Self-reported general health and Body Mass Index: a U-shaped relationship?

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Abstract

Objectives: A sizable literature demonstrates an increased likelihood of self-reported poor health with increasing Body Mass Index (BMI). A U-shaped relationship between BMI and health is evident in research but we do not believe the health of people who are underweight gets the attention it deserves. We investigate the relationship between BMI categories and poor general health including those persons who are underweight.

Study design: Cross-sectional study

Methods: Data were obtained from the Health Survey for England pooled for 2006-08 to provide a sample of 26 596 adults aged 16-74 in a series of binary logistic regression models to determine the likelihood of people reporting their general health as being poor.

Results: Controlling for individual level demographic, socio-economic and health-related behaviour variables and area deprivation we find a clear U-shaped relationship between BMI and health.

Conclusions: The literature largely focuses on the relationship between obesity and health and this is understandable given that many more persons are obese than are underweight. A person who is underweight is about as likely to report poor general health as a person who is obese.

Keywords: Body Mass Index; underweight; obesity; self-reported health; Health Survey for England

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Introduction

Body Mass Index (BMI), weight (kg)/height^2 (m^2), is an anthropometric index which correlates with percentage body fat content [1]. The World Health Organisation (WHO) defines categories of BMI which are associated with risk of some non-communicable diseases: underweight (BMI <18.5), normal weight (BMI >18.5 & <25), overweight (BMI > 25 & <30) and obese (BMI >30) [2]. There is variation in the relationship between BMI and percentage body fat content by ethnic group [3] and it is recognised that the BMI category cut-offs may not be appropriate for all population sub-groups [4].

Obesity has many comorbidities including cardiovascular disease, hypertension, type 2 diabetes, joint disease and is associated with higher mortality [5-8] with "adverse effects of obesity on health … well established, serious, and causal" [9, p245]. There is evidence from studies in the UK [10], Australia [11] and USA [12] that obesity is associated with poorer health related quality of life (HRQoL). Over the last few decades there have been large rises in the prevalence of obesity across the globe [9] but there is evidence that increases in obesity have levelled off since 1999 in various age-groups in a number of countries [13].

In contrast there is less emphasis in the literature on the association between underweight and health outcomes which may in part be due to the low prevalence of underweight in the developed world. In 2006 compared with the prevalence of obesity in England being 24% for both adult males and females, just 1% of adult males and 3% of adult females in England were underweight [14]. There are, though, studies in various countries which show a U-shaped relationship between BMI and psychological and psychiatric conditions such as depression [15-18], mental health disorders [19] and severe psychological distress [20] as well as HRQoL [21], often with a focus on population subgroups such as young women [e.g. 16,18]. Many studies, however, either combine underweight with the normal weight category or do not report or highlight results from the underweight group [e.g. 22, 10]. A U-shaped relationship between BMI and mortality is also demonstrated with increased mortality risk found at both high and low body weight extremes [8,23-4] but little evidence of increased risk for those in the overweight category [25-6]. Why those who are underweight have an increased risk of mortality is debated but it is suggested that persons in this BMI category may have undiagnosed disease [27].

Self-assessed health questions are included in social surveys and population censuses with a large body of work supporting the validity of self-reported health [28]. A sizable literature demonstrates an increased likelihood of self-reported poor health with increasing BMI [e.g. 29,30,] but little work reports the relationship between underweight and poor general health. There is evidence of a U shaped

relationship between BMI and self-rated health [31-3] but we do not believe these findings are given the emphasis they deserve.

The lack of research into persons of underweight BMI in comparison with those whose BMI is higher than normal weight has been noted [27,34]. This work reveals demographic and health differences between people of different BMI categories and nonlinear associations between BMI and mental health. Using the Health Survey for England (HSE), U-shaped relationships were found in univariate models between BMI and activities of daily living, respiratory disease, physical activity and mental health variables [27]. However, later work using an Australian sample found significantly greater odds of mental ill-health in the obese but not in the underweight, controlling for age, health-related behaviours and educational achievement [34].

It is telling there may be an increased risk of poor health (measured in various ways) for persons who are underweight as well as for those who are obese, and the latter group, being more numerous, receive more attention. Being underweight needs to be recognised as a health risk even though the numbers are small. This paper investigates the association between BMI category and self-reported health in a representative sample of the residential adult population in England. We build on previous analyses using the HSE [27] to model the likelihood of poor general health across BMI categories whilst controlling for factors expected to influence health including socioeconomic characteristics, health-related behaviours and area deprivation.

Methods

The study sample is drawn from the Health Survey for England (HSE) which is sponsored by the Department of Health. The HSE includes questionnaire-derived answers and physical measurements in an annual survey on socioeconomic aspects, smoking, drinking, general health, height and weight, blood pressure, etc. Particular surveys focusing on specific diseases or population groups but the core content used in this analysis is available in all surveys.

We pool data from the 2006 to 2008 versions of the HSE and utilise categorical variables on self-reported general health, the four Body Mass Index categories defined above and other information expected to relate to health (Table 1). We harmonise variable definitions across the three HSE datasets and focus analyses on adults aged 16 to 74. We exclude persons aged 75 and over since BMI is affected by factors such as change in bone density [35]. In the HSE, BMI is calculated using each participant's weight and height recorded by trained nurses.

Table 1: Summary of variables from the Health Survey for England (2006-08)

Topic	Variable	Sample Categories	26,596	%
Self-reported health	General health	Good	21,064	79.20
		Fair, bad, very bad	5,532	20.80
Independent variables				
Demographic	Sex	Male	13,511	50.80
		Female	13,085	49.20
	Age Group	16-24	3,298	12.40
		25-34	4,734	17.80
		35-44	5,931	22.30
		45-54	5,000	18.80
		55-64	4,575	17.20
		65-74	3,059	11.50
	Ethnic Group	White	23,963	90.10
		South Asian	1,410	5.30
		Black	665	2.50
		Chinese & Other	532	2.00
Body Mass Index	Weight Status (BMI)	Underweight	372	1.40
		Normal Weight	9,601	36.10
		Overweight	10,000	37.60
		Obese	6,622	24.90
Socioeconomic	Economic Activity	Employed	18,032	67.80
		Unemployed	1,516	5.70
		Retired	3,830	14.40
		Other inactive	3,218	12.10
	Social Class	I Professional	1,463	5.50
		II	8,458	31.80
		IIIN	6,117	23.00
		IIIM	4,707	17.70
		IV	4,548	17.10
		V Unskilled	1,303	4.90
	Tenure	Owner	19,761	74.30
		Private Rent	3,457	13.00
		Public Rent	3,404	12.80
	Car Access	Yes	22,926	86.20
		No	3,670	13.80
	Education	Degree	6,064	22.80
		A level	7,420	27.90
		GCSE	13,112	49.30
Health behaviour	Smoker	No	20,399	76.70
		Yes	6,197	23.30
	Fruit & Vegetable Portions	None	6,144	23.10
		2-4 portions	12,713	47.80
		5+portions	7,739	29.10
	Level of Activity	Inactive	14,309	53.80
		Light	2,394	9.00
		Moderate	4,202	15.80
		Vigorous	5,665	21.30
Area deprivation	Deprivation Quintile	1 Least deprived	5,638	21.20
		2	5,559	20.90
		3	5,665	21.30
		4	5,186	19.50
		5 Most Deprived	4,521	17.00

Notes: Underweight (BMI <18.5); Normal weight (BMI >18.5 & <25); Overweight (BMI > 25 & <30); Obese (BMI >30)

The outcome is people's response to the question, "How is your health in general? Would you say it was: Very Good, Good, Fair, Bad, or Very Bad?" We dichotomise responses to contrast Very Good / Good general health with the other categories and refer to these as 'good' health and 'poor' or 'not good' general health. In terms of demographic factors we consider the effect on self-reported health of a person's: sex, age-group and broad ethnic group. For peoples' socioeconomic characteristics we have variables on: economic activity, Social Class, tenure, car access and their highest level of education attainment. We consider peoples' health-related behaviour using variables relating to: whether somebody is a smoker; their daily consumption of fruit and vegetables and their level of physical activity. We include the deprivation of the small area in which people live using the Index of Multiple Deprivation [36] categorised into quintiles.

Given a dichotomous outcome variable and categorical explanatory variables, binary logistic regression (using Stata v.12) is an appropriate modelling technique. Following some descriptive statistics, the modelling strategy we adopt is to establish the odds of reporting poor general health in a model controlling for the demographic variables sex, age-group and ethnic group and the BMI categories of underweight, normal weight, over weight and obese. Subsequent models add in socioeconomic variables, health-related behaviours and then area deprivation along with all the other variables.

Results

The Health Survey for England (2006-08) comprises a sample of 26 596 individuals aged 16 to 74 of whom 51% are male and 49% are female (Table 1). 1.4% of these persons are classified as being underweight, 36% are normal weight, 38% are overweight and 25% are obese. A U-shaped relationship between general health and BMI category is revealed with 27% of those persons who are underweight reporting poor health, compared with 15% of persons who are of normal weight and 19% of persons who are overweight. 32% of persons who are obese report poor general health.

Model 1: The percentages above do not control for demographic characteristics. Model 1 estimates the likelihood of reporting poor general health controlling for sex, age, ethnic group and BMI category. Table 2 records the odds ratios (and 95% confidence intervals) of reporting poor general health compared with a reference category. In this model there is no difference in health between males and females. For age-group, compared with those aged 16-24 there is no difference in the likelihood of reporting poor health for persons aged 25-34 but the odds ratios then increase significantly with age. Compared with the White group, the South Asian and Chinese & Other ethnic groups are significantly more likely to report poor health.

Table 2: Odds ratios of reporting poor general health for individuals in the Health Survey for England (2006-08)

		Model 1	Model 2	Model 3	Model 4
Pseudo R^2		0.055	0.135	0.155	0.160
Akaike information criterion		25 729	23 572	23 050	22 981
		OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Sex	Male	Ref	Ref	Ref	Ref
	Female	1.01 (0.95,1.07)	0.83 (0.77,0.89)	0.84 (0.78,0.91)	0.85 (0.79,0.92)
Age Group	16-24	Ref	Ref	Ref	Ref
	25-34	0.93 (0.80,1.09)	1.19 (0.99,1.43)	1.09 (0.91,1.29)	1.07 (0.90,1.27)
	35-44	1.18 (1.02,1.37)	1.57 (1.31,1.88)	1.44 (1.22,1.70)	1.45 (1.23,1.70)
	45-54	1.70 (1.48,1.97)	2.34 (1.94,2.81)	2.19 (1.87,2.58)	2.23 (1.90,2.62)
	55-64	2.41 (2.09,2.77)	2.67 (2.21,3.22)	2.61 (2.21,3.07)	2.66 (2.25,3.13)
	65-74	3.13 (2.71,3.62)	2.56 (2.07,3.16)	2.42 (1.99,2.93)	2.50 (2.06,3.03)
Ethnic Group	White	Ref	Ref	Ref	Ref
	South Asian	1.35 (1.02,1.82)	1.43 (1.22,1.68)	1.52 (1.30,1.79)	1.41 (1.20,1.66)
	Black	1.17 (0.95,1.43)	0.88 (0.70,1.10)	0.99 (0.80,1.25)	0.92 (0.73,1.16)
	Chinese & Other	1.31 (1.03,1.67)	1.21 (0.92,1.59)	1.28 (0.98,1.67)	1.22 (0.93,1.59)
Weight Status (BMI)	Underweight	2.34 (1.82, 3.02)	1.91 (1.44,2.52)	1.73 (1.30,2.30)	1.74 (1.31,2.31)
	Normal Weight	Ref	Ref	Ref	Ref
	Overweight	1.14 (1.05,1.24)	1.19 (1.09,1.29)	1.21 (1.11,1.32)	1.20 (1.11,1.31)
	Obese	2.33 (2.15,2.53)	2.29 (2.10,2.49)	2.29 (2.10,2.50)	2.25 (2.06,2.46)
Economic Activity	Employed		Ref	Ref	Ref
	Unemployed		1.57 (1.32,1.87)	1.56 (1.31,1.85)	1.54 (1.29,1.84)
	Retired		1.95 (1.73,2.19)	2.01 (1.78,2.26)	2.01 (1.79,2.27)
	Other inactive		3.74 (3.47,4.09)	3.67 (3.50,4.02)	3.66 (3.34,4.01)
Social Class	I Professional		Ref	Ref	Ref
	II		1.22 (1.00.1.47)	1.21 (0.99,1.47)	1.19 (0.98.1.45)
	IIIN		1.23 (0.99,1.51)	1.21 (0.98,1.50)	1.18 (0.96,1.46)
	IIIM		1.50 (1.22,1.85)	1.39 (1.13,1.71)	1.32 (1.07,1.63)
	IV		1.53 (1.23,1.89)	1.45 (1.17,1.79)	1.37 (1.11,1.70)
	V Unskilled		1.66 (1.31,2.10)	1.53 (1.21,1.94)	1.45 (1.14,1.84)
Tenure	Owner		Ref	Ref	Ref
	Private Rent		1.33 (1.19,1.50)	1.23 (1.09,1.38)	1.22 (1.08,1.37)
	Public Rent		2.02 (1.83,2.23)	1.75 (1.59,1.93)	1.62 (1.46,1.79)

Car Access	Yes	Ref	Ref	Ref
	No	1.24 (1.10,1.39)	1.28 (1.16,1.41)	1.19 (1.08,1.32)
Education	Degree	Ref	Ref	Ref
	A level	1.33 (1.18,1.49)	1.22 (1.08,1.37)	1.22 (1.08,1.38)
	GCSE	1.68 (1.50,1.88)	1.41 (1.26,1.59)	1.39 (1.23,1.56)
Smoker	No		Ref	Ref
	Yes		1.68 (1.55,1.82)	1.64 (1.51,1.78)
Fruit & Vegetable Portions	None		Ref	Ref
	2-4 portions		0.80 (0.74,0.87)	0.81 (0.75,0.89)
	5+portions		0.69 (0.62,0.76)	0.70 (0.64,0.77)
Level of Activity	Inactive		Ref	Ref
	Light		0.91 (0.81,1.03)	0.93 (0.82,1.04)
	Moderate		0.67 (0.61,0.75)	0.68 (0.61,0.75)
	Vigorous		0.49 (0.44,0.54)	0.50 (0.45,0.55)
Deprivation Quintile	1 Least deprived			Ref
	2			1.02 (0.91,1.14)
	3			1.24 (1.11,1.38)
	4			1.37 (1.23,1.53)
	5 Most Deprived			1.52 (1.35,1.79)

Notes: Underweight (BMI <18.5); Normal weight (BMI >18.5 & <25); Overweight (BMI > 25 & <30); Obese (BMI >30); OR = Odds Ratio; CI = Confidence Interval

A clear U-shaped relationship is shown between BMI category and poor health with the odds significantly higher for both underweight and obese categories than the reference category, normal weight. Overweight persons are marginally, but significantly, more likely to report poor health than those of normal weight.

Model 2: In addition to the demographic variables in Model 1, we include a range of socioeconomic variables. The demographic variables have some different effects from the previous models with females now less likely to report poor health than males. The gradient by age is a little reduced with the odds for the oldest age-group marginally lower than the odds for the next oldest. The likelihood of South Asians reporting poor health has increased in comparison with the White group but there is no significant difference for the other groups.

Compared with persons who are in employment, the odds of reporting poor health are progressively and significantly higher for those who are unemployed, retired or economically inactive. There is an increasing likelihood of reporting poor health down the Social Class gradient but only the lower Social Classes have significantly greater odds than the reference category, Social Class I. Compared with Owner Occupiers, those in private and public rental tenures have significantly greater odds of reporting poor health. Lack of access to a car and lower levels of educational achievement are associated with increased odds of reporting poor health. As in Model 1, there is a U-shaped relationship between BMI category and the reporting of poor health.

Model 3: Here, variables on health-related behaviour are added to those included in Model 2. The differences in reporting by sex, age-group and ethnic group follow similar patterns with the odds for the oldest age-group still marginally lower than odds for the next oldest. For the socioeconomic variables the differences between the reference categories and alternatives are largely attenuated but differences for both the retired compared with the employed and lack of car ownership compared with owners increase. Comparisons of the differences in variable categories between the models have overlapping class intervals though.

For health related behaviours, smokers are significantly more likely than non-smokers to report poor health. Increases in portions of fruit and vegetable and of levels of physical activity are associated with significantly lower odds of reporting poor health compared with their reference levels. Controlling for demographic, socioeconomic and health-related behaviour variables, the U-shaped relationship between BMI category and poor health is still found.

Model 4: In addition to the demographic, socioeconomic and health-related behaviour variables we include area deprivation. The patterns for the demographic variables are very similar but the gradient

across age has steepened whilst the differences by ethnic group are reduced. The situation is similar for the socioeconomic variables with the differences in odds ratios from the references categories not quite so large in this model. Smokers are still more likely, and those with a better diet and exercise regime less likely, to report poor health.

There is an increasing likelihood of reporting poor health with significantly higher odds for each quintile of deprivation compared with the least deprived areas and the U-shaped relationship between BMI category and the reporting of poor health is still found. Persons who are underweight and persons who are obese are significantly more likely than those who are in the normal weight category to report poor health. People who are overweight are also significantly more likely to report poor health but the difference is not as large as for the underweight and the obese.

Assessing model fit: For logistic regression, a pseudo R^2 is an indicator of fit though values tend to be closer to 0 even for well fitting models, compared with R^2 values in linear regression models. To inform model evaluation, Akaike's information criterion (AIC) accounts for both goodness of fit and the number of parameters used. Lower AIC values indicate a preferred model. We tested for interactions between variables but none of the interaction terms were significant so they were not retained.

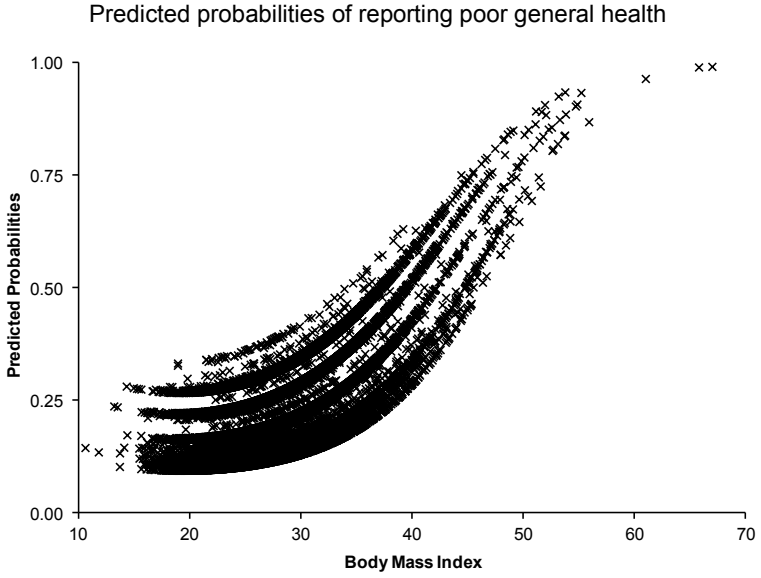
The psuedo R^2 increases from Model 1 to 2 with the addition of the socioeconomic variables to the demographic variables and a reduction in AIC (Table 2). The inclusion of health related variables in Model 3 improves model fit further. The fit improves with the addition of area deprivation in Model 4. AIC values are lowest in Model 4 despite the number of variables and we conclude this is an appropriate model. We recognise that the inclusion of area deprivation along with the other variables risks over-fitting since variables relating to aspects of economic activity, social class, tenure and car ownership are either included in or correlate strongly with area deprivation measures. Also, some ethnic minority groups and persons who smoke may be concentrated in more deprived areas.

As a sensitivity test, we ran Model 4 without BMI categories which resulted in a pseudo R^2 of 0.139 and AIC of 23 461. There is a better fit with BMI included. As a further test to investigate the nonlinear relationship between BMI and health [17,19,25], we ran Model 5, an equivalent to Model 1 but substituting the BMI categories with the continuous measure of BMI included in the HSE along with BMI squared. In Model 5 (Table 3) females are less likely to report illness whereas in Model 1 (Table 3) they are more likely to report poor health, but in both models the differences are not significant. The patterns of differences in odds ratios from the reference level in Model 5 are the same for age and ethnic group as in Model 1 with the confidence intervals overlapping between the models. For these variables then, one would not conclude anything different. In Table 3, the graph of the

relationship between BMI (continuous) and the predicted probabilities of self-reported health clearly demonstrates that the relationship is nonlinear with a degree of upturn in probabilities at low BMI values.

Table 3: Odds ratios of reporting poor general health for individuals in the Health Survey for England (2006-08) (BMI Continuous)

		Model 5
Pseudo R^2		0.057
Akaike information criterion		25 651
		OR (95% CI)
Sex	Male	Ref
	Female	0.98 (0.92,1.00)
Age Group	16-24	Ref
	25-34	0.89 (0.76,1.04)
	35-44	1.12 (0.97,1.30)
	45-54	1.65 (1.43,1.91)
	55-64	2.35 (2.04,2.71)
	65-74	3.07 (2.65,3.55)
Ethnic Group	White	Ref
	South Asian	1.36 (1.17,1.58)
	Black	1.17 (0.95,1.43)
	Chinese & Other	1.33 (1.05,1.70)
Weight Status	BMI	0.89 (0.85,0.94)
	BMI^2	1.003 (1.002,1.003)



Notes: OR = Odds Ratio; CI = Confidence Interval

Discussion

Here we used answers to a question, "How is your health in general?" There is potential for self-assessment to be affected by subjective factors [37], so apparent health differences between population sub-groups could be due to varying interpretations of health [38]. Self-reported poor health is influenced by expectation and comparison which themselves may be culturally determined [28]. A long-running debate exists about whether self-rated health it is a reliable measure of health [39]. Nevertheless, many studies demonstrate that self-reported health is a predictor of subsequent mortality and it is a commonly-used morbidity indicator [40-1]. Self-reported poor health is strongly associated with general health perceptions, serious conditions and mental health status [42-3]. The usefulness of self-reported health holds for different countries, different populations, question formulations and in relationships with different outcome measures including mortality and sickness benefits claims [44]. In the UK, measures derived from the Health Survey for England's self-rated health question are included in Department of Health / Public Health Observatory health profiles.

We included demographic, socioeconomic, health-related behaviour variables and area deprivation variables in a series of models. We found females to have marginally better health than males and for the likelihood of poor health to increase with age. The relatively poor health of the South Asian population we find is consistent with other work [38] as are the socioeconomic variables whereby those who are not employed are more likely to report poor health as are persons in public housing, of low educational achievement, of low social class or without access to a car [45-7]. The relationships we find for health-related behaviours are in line with other work [31] though variables are differently defined, including use of a BMI of 20 as the cut-off to identify persons as underweight rather than the WHO cut-off of 18.5 we use. Similar to other studies, we find health advantages for persons in less deprived areas [48].

We observed that U-shaped relationships between BMI categories and health are noted in some literature and presented in results but without emphasis [though see 27,34]. Controlling for socioeconomic, health behaviour and deprivation variables, using the Health Survey for England (2006-08), compared with persons of normal weight, we find significantly increased likelihoods of persons to report poor general health for both underweight and obese BMI categories and a slight but significant increase for persons who are overweight. Our findings for self-reported health are consistent with other work which finds a clear U-shape between BMI and depression [17] and self-rated health [31-3].

We used the Health Survey for England, a nationally representative study with a good response rate, pooled over three years to increase the sample size and have utilised BMI categories derived from

professionally measured weight and height for adults. We have shown that a person's self-reported health is related to their BMI but must recognise that peoples' health status may affect their BMI since ill people may be less able to adopt a healthy lifestyle. Similarly, poor health can mean that people may not be able to benefit from higher education, have a fruitful career, enter the housing market or be able to live in an advantageous location.

We recognise that a person's health *and* their BMI are both related to their socioeconomic status and their lifestyle; these factors relate to each other and all aspects may vary geographically. Whilst the focus is on obesity, the literature investigates factors associated with BMI [see 49-52] and the variables commonly identified are also associated with health status. It may be that poor body image leads somebody to report poor health [53].

Obesity is seen as an inherently political issue with media reporting on the perils of being obese with this reflecting underlying moral assumptions that fat people are being irresponsible [54]. For the underweight the media highlights the size zero debate and the issues around eating disorders [55]. The literature largely focuses on the relationship between obesity and health and this is understandable given that many more persons are obese than are underweight. Depending on other characteristics, it appears that a person who is underweight is about as likely to report their health as being poor as a person who is obese. Further work will look at the relationship between BMI category and diagnosed, rather than self-reported, health.

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