffee)	0	1	2	3	4		
14	Sports drinks (pulse, farmer screams, etc.)	0	1	2	3	4		
15	Bottled water (mineral water, purified water)	0	1	2	3	4		

THE THIRD PART, PHYSICAL ACTIVITY RECORDS (FAMILY PART)

Please record your child's physical activity before and after school today (not including physical activity in kindergarten), Activity refers to physical activity that allows children to exercise their muscles. Note: the last column of"Metabolic equivalents" is not recorded, only the activity and duration as follows:

Activity Content P6	activity site P7 1. Outdoors 2. Indoors	Duration (min) P8	Metabolic equivalent P9
Dance	2	40 minutes	not fill

Activity Content P6	activity site P7 1. Outdoors 2. Indoors	Duration (min) P8	Metabolic equivalent P9
Skip the rubber band			not fill
Running			not fill
Cycling			not fill
Swimming			not fill
Walk			not fill
Skip rope			not fill
Dance blanket			not fill
Play football			not fill
Hit the ball			not fill
Roller Derby			not fill
Hula hoops			not fill
Skateboard			not fill
Take execise			not fill
Dance			not fill
Hide and seek			not fill
Badminton			not fill
Ping-pong			not fill
Sit-ups			not fill
Sweep the floor			not fill
Other:			not fill
Other:			not fill
Other:			not fill
Other:			not fill
Other:			not fill

THE FOURTH PART, PHYSICAL ACTIVITY RECORDS (KINDERGARTEN PART)

Please record your activities in the kindergarten in the past 24 hours. For example:

Age P1	Activity Log				
	Project P2	Property 1. Individuals 2. group	Venues P4 1. Outdoors 2. Indoors	Duration per session (minutes) P5	Metabolic equivalent P6
②4~ (secondary)	Take execise	1	1	10 minutes	not fill

Age P1	Activity Log				
	Project P2	Property P3 1. Individuals 2. group	Venues P4 1. Outdoors 2. Indoors	Duration per session (minutes) P5	Metabolic equivalent P6
① 3~ 4(small class) ② 4~ 5(secondary) ③ 5~6 (Tai Pan)					not fill
					not fill
					not fill
					not fill
					not fill
					not fill
					not fill
					not fill
					not fill
					not fill
					not fill
					not fill
					not fill
					not fill
					not fill
					not fill
					not fill
					not fill