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A Potential Role of the Widespread Use of Microwave Ovens in the Obesity Epidemic

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Abstract
Organisms acquire more calories from eating hot food than eating the identical food cold; thus, the widespread use of microwave ovens might have played a small role in the current obesity epidemic, just as the widespread use of refrigerators might have retarded the historic increase in obesity a century ago. Analysis of the British Cohort Study showed that, net of dietary habit, physical activities, genetic predisposition, and other demographic factors, the ownership of a microwave was associated with an increase of .781 in body mass index (BMI) and 2.1 kg in weight (when the ownership of other kitchen appliances was not associated with increased BMI or weight), and it more than doubled the odds of being overweight. In the United States from 1960 to 2015, the adult overweight, obesity, and extreme obesity rates were very highly correlated (r = .94–.98) with the proportion of households with microwaves, and it was not because both were consequences of increasing wealth. Net of median household income, the proportion of households with microwaves was very strongly (ds > 1.0) associated with adult overweight, obesity, and extreme obesity rates, while median household income was not at all associated with them. Individual data from the United Kingdom and historical data from the United States highlighted the possible role of the widespread use of microwave ovens in the obesity epidemic.

Keywords
specific dynamic action, nutritional science

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Obesity is an international epidemic. It now affects not only the developed areas like the United States (Burkhauser, Cawley, & Schmeiser, 2009; Cutler, Glaeser, & Shapiro, 2003) and Europe (Berghöfer et al., 2008), but, increasingly, developing nations like China (Chen, 2008) and India (Ranjani et al., 2016) as well. Yet the precise cause(s) of the recent increase in the prevalence of obesity are not yet known (Cawley, 2010; James, 2008; Ross, Flynn, & Pate, 2016).

Obesity and the current obesity epidemic have clear significance and implications for clinical psychological science and psychopathology. Prospectively longitudinal studies have shown that obesity increases the risk of mental illness, particularly depression (Faith et al., 2011; Luppino et al., 2010), and significant weight loss among the obese decreases depression and anxiety (Guedes et al., 2016). At the same time, the causal direction goes the other way as well, and individuals suffering from psychopathology are more likely to gain weight and experience obesity (Allison et al., 2009). Thus, exploring the potential causes of obesity illuminates the causes and consequences of psychopathological conditions.

With one exception, to our knowledge (Cutler et al., 2002), one factor that has hitherto been largely neglected in the explanation of the obesity epidemic is the widespread use of microwave ovens in developed nations. In his book *Catching Fire: How Cooking Made*

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Us Human, on the importance of cooking for human evolution, Wrangham (2009) pointed out that "nutritional science is focused so intensively on chemistry that physical realities are forgotten" (p. 196). Exactly how many calories we acquire from our food depends not solely on what we eat but also on how we eat it (Secor, 2009). The basic biological principle is that organisms acquire more calories from food if they have to expend less energy digesting it than they would from the identical food if they had to expend more energy digesting it. "Based on animal studies, we can expect that the costs of digestion are higher for tougher or harder foods than softer foods; for foods with larger rather than smaller particles; for food eaten in single large meals rather than in several small meals; and for food eaten cold rather than hot" (Wrangham, 2009, p. 203). Thus, all else being equal, humans acquire more calories, and are thus more likely to gain weight, if they consume their food at higher temperatures than if they consumed the identical food at lower temperatures because food at lower temperatures has higher costs of digestion (Secor, 2009). Secor (2009) noted that "the effects of meal temperature are most evident for endotherms living in cold environments that consume food that may be more than 30 °C lower than their body temperature" (p. 32). Because typical human body temperature is 37 °C (98.6 °F) and refrigerator temperature is typically set at 4 °C (39.2 °F), these effects apply to food taken directly from the refrigerator and consumed immediately, but they may not apply to food kept at room temperature (~20 °C/68 °F).

The reasoning by Secor (2009) and Wrangham (2009) implies that the rate of overweight and obesity would decrease if the temperature of consumed food became lower.[1] There is indeed some evidence that the historical increase in body mass index (BMI) in the United States throughout the 20th century declined during the 1920s, when the refrigerator was first invented and its domestic use increased (Komlos & Brabec, 2011, pp. 243–246, Figs. 12–15), although causal inference is difficult because the period coincided with the Great Depression.

Before the widespread availability of microwave ovens in homes, individuals normally had to consume any leftover food cold (either refrigerated or at room temperature) unless they were willing to wait for a long time to heat it up in conventional ovens or on the stovetop. Microwave ovens allowed individuals to consume any food at high temperature within seconds. Thus, one would expect consumers in industrialized nations to have acquired, on average, more calories after the spread of microwave ovens *even if* what they ate did not change at all over time.

In these studies, we tested the hypothesis that the widespread use of microwave ovens might have made a small contribution to the obesity epidemic in recent decades. We first estimated the effect of the ownership of microwave ovens on individual BMI and weight with longitudinal survey data in the United Kingdom, and then assessed the possible role of the spread of microwave ovens in the obesity epidemic with historical data from the United States.

Study 1: Individual Data From the United Kingdom

Data

The British Cohort Study (BCS), originally developed as the British Birth Survey and a sequel to the 1958 National Child Development Study, included all babies (N = 17,196) born in Great Britain (England, Wales, and Scotland) during the week of April 5 to 11, 1970. All surviving members of the cohort who still resided in the United Kingdom (Great Britain plus Northern Ireland) were subsequently interviewed in 1975 (Sweep 1 at age 5; N = 13,135), 1980 (Sweep 2 at age 10; N = 14,875), 1986 (Sweep 3 at age 16; N = 11,615), 1996 (Sweep 4 at age 26; N = 9,003), 2000 (Sweep 5 at age 30; N = 11,261), 2004 (Sweep 6 at age 34; N = 9,665), 2008 (Sweep 7 at age 38; N = 8,874), and 2012 (Sweep 8 at age 42; N = 9,841). In each sweep, personal interviews were conducted with and questionnaires were administered to the respondents; their mothers, teachers, and doctors during childhood; and their spouses and children in adulthood. Descriptive statistics (means and standard deviations) for all variables used in Study 1 are presented in Table 1, for the whole sample, and then separately for those with and without microwave ovens in their household.

Dependent variable: BMI

At age 16, each BCS respondent received a full medical examination, which included measurement of height and weight by a physician. We used these physician-measured (rather than self-reported) height and weight to compute the respondent's BMI and overweight (BMI > 25) or obesity (BMI > 30) status. Only 9 BCS respondents (.15%) were extremely obese (BMI > 40) at age 16.

Independent variable: Microwave oven ownership

At age 16 (and no other age), BCS asked the respondents whether their household contained a large number of kitchen appliances, including a microwave oven. We used the dummy measuring microwave ownership (1 if the respondent's household included a microwave, 0 otherwise) as the main independent variable. In 1986, 42.38% of the BCS respondents lived in households with microwave ovens.

Table 1. Descriptive Statistics: United Kingdom Individual Data

			Microwave ownership	
		Full sample	No	Yes
(1)	BMI	21.26 (3.25)	21.05 (3.21)	21.54 (3.29)
(2)	Overweight	.10 (.30)	.09 (.28)	.12 (.32)
(3)	Obese	.02 (.13)	.02 (.13)	.02 (.14)
(4)	Weight	59.84 (10.30)	59.42 (10.38)	60.61 (10.19)
(5)	Height	167.68 (9.52)	167.86 (9.35)	167.78 (9.62)
(6)	Microwave ownership	.42 (.49)	.00 (.00)	1.00 (.00)
(7)	Fat consumption	5.06 (2.17)	5.13 (2.15)	4.98 (2.18)
(8)	Starch consumption	3.79 (1.61)	3.89 (1.65)	3.71 (1.53)
(9)	Sugar consumption	3.04 (1.77)	3.09 (1.77)	2.94 (1.75)
(10)	Eating habit	2.23 (.62)	2.23 (.63)	2.21 (.61)
(11)	Exercise frequency	.57 (.98)	1.25 (1.12)	1.28 (1.14)
(12)	Exercise previous Saturday	.62 (.48)	.63 (.48)	.63 (.48)
(13)	Sports	18.10 (14.22)	17.62 (13.77)	18.11 (13.97)
(14)	Mother's BMI	23.46 (3.87)	23.47 (3.83)	23.35 (3.82)
(15)	Father's BMI	24.49 (3.05)	24.35 (3.00)	24.59 (2.97)
(16)	Family income	2.92 (3.49)	3.58 (3.09)	4.44 (3.44)
(17)	Sex	.50 (.50)	.50 (.50)	.48 (.50)
(18)	IQ	100.00 (15.00)	100.88 (14.96)	101.15 (13.90)
	valid *n* (listwise)	1,059	619	440

Note: Values are means with standard deviations in parentheses. Measurement units and coding: (1) body mass index (BMI); (2) 1 if overweight, 0 otherwise; (3) 1 if obese, 0 otherwise; (4) kilograms; (5) centimeters; (6) 1 if household included a microwave, 0 otherwise; (7–9) on a scale from 0 to 8; (10) 1 = less than average, 2 = about average, 3 = more than average; (11) 0 = never, 1 = occasionally, 2 = regularly; (12) 1 if exercised previous Saturday, 0 otherwise; (13) on a scale from 0 to 172; (14–15) BMI; (16) from 1 = less than £2,600/year to 11 = more than £26,000/year; (17) 0 = female, 1 = male; (18) IQ.

Control variables

In addition to the main independent variable, we controlled for a large number of variables that might be expected to influence the respondent's weight and BMI.

Dietary habit. When the respondents were age 16, BCS asked them to list everything that they ate or drank on the previous day. From this comprehensive list of all the foods and drinks consumed, BCS calculated the total amounts of fats, starchy carbohydrates, and sugary carbohydrates consumed. We controlled for the amounts of these three substances that the respondents consumed on the previous day. We acknowledge that these measures of dietary habit were likely to contain some random measurement errors, as they were based on food consumption on a single day. In addition, we asked respondents how much they thought they ate in general (1 = *less than average*, 2 = *about average*, 3 = *more than average*). We also controlled for this self-perceived amount of food consumed in general.

Physical activities. BCS measured the respondents' level of physical activities by three separate measures. First, BCS asked the respondents' mother how frequently the respondent engaged in physical exercise at age 16 (0 = *never*, 1 = *occasionally*, 2 = *regularly*). Second, BCS asked the respondents at age 16 whether they had engaged in any physical exercise on the previous Saturday (1 = yes, 0 = no). Third, BCS asked the respondents at age 16 whether they engaged in 43 different types of individual and team sports, both in school and out of school (86 questions in total). For each of the 86 questions, BCS asked the respondents whether they engaged in the sport at least once a month or at least once a week. The respondents received two points if they engaged in the sport at least once a week, one point if they engaged in it at least once a month, and zero points otherwise. The respondents' sports score therefore varied from 0 to 172.

Genetic predisposition. In order to control for the respondents' genetic predisposition toward obesity, we controlled for the father's and the mother's BMI (computed from self-reported height and weight) measured at age 10 (Sweep 2).

Demographic factors. We further controlled for the respondent's sex (0 = female, 1 = male) and gross annual family income at age 16 (measured by an 11-point ordinal scale from 1 = less than £2,600 [~$3,410] to 11 = more than £26,000 [~$34,100]). Further, because previous studies suggested that childhood intelligence might affect adult obesity (Belsky et al., 2013; Kanazawa, 2013, 2014), we controlled for the respondents' childhood intelligence measured by four cognitive tests at age 16.

Results

Microwave ownership was significantly positively associated with physician-measured BMI (Pearson's $r = .074$, $p < .001$, $n = 4{,}831$). Table 2 presents the results of the multiple regression analyses. Net of dietary habit, physical activities, genetic predisposition, and demographic

Table 2. Regression Analysis: United Kingdom Individual Data

	Dependent variable			
	BMI	Over weight	Obesity	Weight
Microwave ownership	.781***	.740**	.391	2.090***
	(.174)	(.233)	(.609)	(.482)
	.132	*2.096*	*1.479*	*.106*
Fat consumption	−.002	−.100	−.130	−.010
	(.055)	(.075)	(.191)	(.151)
	−.001	*.905*	*.878*	*−.002*
Starch consumption	−.054	.060	.270	−.152
	(.073)	(.103)	(.259)	(.202)
	−.030	*1.062*	*1.310*	*−.025*
Sugar consumption	−.111*	−.149	.001	−.262
	(.053)	(.080)	(.167)	(.148)
	−.067	*.861*	*1.001*	*−.048*
Eating habits	.411**	.315	.042	1.215**
	(.148)	(.203)	(.511)	(.412)
	.083	*1.371*	*1.043*	*.073*
Exercise frequency	.293*	.204	−.199	.863*
	(.131)	(.182)	(.439)	(.362)
	.068	*1.226*	*.819*	*.060*
Exercise previous Saturday	.197	−.106	−1.085	.689
	(.188)	(.248)	(.647)	(.521)
	.031	*.899*	*.338*	*.033*
Sports	.011	.006	.016	.032
	(.006)	(.008)	(.017)	(.018)
	.054	*1.006*	*1.016*	*.044*
Mother's BMI	.232***	.143***	.128*	.642***
	(.026)	(.029)	(.060)	(.071)
	.271	*1.153*	*1.137*	*.224*
Father's BMI	.190***	.163***	.113	.549***
	(.030)	(.038)	(.087)	(.084)
	.185	*1.177*	*1.119*	*.160*
Family income	.047	−.019	−.059	.151*
	(.027)	(.037)	(.107)	(.075)
	.052	*.982*	*.942*	*.050*
Sex	−.665***	−.904**	.207	−.617
	(.192)	(.283)	(.659)	(.668)
	−.112	*.405*	*1.230*	*−.031*
IQ	−.012	−.007	−.032	−.028
	(.027)	(.008)	(.017)	(.018)
	−.057	*.993*	*.968*	*−.039*
Height				.619***
				(.035)
				.580
Intercept	11.179	−9.327	−7.200	−73.948
	(1.184)	(1.567)	(3.331)	(6.144)
R^2	.182	.085	.019	.439
n	990	990	990	990

Note: Values are unstandardized coefficients with standard errors in parentheses. Values in italics are standardized coefficients for linear regression and effects on log odds (e^b) for binary logistic regression. BMI = body mass index.
*$p < .05$. **$p < .01$. ***$p < .001$.

factors, microwave ownership was significantly positively associated with physician-measured BMI ($b = .781$, $p < .001$, standardized coefficient = .132; Column 1). The unstandardized coefficient suggested that microwave ownership was associated with an increase of .781 in BMI, 15.62% of the difference between being normal weight and being obese. In a binary logistic regression analysis, and net of the same control variables, microwave ownership was significantly positively associated with the likelihood of being overweight ($b = .740$, $p = .002$; Column 2) but not of being obese ($b = .391$, $p = .521$; Column 3). The unstandardized coefficient suggested that microwave ownership more than doubled the odds of being overweight ($e^{.740} = 2.096$). Net of the same control variables and physician-measured height, microwave ownership was associated with an increase of weight by 2.1 kg ($b = 2.090$, $p < .001$, standardized coefficient = .106; Column 4).

One possible alternative explanation is that individuals and families that like to eat a lot (and are thus more likely to be overweight or obese) are more likely to invest in purchasing kitchen appliances like a microwave. This does not appear to be the case. Ownership of none of the other kitchen appliances was significantly associated with physician-measured BMI in Pearson correlation coefficient (blender: $r = .012$, $p = .379$, $n = 5{,}103$; electric range: $r = .024$, $p = .096$, $n = 4{,}713$; freezer: $r = -.002$, $p = .870$, $n = 5{,}301$; refrigerator: $r = -.002$, $p = .870$, $n = 5{,}301$; gas range: $r = -.012$, $p = .405$, $n = 4{,}687$; solid-fuel range: $r = .001$, $p = .967$, $n = 4{,}255$). Net of the same control variables in multiple linear regression analyses, the ownership of none of these kitchen appliances was significantly positively associated with BMI—except for electric range, perhaps because it also increases the temperature of the food (blender: $b = .049$, $p = .847$, standardized coefficient = .006; electric range: $b = .393$, $p = .027$, standardized coefficient = .066; freezer: $b = .219$, $p = .857$, standardized coefficient = .005; refrigerator: $b = .219$, $p = .857$, standardized coefficient = .005; gas range: $b = -.225$, $p = .194$; standardized coefficient = −.039; solid-fuel range: $b = .285$, $p = .501$, standardized coefficient = .021). Net of the same control variables in binary logistic regression analyses, the ownership of none of these appliances was associated with a greater likelihood of being overweight or obese, while the ownership of a blender was associated with a lower likelihood of being obese ($b = -1.453$, $p = .026$).

Study 2: Historical Data From the United States

There does appear to be consistent evidence from the BCS that microwave ownership might be associated with a small increase in weight, BMI, and the likelihood of being overweight (though not obese). If this is the case, then one macrosocial consequence of the effect of household microwave ownership may be that the current obesity epidemic might at least in small part result from an increasing rate of microwave ownership. We tested this prediction with historical data from the United States.

Data

Obesity/overweight rates. The National Center for Health Statistics at the Centers for Disease Control and Prevention has conducted the National Health and Nutrition Examination Surveys (NHANES) periodically since 1960. NHANES conducts household interviews and physical examinations with a nationally representative sample of the noninstitutionalized civilian population of the United States. There have been 12 NHANES surveys (1960–1962, 1971–1974, 1976–1980, 1988–1994, 1999–2000, 2001–2002, 2003–2004, 2005–2006, 2007–2008, 2009–2010, 2011–2012, 2013–2014). During the physical examination, trained health technicians measure each respondent's height and weight with mobile equipment. NHANES provides the only longitudinal data on interviewer-measured (rather than self-reported) height and weight in the United States, and estimates the proportion of the adult American population that is overweight (BMI > 25), obese (BMI > 30), and extremely obese (BMI > 40; Fryar, Carroll, & Ogden, 2016).

Microwave ownership. Data on the proportion of American households with microwaves come from Cox and Alm (2016). Cox and Alm (2016) relied on and compiled data from multiple sources to estimate the percentage of households that owned a microwave in the United States from 1960 (when it was 0.0%) to 2015 (when it was 98.4%).

Median household income. In order to control for the wealth of American households, we controlled for the median household income in $1,000 increments (constant 2014 dollars, available from DeNavas-Walt and Proctor, 2015).

Results

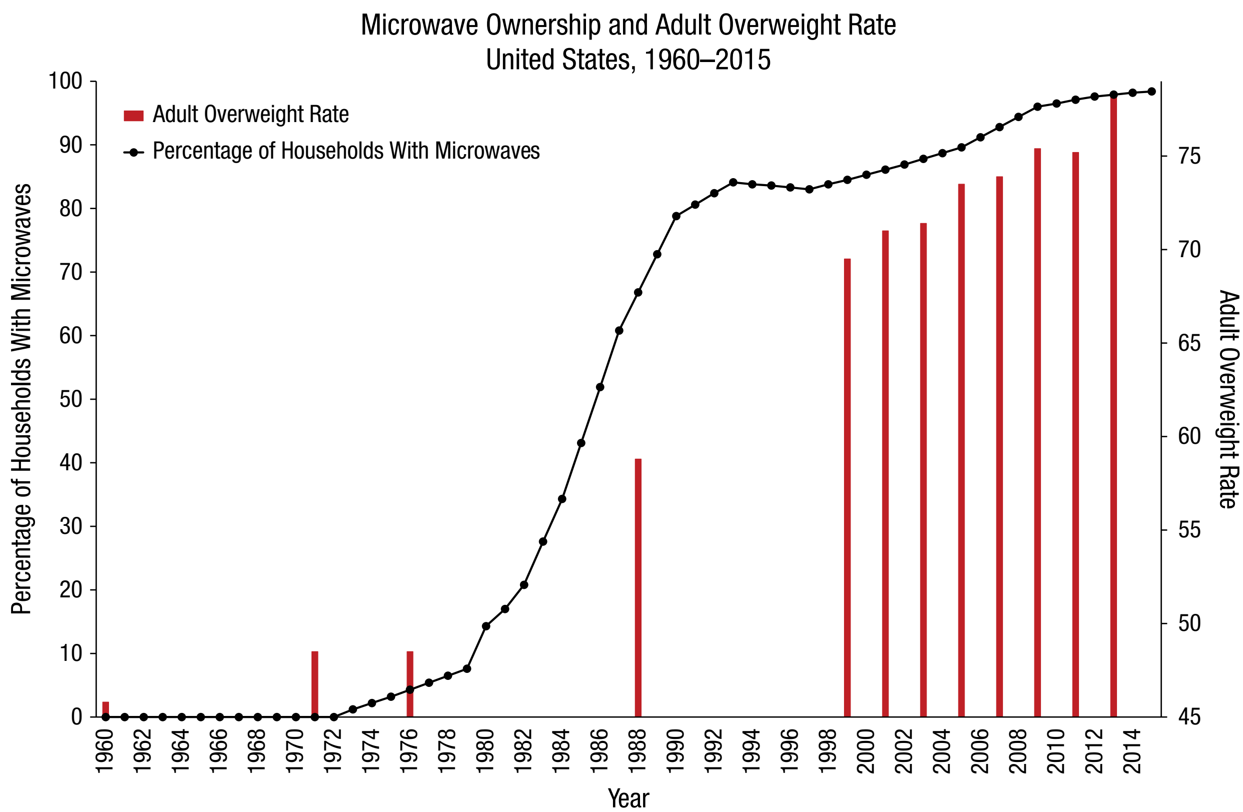
Figure 1 presents the historical trend of microwave ownership and the adult overweight rate (Panel a), adult obesity rate (Panel b), and adult extreme obesity rate (Panel c). As evident from the figure, the association between microwave ownership and the rates of overweight, obesity, and extreme obesity were extremely high in Pearson correlation coefficient (overweight: $r = .977$, $p < .001$, $n = 12$; obesity: $r = .971$, $p < .001$, $n = 12$; extreme obesity: $r = .942$; $p < .001$, $n = 12$).

Table 3 shows that the extremely high correlation between the proportion of households with microwaves and the rates of adult overweight, obesity, and extreme obesity was not the result of the fact that both were consequences of increasing wealth. Net of median household income in constant dollars, the proportion of households with microwaves was still significantly and very strongly associated with the rates of overweight ($b = .303$, $p < .001$, standardized coefficient = 1.024; Column 1), obesity ($b = .314$, $p < .001$, standardized coefficient = 1.076; Column 2), and extreme obesity ($b = .071$, $p = .002$, standardized coefficient = 1.166; Column 3), whereas median household income was not at all associated with the rate of overweight ($b = -.189$, $p = .733$, standardized coefficient = −.064), obesity ($b = -.384$, $p = .523$, standardized coefficient = −.131), or extreme obesity ($b = -.170$, $p = .322$, standardized coefficient = −.278). The standardized coefficients suggested that the associations between the proportion of households with microwaves and the rates of obesity, overweight, and extreme obesity in the United States from 1960 to 2015 were very large (*d*s > 1.0; Cohen, 1992).

Discussion

The analyses of the individual data from the United Kingdom (BCS) and historical data from the United States suggest that the widespread use of microwaves in advanced industrial nations might have contributed to the current obesity epidemic in such nations. Ownership of a microwave was associated with a small but statistically significant increase in BMI and body weight in the United Kingdom, even net of dietary habits, physical activities, genetic predisposition, and other demographic factors. Historically, the rates of overweight, obesity, and extreme obesity in the United States have been very strongly correlated with the proportion of households with microwaves, and this was not because both were consequences of increasing wealth.

One possibility is that microwave ownership may be associated with higher BMI and weight, not because owners are eating their leftovers at higher temperatures but because the microwave allows them to snack more frequently, eat more or more frequently, or cook meals more quickly. Some of this undoubtedly takes place; however, we believe that the predominant mechanism behind the association between microwave ownership and higher BMI and weight may be the possibility of consuming otherwise cold food at higher temperatures. First, in all of our multiple regression analyses detailed a



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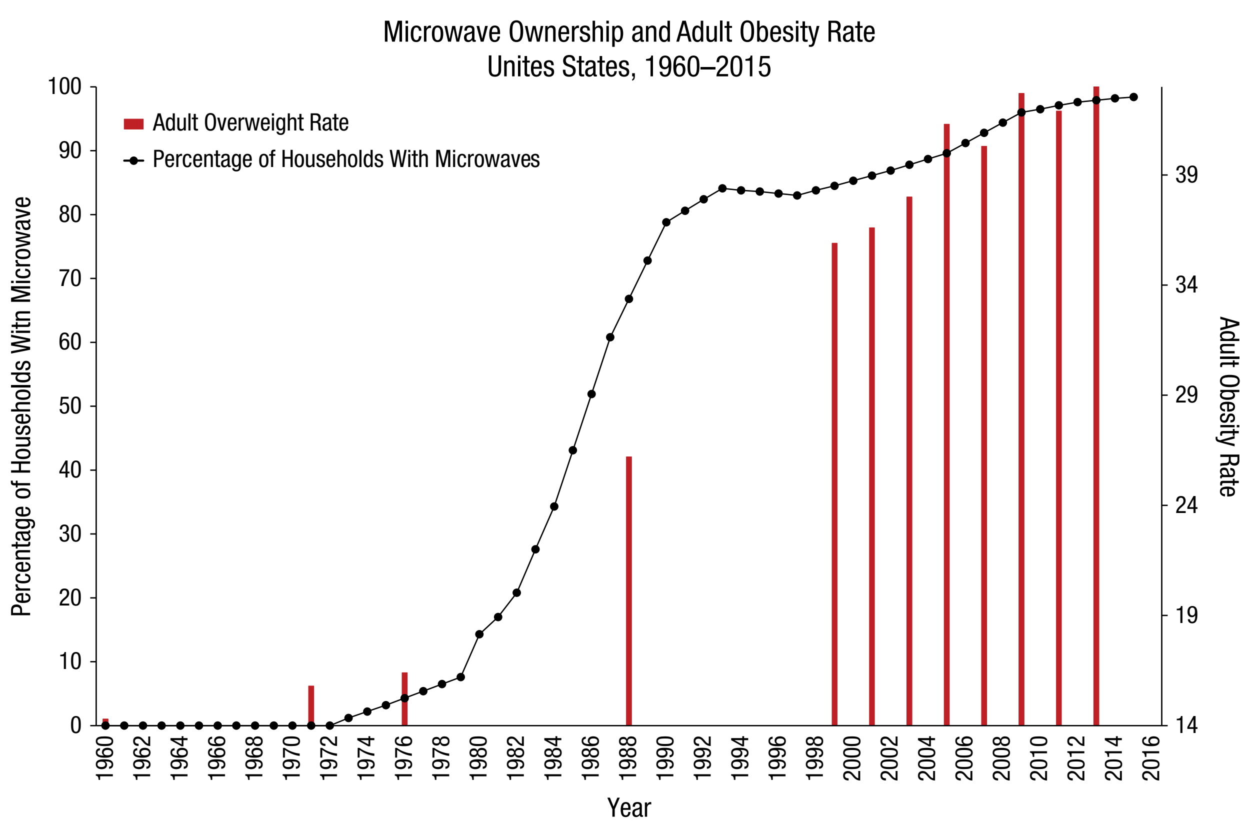

Fig. 1. (*continued on next page*)

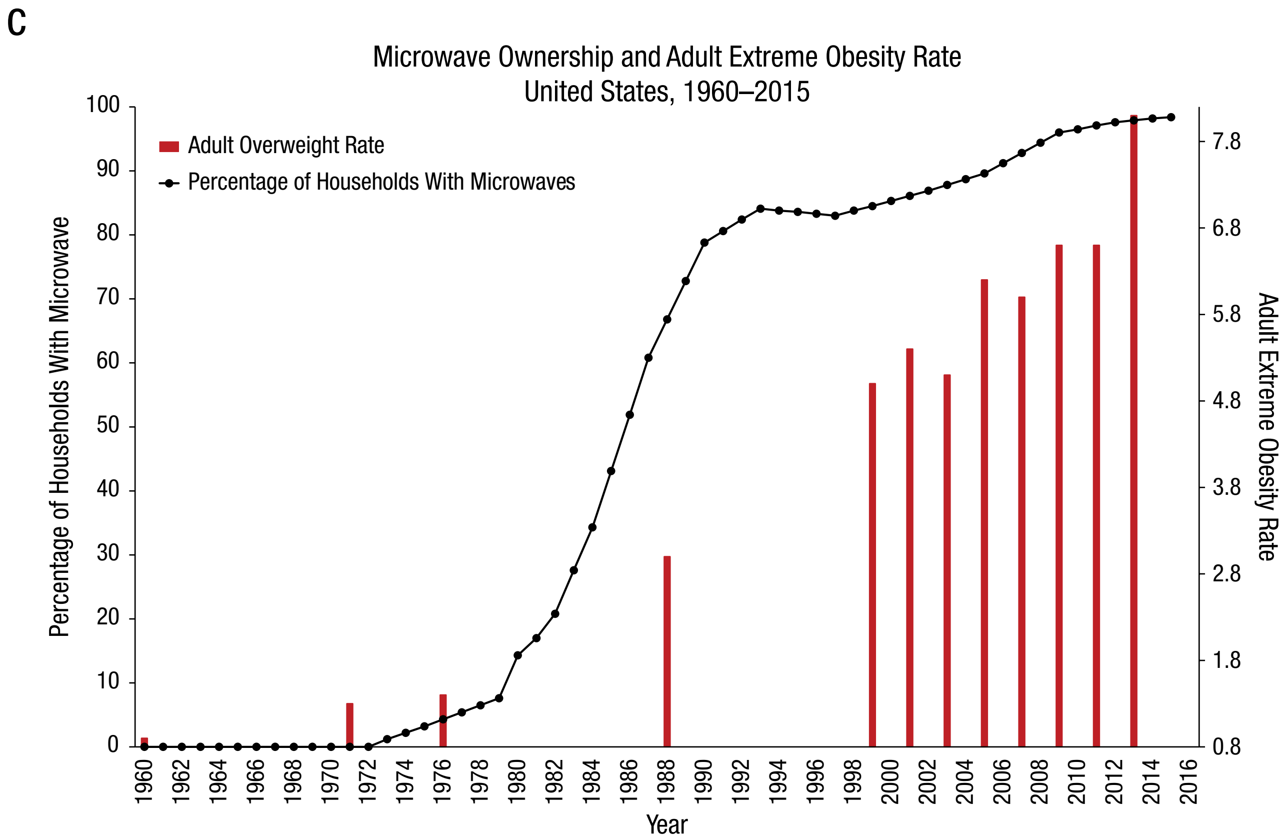

Fig. 1. Microwave ownership and adult (a) overweight, (b) obesity, and (c) extreme obesity rates, United States, 1960–2015.

above, we controlled for the respondent's dietary habit—what they ate and how much they ate. If microwave ownership altered their dietary habits, its effects would be captured by these control variables. Second, the available survey evidence in the United Kingdom and the United States suggests that although microwave owners use the appliance for various purposes, they most frequently use it to heat leftovers. The Omnibus Survey, conducted in November 1991 (5 years after Sweep 3 of the BCS) by the Office of Population Censuses and Surveys in the United Kingdom, asked microwave owners (N = 1,151) in a nationally representative sample how frequently ("frequently," "sometimes," "never") they used their microwaves for three specific purposes: cooking raw food, heating leftovers, and defrosting. Responses were as follows: to cook raw food, "frequently" = 20.2%, "sometimes" = 39.4%, and "never" = 39.7%; to heat leftovers, "frequently" = 50.2%, "sometimes" = 39.8%, and "never" = 9.8%; and to defrost food, "frequently" = 29.3%, "sometimes" = 51.7%, and "never" = 18.6%. In other words, two and half times as many microwave owners "frequently" used the appliance to heat leftovers as to cook raw food, four times as many "never" used it to cook raw food as to heat leftovers, and twice as many "never" used it to cook raw food as they did "frequently." It therefore appears that British microwave owners mostly (though not exclusively) used their microwave ovens to reheat leftover foods.

A more recent survey from the United States also suggests that reheating leftovers might still be the predominant use of microwaves (Williams et al., 2012). The survey asked a sample of microwave owners (N = 2,005) how long they typically used their microwaves. The results showed that a large majority (70%) of microwave owners used the appliance for less than three minutes: 7% used it for less than 1 minute, 34% used it for between 1 and 2 minutes, and 29% used it for between 2 and 3 minutes. Only 6% of microwave owners surveyed used it for 5 minutes or longer. Since 3 minutes is not sufficient to cook any raw food or prepare frozen TV dinners (although it might be sufficient to prepare *chilled* TV dinners), it seems reasonable to conclude that most American microwave owners use the appliance for reheating leftovers.

As further evidence that the direction of causality may go from microwave ownership to higher BMI, microwave ownership in our analysis of the BCS data was still significantly associated with higher BMI at age

Table 3. Regression Analysis: United States Historical Data

	Dependent variable		
	Overweight	Obesity	Extreme obesity
Percentage of households with a microwave oven	.303***	.314***	.071**
	(.053)	(.057)	(.016)
	1.024	*1.076*	*1.166*
Median household income	−.189	−.384	−.170
	(.536)	(.575)	(.161)
	−.064	*−.131*	*−.278*
Intercept	55.690	32.484	8.945
	(25.582)	(27.442)	(7.671)
R^2	.939	.927	.869
n	11	11	11

Note: Values are unstandardized regression coefficients with standard errors in parentheses. Values in italics are standardized regression coefficients.
*p < .05. **p < .01. ***p < .001.

16, *even when* we controlled for physician-measured BMI at age 10 (in 1980, when very few British households owned microwaves) in addition to all the other control variables (b = .565, p < .001, standardized coefficient = .096). It is also associated with greater weight by 1.4 kg (b = 1.430, p < .001, standardized coefficient = .074). As before, in binary logistic regression analyses, microwave ownership was associated with greater likelihood of being overweight (b = .645, p = .018) but not obese (b = -.580, p = .439). Even net of BMI at age 10, microwave ownership still nearly doubled the odds of being overweight at age 16 ($e^{.645}$ = 1.905).

The obesity epidemic is a complex phenomenon. One possible reason that researchers have not been able to discover or agree on a single cause for the obesity epidemic (Ross et al., 2016) is that there are likely multiple causes, each contributing in a small way to the increased prevalence of obesity. In this article, we have highlighted one such potential cause that has hitherto been neglected by obesity researchers. By nearly instantaneously increasing the temperature (and thereby reducing the cost of digestion) of any food consumed, microwave ovens can increase the calories acquired by individuals, *even if* what they eat has not changed over the years. We do not believe that the widespread use of microwaves has been a major or predominant contributor to the obesity epidemic. The available evidence does seem to suggest, however, that it might be one of several causes that might have increased the prevalence of obesity in a small but statistically significant way. Caution is necessary in interpreting our results because, while they were highly statistically significant, the effect sizes were relatively small. We encourage researchers to subject our hypothesis to rigorous experimental testing by directly manipulating microwave use and temperature of consumed food (while holding constant its contents and calories) and subsequently measuring changes in weight.

Action Editor

Kelly L. Klump served as action editor for this article.

Author Contributions

S. Kanazawa and M.-T. von Buttlar formulated the original idea together. S. Kanazawa conducted the data analyses and wrote the first draft of the manuscript. S. Kanazawa and M.-T. von Buttlar both contributed to revisions. Both authors approved the final manuscript for submission.

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Declaration of Conflicting Interests

The author(s) declared that there were no conflicts of interest with respect to the authorship or the publication of this article.

Note

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References

Allison, D. B., Newcomer, J. W., Dunn, A. L., Blumenthal, J. A., Fabricatore, A. N., Daumit, G. L., . . . Alpert, J. E. (2009). Obesity among those with mental disorders: A National Institute of Mental Health meeting report. *American Journal of Preventive Medicine*, *36*, 341–350.

Belsky, D. W., Caspi, A., Goldman-Mellor, S., Meier, M. H., Ramrakha, S., Poulton, R., & Moffitt, T. E. (2013). Is obesity associated with a decline in intelligence quotient during the first half of the life course? *American Journal of Epidemiology*, *178*, 1461–1468.

Berghöfer, A., Pischon, T., Reinhold, T., Apovian, C. M., Sharma, A. M., & Willich, S. N. (2008). Obesity prevalence from a European perspective: A systematic review. *BMC Public Health*, *8*, Article 200. doi:10.1186/1471-2458-8-200

Burkhauser, R. V., Cawley, J., & Schmeiser, M. D. (2009). The timing of the rise in U.S. obesity varies with measure of fatness. *Economics and Human Biology*, *7*, 307–318.

Cawley, J. (2010). The economics of childhood obesity. *Health Affairs*, *29*, 364–371.

Chen, C. M. (2008). Overview of obesity in mainland China. *Obesity Reviews, 9* (Suppl. 1), 14–21.

Cohen, J. (1992). A power primer. *Psychological Bulletin*, *112*, 115–159.

Cox, W. M., & Alm, R. (2016). *Onward and upward! Bet on capitalism—It works*. William J. O'Neil Center for Global Markets and Freedom, Southern Methodist University Cox School of Business. Retrieved from https://www.smu.edu/-/media/Site/Cox/.../Research/.../2016_annual_report_full.ashx?

Cutler, D. M., Glaeser, E. L., & Shapiro, J. M. (2003). Why have Americans become more obese? *Journal of Economic Perspectives*, *17*, 93–118.

DeNavas-Walt, C., & Proctor, B. D. (2015). *Income and Poverty in the United States: 2014*. (Current Population Reports No. P60-252). Washington, DC: U.S. Census Bureau. Retrieved from https://www.census.gov/content/dam/Census/library/publications/2015/demo/p60-252.pdf

Faith, M. S., Butryn, M., Wadden, T. A., Fabricatore, A., Nguyen, A. M., & Heymsfield, S. B. (2011). Evidence for prospective associations among depression and obesity in population-based studies. *Obesity Reviews*, *12*, e438–e453.

Fryar, C. D., Carroll, M. D., & Ogden, C. L. (2016). *Prevalence of overweight, obesity, and extreme obesity among adults aged 20 and over: United States, 1960–1962 through 2013–2014*. Retrieved from https://www.cdc.gov/nchs/data/hestat/obesity_adult_13_14/obesity_adult_13_14.htm

Guedes, E. P., Madeira, E., Mafort, T. T., Madeira, M., Moreira, R. O., Mendoça, L. M. C., . . . Farias, M. L. F. (2016). Impact of a 6-month treatment with intragastric balloon on body composition and psychopathological profile in obese individuals with metabolic syndrome. *Diabetology & Metabolic Syndrome*, *8*, Article 81. doi:10.1186/s13098-016-0197-6

James, W. P. T. (2008). The fundamental drivers of the obesity epidemic. *Obesity Reviews*, *9*(Suppl. 1), 6–13.

Kanazawa, S. (2013). Childhood intelligence and adult obesity. *Obesity*, *21*, 434–440.

Kanazawa, S. (2014). Intelligence and obesity: Which way does the causal direction go? *Current Opinion in Endocrinology, Diabetes, and Obesity*, *21*, 339–344.

Komlos, J., & Brabec, M. (2011). The trend of BMI values of US adults by deciles, birth cohorts 1882–1986 stratified by gender and ethnicity. *Economics and Human Biology*, *9*, 234–250.

Luppino, F. S., de Wit, L. M., Bouvy, P. F., Stijnen, T., Cuijpers, P., Penninx, B. W., & Zitman, F. G. (2010). Overweight, obesity, and depression. *Archives of General Psychiatry*, *67*, 220–229.

Ranjani, H., Mehreen, T. S., Pradeepa, R., Anjana, R. M., Garg, R., Anand, K., & Mohan, V. (2016). Epidemiology of childhood overweight & obesity in India: A systematic review. *Indian Journal of Medical Research*, *143*, 160–174.

Ross, S. E., Flynn, J. I., & Pate, R. R. (2016). What is really causing the obesity epidemic? A review of reviews in children and adults. *Journal of Sports Sciences*, *34*, 1148–1153.

Secor, S. M. (2009). Specific dynamic action: A review of the postprandial metabolic response. *Journal of Comparative Physiology, Series B*, *179*, 1–56.

Williams, A., Yang, H.-C., Beraki, B., Desroches, L.-B., Young, S. J., Ni, C. C., . . . Donovan, S. M. (2012). *Surveys of microwave ovens in U.S. homes*. Berkeley, CA: Lawrence Berkeley National Laboratory. Retrieved from https://eta.lbl.gov/sites/all/files/publications/lbnl-5947e.pdf

Wrangham, R. (2009). *Catching fire: How cooking made us human*. London, England: Profile Books.