ORIGINAL ARTICLE

Early-life exposures and childhood obesity and overweight in Türkiye

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Abstract

Objective: Childhood overweight and obesity have seen a dramatic increase in Turkey and other middle-income countries over the last decades. By using anthropometric data, this study examines the influence of early-life exposures during pregnancy and infancy on young children's risk of developing overweight and obesity.

Methods: Study uses five cross-sections of Demographic and Health Surveys (DHS) conducted in Turkey between 1993 and 2013. A total of 9719 children between the ages of 2 and 5 are used to estimate the prevalence rates of obesity and overweight. In addition, a logistic regression model is applied to 5013 children in order to assess the main determinants of obesity and overweight.

Results: There is a notable increase in the prevalence rates of obesity and overweight in children between 1993 and 2013, the peak prevalence has been reached in 2008. Results of the logistic regression reveal that early-life factors; maternal obesity and high birth weight are significantly associated with the risk of obesity and overweight in young children. Among socio-economic variables, living both in the richest and poorer households are positively and significantly associated with the risk of obesity and overweight.

Conclusion: Public health efforts to prevent childhood obesity and overweight would be incomplete without considerations of maternal health and nutrition during pregnancy.

Keywords: Childhood Obesity, Childhood Overweight, Fetal Programming, Breastfeeding, Chronic Diseases

INTRODUCTION

Childhood overweight and obesity constitute a serious health problem. Excess body fat have immediate consequences on children's physical health, including insulin resistance and metabolic syndrome, Type 2 diabetes mellitus, high blood pressure and raised markers of inflammation.[1] Discrimination, low self-esteem, anxiety and depression are commonly experienced psycho-social consequences.[2] From a population health perspective, however, the real impact of rising overweight and obesity prevalence rates manifests only after a time lag, when children reach adulthood and face elevated risks of premature illness and death: Studies have repeatedly shown that children with excess weight are more prone to staying overweight and obese into adulthood,[3] and more likely to develop serious chronic diseases such as hypertension, diabetes, heart disease and some types of cancer.[4]

Previous studies have drawn attention to a dramatic increase in childhood overweight and obesity in developing countries, [1,3,20,21] and in Turkey.[22] Recent data published by UNICEF, WHO and World Bank show that the percentage of children under the age of 5 affected by excess body weight increased from 6.7 to 8.8 in upper-middle income countries between 2000 and 2020. [23] The increase in percentage of young children with excess body weight was much larger in Turkey during the same period and in fact it was by more than twofold: The prevalence rate that was equal to 3.8 in 1998 reached 11.1 in 2013, albeit decreasing to 8.1 in 2018. [24]

This study approaches the problem of childhood overweight and obesity from the perspective of the Developmental Origins of Health and Disease (DOHaD) theory. Recent years have seen an explosive growth in DOHaD, a field of research that is best, but only incompletely, associated with the work of Barker and his group.[25] The main conjectures put forward in this literature revolve around the idea that early life environment can impact the risk of chronic diseases from childhood to adulthood. Thus, child growth problems manifested as short gestation, low birthweight, growth-faltering, stunting, and overweight and obesity, are in fact imprints of nutrition and other environmental factors during prenatal and postnatal development, which have influenced developmental plasticity and this way altered susceptibility to adult chronic disease.

With regard to the risk of obesity, previous studies explored a number of prenatal exposures that influence the satiety, food preference, muscle mass and insulin resistance in the offspring through intrauterine programming.[26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36] For instance, maternal undernutrition during pregnancy is linked to the fetal programming of obesity: When fetal nutritional insufficiency triggers a set of anatomical, hormonal and physiological changes to enhance survival in resource-poor environments, and when these early nutritional deficits and their developmental adaptations are followed by excesses in the postnatal environment with plentiful resources, they do increase the risk of developing obesity. [31]

Second, like fetal undernutrition, fetal overnutrition also contributes to the intrauterine programming of adiposity: Evidence shows that maternal diabetes and gestational diabetes expose the fetus to an excess of nutrients, an important risk factor

for later obesity.[27, 33] In addition, studies have shown that the newborns of obese mothers have more body fat and there is a link between higher maternal BMI (or maternal obesity during pregnancy) and a greater risk of overweight and obesity in children, which suggest that maternal obesity programs obesity in children through an effect on fetal nutrition.[36,37,38]

In the post-natal environment, it is suggested that lack of breastfeeding increases the risk of obesity for at least two reasons: First, infants who are fed formula have a higher energy intake and greater early gain in body weight than breast-fed infants, increasing the risk of obesity in early childhood.[39, 40] Second, breastfeeding is well known to contribute to healthy development and a reduced risk of stunting, not raising the weight to height proportions in children. Other early life exposures that are known to lead to programming of adiposity include maternal smoking and alcohol consumption, maternal stress and exposure to environmental pollutants or chemical toxins during pregnancy. [27, 28,29,34]

This study examines the role of some of the key maternal exposures during pregnancy and infancy in determining young children's risk of obesity and overweight. These exposures are maternal obesity, birth weight, and breastfeeding during infancy. Using five cross-sections of Demographic and Health Surveys (DHS) conducted in Turkey between 1993 and 2013, the paper first decribes the prevalence rates of excess weight in children between the ages of 2 and 5. Having established an increasing trend in both childhood overweight and obesity , logistic regression models are employed to assess the relative significance

of early-life exposures and socio-economic factors, such as maternal education, urban or rural place of residence, or household wealth, as the determinants of obesity and overweight. Results reveal that maternal obesity, high birth weight, and duration of breastfeeding, as well as household wealth, geographical region and place of residence, are significant determinants of childhood overweight and obesity. In the final section, the paper discusses the implications of these findings for public health efforts to combat overweight and obesity.

METHODS

This study uses five cross-sections of DHS conducted in Turkey between 1993 and 2013. DHS are nationally representative surveys of on fertility, family planning, and maternal and child health. Each cross-sectional sample consists of ever-married women in their reproductive ages, that is available with social and economic background variables at the individual and household level. Even though each ever married woman aged 15-49 reports data about all her live-born births starting from the first to the most recent birth, detailed pregnancy, birth and postnatal histories are only available for children born in the last 5 years before the time of the survey. These histories include the antenatal and delivery care information and the problems encountered in accessing health care, child size and weight at birth, vaccination reports based on the national schedule of vaccines, and breastfeeding information. DHS Data additionally include current anthropometric data for mothers and children, making it ideal to study the influence of maternal BMI and other conditions, exposures and environments on children's risk of overweight and obesity.

The main variables of interest from DHS are height and weight for both mothers and children, that enable us to calculate Body Mass Index (BMI) scores. This information is available in the Individual Recode file of mothers, which is reformatted from wide to long format so that each observation represents a child. Those children for whom current weight and height information is unavailable are excluded from analysis, and only children between the ages of 2 and 5 are kept. After these exclusions, the sample consists of 6285 mothers and 9719 children born to these mothers. The BMI scores calculated for children (in kg/m^2) are then adjusted for age and sex, to construct three BMI categories (normal weight, overweight and obese). In the last step, the categories of obesity and overweight are collapsed to create a binary variable that indicates whether a child is obese or overweight, or not. In the case of mothers, maternal obesity is defined as a BMI $\geq$ 30kg/m^2, and similarly constructed as a binary measure.

The variable 'birthweight' is constructed from the reports of mothers on the birth weight of their children in grams. It is a categorical variable that measures whether a given child is born with 'Low birth weight', 'Normal birth weight' or 'High birth weight'. If birth weight is less than 2500 grams, it is considered 'Low birth weight'. If birth weight is equal to or more than 2500 grams and less than 4000 grams, it is considered "Normal birth weight". If a child is born with a birth weight that is equal to or more than 4000 grams, it indicates a "High birth weight". Breastfeeding is represented by a continuous variable that indicates the duration of breastfeeding in months.

Other independent variables include maternal age and education, urban - rural type of residence, geographical region and wealth index. Mothers' education is constructed as a categorical variable that differentiates between women who have no education, women with primary education, and women with secondary education or higher. The place of residence is a binary variable taking a positive value if the residence is urban. Household wealth differentiates between five categories of household economic status: "Poorest households", "Poorer Households", "Middle-wealth households", "Richer households" and "Richest households". Finally, control variables for the age, sex, birth year, and birth order of children are added to the estimation.

Logistic regression model is used to estimate the main determinants of child overweight and obesity. All analyses are performed using the software STATA 13. Type I error is set to 0.05.

RESULTS

Estimations of childhood overweight and obesity prevalence rates reveal that both increased notably between 1993 and 2013, even though the relative increase in childhood obesity is larger than the increase in childhood overweight: Childhood obesity prevalence rate increased from 3.1 percent in 1993 to 4.5 percent in 2013, and childhood overweight prevalence rate increased from 9.8 percent in 1993 to 10.8 in 2013. If one collapses the two categories of childhood overweight and obesity together, these numbers suggest that the total prevalence rate of excess body weight in young children increased from 12.9 percent in 1993 to 15.3 percent in 2013. In addition, the peak prevalence of obesity and overweight was witnessed in the year 2008,

reaching 20.5 percent, and indicating that more than 1/5 of children were either obese or overweight at that time.
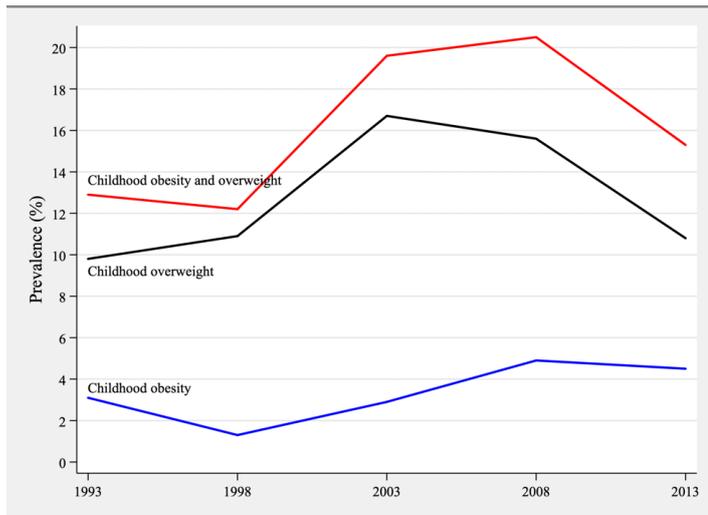

Figure 1. Prevalence rates of childhood overweight and obesity in Turkey between 1993 and 2013.

Notes:

i. Prevalence rates are calculated with Turkey DHS data, 1993, 1998, 2003, 2008 and 2013. ii. DHS sample weights are used in the calculation of prevalence rates.

Results of the logistic regression model suggest that there are several signficant determinants of excess body weight in children. For children of obese mothers, the odds of obesity and overweight are 1.57 times higher than for children of non-obese mothers (95% CI: 1.33-1.86). In addition to maternal obesity, birthweight is another significant predictor of obesity and overweight: The odds for children born with high birth weight is 1.49 times higher than for children born with normal birthweight (95% CI: 1.33-1.86). Finally, one month increase in the duration of breastfeeding decreases the likelihood of childhood overweight and obesity by 1 percent.

Among socio-economic variables, two categories of household wealth are significantly and positively associated with the risk of childhood overweight and obesity: For children in poorer households and children in the richest households, the odds of obesity and overweight are 1.34 times (95% CI: 1.06-1.69) and 1.38 times (95% CI: 1.06-1.78) greater than for children in middle-wealth households, respectively. Two geographical regions, and urban areas, are significantly and negatively associated with the risk of obesity and overweight: For children living in the southern and eastern regions, the odds are 0.60 times (95% CI: 0.47-0.78) and 0.76 times (95% CI: 0.61-0.95) lower than the western region, respectively. For children living in urban areas, the odds of obesity and overweight is 0.80 times lower than for children living in rural areas (95% CI: 0.65-0.97).

Among control variables, child's age, sex and birth year are significantly related to the risk of obesity and overweight. For female children, the odds of obesity and overweight is 1.41 times greater than for male children (95% CI: 1.21-1.64). The odds of obesity and overweight is 0.99 times lower for one month increase in age (95% CI: .98-1.00). Lastly, the odds of obesity and overweight is 1.03 times greater for one year increase in the year of birth (95% CI: 1.01-1.04).

Table 1. Descriptive statistics for the analysis of childhood overweight and obesity (DHS 1993-2013)

		1993		1998		2003		2008		2013	
Child variables		%	n	%	n	%	n	%	n	%	n
Childhood obesity	Obese children	3.0	55	1.4	23	3.3	83	4.8	80	3.4	71
Childhood overweight	Overweight children	9.7	180	10.1	165	17.7	444	15.4	259	9.8	203
Total			1847		1624		2506		1680		2062
	Low birth weight	N/A	N/A	12.8	127	11.7	182	12.3	157	12.0	229
Birthweight	Normal birth weight	N/A	N/A	68.8	683	75.0	1168	75.2	959	78.6	1502
	High birth weight	N/A	N/A	18.4	183	13.3	208	12.4	158	9.4	179
Total			-		993		1558		1274		1910
Duration of breastfeeding (months)	Mean	12.1		12.2		12.9		14.5		16.8	
	SD	9.1		9.2		9.2		9.3		10.0	
Total		1846		1616		2496		1676		1415	
		%	n	%	n	%	n	%	n	%	n
	1	30.4	561	32.9	535	30.6	767	31.2	524	34.5	712
Birth order	2	27.0	498	27.0	439	26.0	651	29.9	502	32.3	666
	3+	42.7	788	40.0	650	43.4	1088	38.9	654	33.2	684
Total			1847		1624		2506		1680		2062
Child sex	Female	49.2	909	47.0	763	48.8	1222	48.4	813	47.2	973
Total			1847		1624		2506		1680		2062
Child age (months)	Mean	41.7		42.0		41.8		41.7		41.9	
	SD	10.2		10.3		10.3		10.5		10.4	
Total		1847		1624		2506		1680		2062	
Birth year	Min	1988		1993		1999		2003		2008	
	Max	1991		1996		2002		2006		2011	
Total		1847		1624		2506		1680		2062	
Maternal and SES variables		%	n	%	n	%	n	%	n	%	n
Maternal obesity	Obese mothers	23.0	267	21.0	212	27.6	434	25.9	290	28.8	366
Total			1159		1007		1574		1120		1269
Urban or rural place of residence	Urban	65.6	763	69.6	705	73.3	1157	72.9	825	73.8	1032
Total			1163		1013		1579		1132		1398
	West	26.0	303	23.4	237	26.0	410	21.5	243	23.7	332
	South	21.3	248	20.1	204	13.5	214	16.3	185	13.9	194
Geographical region	Central	21.0	244	19.5	198	18.0	284	19.1	216	18.7	262
	North	15.3	178	13.0	132	9.2	146	9.5	108	14.4	202
	East	16.3	190	23.9	242	33.2	525	33.6	380	29.2	408
Total			1163		1013		1579		1132		1398
	Poorest households	16.7	194	18.1	183	19.2	303	24.3	275	24.3	340
	Poorer households	18.4	214	18.6	188	21.1	334	24.7	280	23.1	323
Wealth index	Middle-wealth households	22.4	261	23.8	241	18.7	295	20.2	229	20.6	288
	Richer households	22.0	256	21.4	217	22.0	347	17.7	200	17.2	240
	Richest households	20.5	238	18.2	184	19.0	300	13.1	148	14.8	207
Total			1163		1013		1579		1132		1398
	No education	23.6	274	21.4	217	18.6	293	16.6	188	12.3	172
Maternal education	Primary education	56.1	653	54.5	552	54.2	856	54.3	615	44.2	618
	Secondary education and Higher	20.3	236	24.1	244	27.2	430	29.1	329	43.5	608
Total			1163		1013		1579		1132		1398
Maternal age	Mean	29.2		29.5		30.1		30.4		31.3	
	SD	5.8		5.9		5.8		5.9		5.6	
Total		1163		1013		1579		1132		1398	

Table 2. Results of the Logistic Regression Predicting Childhood Obesity and Overweight in Turkey (1998-2013)

	Dependent Variable	Childhood Obesity and Overweight						
	Number of Observations	5013						
	LR chi2(18)	118.9						
	Prob>chi2	0.000						
	Preudo R2	0.03						
		Coefficient	S.E	Odds Ratio	[95% Conf. Interval]		z	*P-value*
Maternal obesity		0.45	0.09	1.57	1.33	1.86	5.2	*P < .001*
Birthweight	Low birth weight	-0.14	0.13	0.87	0.68	1.12	-1.1	*P = .28*
	Normal birth weight	-	-	-	-	-	-	-
	High birth weight	0.40	0.11	1.49	1.20	1.84	3.7	*P < .001*
Duration of breastfeeding (in months)		-0.01	0.00	0.99	0.98	1.00	-2.6	*P = .009*
Maternal age		0.01	0.01	1.01	0.99	1.02	0.8	*P = .40*
Maternal education	No education	0.19	0.14	1.21	0.92	1.59	1.4	*P = .17*
	Primary education (Omitted)	-	-	-	-	-	-	-
	Secondary education and Higher	0.08	0.10	1.08	0.89	1.30	0.8	*P = .42*
Place of residence = Urban		-0.23	0.10	0.80	0.65	0.97	-2.3	*P = .02*
Geographical region	West (Omitted)	-	-	-	-	-	-	-
	South	-0.51	0.13	0.60	0.47	0.78	-3.9	*P < .001*
	Central	-0.03	0.11	0.97	0.78	1.20	-0.3	*P = .76*
	North	-0.09	0.13	0.92	0.72	1.17	-0.7	*P = .49*
	East	-0.28	0.11	0.76	0.61	0.95	-2.4	*P = .02*
Wealth index	Poorest households	0.06	0.14	1.06	0.80	1.40	0.4	*P = .68*
	Poorer households	0.29	0.12	1.34	1.06	1.69	2.4	*P = .01*
	Middle-wealth Households	-	-	-	-	-	-	-
	Richer Households	0.21	0.12	1.23	0.97	1.56	1.7	*P = .09*
	Richest Households	0.32	0.13	1.38	1.06	1.78	2.4	*P = .01*
Child age (in months)		-0.01	0.00	0.99	0.98	1.00	-2.3	*P = .02*
Child sex = Female		0.34	0.08	1.41	1.21	1.64	4.5	*P < .001*
Birth order	1 (Omitted)	-	-	-	-	-	-	-
	2	0.01	0.10	1.01	0.84	1.22	0.2	*P = .88*
	3+	-0.14	0.12	0.87	0.69	1.10	-1.2	*P = .24*
Birth year		0.03	0.01	1.03	1.01	1.04	3.2	*P = .001*
Constant		-54.29	15.80	-	-	-	-	*P = .001*

DISCUSSION

Results presented in the previous section demonstrate the role of prenatal and postnatal exposures on the risk of childhood overweight and obesity, and thus identify intergenerational pathways of the risk of obesity and related chronic diseases. Findings support the arguments of the DOHaD theory with one exception: Fetal undernutrition (indicated by 'low birth weight' in estimation) does not increase the likelihood of obesity and overweight. On the other hand, other early-life factors maternal obesity and excess weight gain during pregnancy (indicated by 'high birth weight') are significant and strong predictors of childhood overweight and obesity. The protective effect of breastfeeding against the risk of obesity and overweight is statistically meaningful but weak in comparison to magnitude of other early-life effects. Given that mixed feeding is a common problematic practice in Turkey, we would expect the effect of this variable to be greater if it measured the duration of 'exclusive breastfeeding' instead.

From a public health perspective, these findings suggest that maternal health and nutrition during peri-conceptional and pregnancy periods, and fetal nutrition during pregnancy, should be incorporated into future strategies to prevent obesity and overweight in children. They show that it will not suffice to exclusively focus on childhood environments and patterns of unhealthy diet and low physical activity in the fight against obesity as without promotion of good maternal health and nutrition before and during pregnancy, health risks from obesity and associated chronic diseases cannot be averted to a meaningful extent.

The results of logistic regression did not only show that maternal obesity and high birth weight are significant predictors of childhood overweight and obesity, but that they are as important as some of the key socio-economic determinants of child health, such as household wealth, the place of residence and geographical region. It is also important to note that even though maternal education was not found to be significantly associated with the risk of obesity and overweight in children, the most significant early-life exposure in the model, maternal obesity, has an education gradient. In the peak prevalence year of 2008, for example, the prevalence of obesity among mothers who have at least a secondary education is 13.8 percent, whereas the prevalence is in the range of 26.1-31.3 percent in lower education categories. Similarly, the proportion of children who were born with excess weight (with a birth weight that is equal to or more than 4000 grams) is the highest among women with no education at 27.3 percent in 2008. This proportion is in the range 8.3-9.8 percent in higher education categories. Thus, public health efforts have more to gain if they prioritize low-educated mothers and their children.

Limitations of Research

Maternal obesity, high birth weight, and infant breastfeeding are not the only early life exposures that might increase children's risk of overweight and obesity. There are other factors identified by DOHaD that might increase this risk, including gestational diabetes, tobacco use and exposure to harmful toxins during pregnancy.[27,33,36,37,38] Children born after a gestational diabetes mellitus-affected pregnancy, for instance, are more likely to have excess weight suggesting

that fetal exposure to hyperglycemia might also be responsible for increased adiposity in children. Unfortunately, these early exposures are not available as DHS measures during the time window of this study and therefore could not be integrated into analyses.

Another major limitation is our inability to directly measure the immediate environmental factors of childhood overweight and obesity, which specifically refer to daily nutritional energy intake and levels of physical activity. These are the most important obesogenic factors in modern human environment characterized by unhealthy dietary behaviors and physical inactivity, which undoubtly contributes to excess weight gains during the very early years of life.[18] DHS data do not have this information for 2-5 years old. Despite this limitation, however, socio-economic indicators in the analyses such as maternal education and household income can be viewed as strong correlates of nutritional quality and physical exercise: Children of educated mothers and children of high-income households have better diet and lifestyles, whereas children of uneducated mothers who live in poor households are more likely to suffer from unhealthy dietary patterns and low levels of physical activity.

A final limitation concerns our inability to measure *exclusive breastfeeding* during infancy. DHS has information to distinguish exclusive breastfeeding from mixed feeding (consuming plain water, non-milk liquids, other milk, and solid or semi-solid foods in addition to breastfeeding), however, it is available only for the youngest children under 2 years of age for the time period 24 hours before the survey. Therefore, if mixed feeding is a common practice in Turkey and

associated with an increased risk of obesity and overweight in children, then the variable "duration of breastfeeding" in this analysis does not adequately exclude the risk.

Despite these limitations, the study has important policy implications for Turkey and other developing countries, where nutritional deficits that continue to contribute to most of the growth and development problems in children have been in fact a chronic population problem spanning over generations. The emphasis of this study on early-life exposures does not contradict with current public health efforts and their serious dietary challenges but imply that we can expect only limited success if we ignore these factors.

CONCLUSION

There are many factors behind the global rise of obesity and overweight in children, but Turkey has been disproportionately affected by this trend and displayed higher prevalence rates than most other developing countries during the last decades. This study was theoretically built on the concepts and mechanisms identified by DOHaD researchers on how early life exposures in utero and during infancy shape the obesity and overweight risk in young children. According to this theory, obesity evolves as an adjustment to immediate or predicted environmental threats, affects early physical growth and development, and ultimately generates excess risk of adult chronic conditions.

This study used logistic regression modeling in order to capture the most important determinants of child obesity and overweight in Turkey with DHS data. The independent variables consisted of well-established socio-economic determinants of child health,

such as maternal education, urban or rural place of residence, geographical region, and household wealth, in addition to the indicators of early-life exposures in the prenatal and postnatal environments. The results suggest strong evidence to support a role for early-life exposures in the development of obesity and overweight risk in children, in addition to the role of socio-economic variables: Maternal obesity and high birth weight significantly increase the risk of excess body weight in young children, and breastfeeding modestly protects against the risk of obesity and overweight. Household wealth status, type of residence and geographical region are significantly associated with the risk of obesity and overweight.

These findings have several important implications for public health efforts that target obesity. In the first place, they warn against the intergenerational (mother-offspring) pathways of obesity risk in developing countries, where larger numbers of women malnourished as children and now at an increased risk of being obese experience pregnancy conditions that expedite the onset of obesity in the offspring to younger and younger ages. Secondly and more specifically, they stress the importance of maternal health and nutrition in the periconceptional and pregnancy periods. An obvious goal is encouraging women to attain a healthy weight before conception, while another is avoiding excess weight gain during pregnancy in order to prevent high birth weight. Thirdly, they reassert the importance of socio-economic conditions as significant determinants of child health, demonstrated in this study with an analysis of obesity and overweight.

ACKNOWLEDGEMENT

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