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## Alcohol consumption is inversely associated with adherence to diabetes self-care behaviours

A. T. Ahmed, A. J. Karter, and J. Liu

Kaiser Permanente Division of Research, Oakland, CA, USA

### Abstract

**Aims**—Our aim was to examine the associations of alcohol consumption with six diabetes self-care behaviours.

**Methods**—We determined levels of alcohol consumption and examined associations between alcohol consumption and six self-care behaviours in 65 996 adults with diabetes who received care through Kaiser Permanente Northern California and who responded to a 1994–1997 survey. Adherence with recommendations for self monitoring of blood glucose, HbA<sub>1c</sub> testing, and diabetes medications were determined from electronic records; smoking and use of diet and exercise to treat diabetes were self reported. Multiple logistic regression models were used to determine the associations between alcohol consumption (average number of drinks/day in the past year) and the probability of adherence to each self-care behaviour.

**Results**—Current alcohol consumption was reported by 50.8% of adults with diabetes. In adjusted models, we observed a gradient of increasing risk for poor adherence to diabetes self-care behaviours with increasing alcohol consumption, starting with those who consume even one drink a day. Former drinkers had the greatest compliance with each self-care behaviour, except for current smoking.

**Conclusions**—Alcohol consumption is a marker for poorer adherence to diabetes self-care behaviours. These findings highlight the importance of routine assessment of alcohol intake in people with diabetes, particularly as half of adults with diabetes consume alcohol. Given extant evidence that moderate alcohol intake may have cardiovascular benefits for patients with diabetes, examination of the trade-offs between cardiovascular benefits vs. potential risk of lower adherence with self-care behaviours deserves study.

### Keywords

adherence; alcohol; blood glucose; diet; exercise

### Introduction

Diabetes is a significant and growing health problem worldwide. In the USA, the prevalence of diabetes is 7%, and this figure continues to grow in parallel with the prevalence of obesity [1]. Diabetes is a strong risk factor for cardiovascular disease and end-stage renal disease, is the most common cause of blindness among working-age adults, and is responsible for half of non-traumatic lower extremity amputations in the USA [2–8]. In 2002, per capita medical expenditures for people with diabetes in the USA were \$13 243, compared with \$2560 for persons without diabetes and total direct medical expenditures exceeded \$91 billion [9].

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Correspondence to: Ameena T. Ahmed MD MPH, Kaiser Permanente Division of Research, 2000 Broadway, Oakland, CA 94612, USA.  
E-mail: Ameena.T.Ahmed@kp.org.

Competing interests  
None declared.

Self-care behaviours are considered a cornerstone of diabetes care, and are important determinants of diabetes disease course. Appointment keeping [10], self monitoring of blood glucose [10,11], exercise [12,13], diet [13,14], and adherence to medication regimen [15,16] have all been shown to be associated with better glycaemic control, as measured by HbA<sub>1c</sub>, an important predictor of diabetes complications [17–21].

While half of all people aged 12 years or older in the USA currently consume alcohol [22], little is known about the patterns of alcohol use among people with diabetes, or how alcohol use is related to diabetes self-care behaviours. The prevalence of alcohol abuse and dependence in the general US population were 4.7 and 3.8%, respectively, in 2001–2002 [23]. It is unknown whether people with diabetes have a similarly high prevalence of alcohol consumption and alcohol use disorders compared with the general population. While the relationship between alcohol consumption and cardiovascular outcomes has been an active focus of investigation, little research has been conducted on the relationship between alcohol consumption and self-care behaviours in people with diabetes. The purpose of this study was to determine levels of alcohol consumption and to examine the cross-sectional associations between levels of alcohol consumption and self-care behaviours (use of exercise and diet as treatment for diabetes, medication-taking adherence, self-monitoring of blood glucose, HbA<sub>1c</sub> testing, and smoking) in a large, representative sample ( $n = 65\,996$ ) of persons with diabetes who receive care in a non-profit, group model, integrated medical care setting, Kaiser Permanente Northern California.

## Patients and methods

### Setting

The Kaiser Permanente Northern California Medical Care Program (KP) is a non-profit, group practice, prepaid, health plan that is one of the largest and oldest integrated, group model health plans in the USA. KP currently provides comprehensive medical services in 17 hospitals and 32 outpatient clinics to ~3.2 million health-plan members in a 14-county region of Northern California, including the San Francisco Bay and Sacramento metropolitan areas. Approximately 30% of the population in the catchment area are members of KP. The sociodemographic characteristics of KP members are representative of the underlying population, except with respect to income, where the very poor and very wealthy are somewhat under-represented relative to the general population [24–26]. The ethnic composition is quite close to that of the US census-enumerated population in the Bay Area, Metropolitan Statistical Area (MSA): 7% African American vs. 9% in the underlying MSA population, 10 vs. 11% Asian/Pacific Islander, 10 vs. 14% Hispanic, and 71 vs. 64% Caucasian. The health plan maintains comprehensive administrative and clinical electronic databases that are linked through a unique medical record number assigned to each member at enrolment.

This study was approved by the Kaiser Permanente Institutional Review Board.

### Source population

The Kaiser Permanente Northern California Diabetes Registry (the ‘registry’), for which methods have been described previously [11,17,27–33], has been maintained continuously since its establishment in October 1993. The registry is a well-characterized population used for the study of the epidemiology and health services aspects of diabetes. Registry eligibility is based on multiple sources of case ascertainment including pharmacies (prescriptions for diabetic medications), laboratories (HbA<sub>1c</sub>  $\geq 7\%$ ), and outpatient, emergency room and hospital admission records listing a diagnosis of diabetes. The registry was 99.5% sensitive for diagnosed diabetes (compared with survey-derived self report) in January 2003. All automated clinical information (pharmacy, laboratory, outpatient and inpatient diagnoses and

procedures, outpatient visits with providers, and hospital admissions) is downloaded annually to provide a comprehensive, longitudinal follow-up of each registry member.

In an attempt to collect data not captured electronically, such as self-care and lifestyle behaviours, diabetes symptoms, type of diabetes and family history, all members of the KP Diabetes Registry were surveyed by mail and computer-assisted telephone interview in 1994–1997. A total of 77 722 persons responded, yielding an 83% response rate. Survey respondents were asked to report frequency of alcohol intake (days per month, in the past year) and usual consumption (number of drinks usually consumed on a day of any intake, during the past year). We include the 65 996 survey respondents who completed a version of the survey that asked for report of alcohol intake. We exclude from analysis the 11 726 survey respondents who did not respond to the first wave of mailed surveys and who then completed a shortened version of the survey that did not include questions about alcohol consumption.

We also characterized neighbourhood-level (census block group) socio-economic status by geocoding each member's address, and linking each to 1990 census-derived neighbourhood characteristics, including average annual per capita income and proportion in a working-class profession. Type of diabetes was determined from self-reported characteristics, using a published algorithm [11].

### Alcohol consumption and self-care behaviours

Survey respondents were asked to report frequency of alcohol intake (days per month, in the past year) and usual consumption (number of drinks usually consumed on a day of any intake, during the past year). From these data, we calculated average daily alcohol consumption, our exposure of interest. Survey-derived self-reported alcohol consumption is a reliable measure of alcohol intake, and mailed survey and interview have been demonstrated in previous studies to yield comparable results [34–37]. Cigarette smoking (current, former, never), use of exercise as treatment for diabetes, and use of diet for treatment of diabetes were also self reported in the survey.

Compliance with then-current American Diabetes Association recommendations for self-monitoring of blood glucose (SMBG) was determined among the subset of patients who were taking insulin or oral glucose-lowering medications at the time of the survey. SMBG frequency was based on a validated measure of strip utilization [11,29]. No recommendations for SMBG frequency had been promulgated for those whose diabetes was controlled without the use of medication. Among people with Type 1 diabetes, testing of blood glucose at least three times daily was recommended; for medication-treated Type 2 diabetes, testing at least once daily was recommended. In order to account for occasionally forgetting to test, we considered average use of at least 2.5 test strips/day in Type 1 diabetes and at least 0.75 test strips/day in Type 2 diabetes to be in compliance with recommendations. We employed a standard algorithm [38] to determine medication-taking adherence. We defined poor medication refill adherence as having been without sufficient oral glucose-lowering medications at least 20% of the days of the calendar year of survey response. We also determined HbA<sub>1c</sub> testing within 1 year prior to baseline. HbA<sub>1c</sub> testing can be considered a self-care behaviour, as the test is typically requested by physicians at least annually, and patients with diabetes can obtain an HbA<sub>1c</sub> test without a health-care provider's laboratory request (i.e. without a clinic visit) in several Kaiser facilities. Thus, much of the variation in testing rates is likely to be attributable to patient follow-through. Testing for HbA<sub>1c</sub> was determined from computerized laboratory records.

### Statistical methods

A series of increasingly saturated logistic regression models were specified to assess the associations of alcohol consumption with each diabetes self-care behaviour. We first specified

sex- and age-adjusted models for each behaviour (model 1). In addition to alcohol consumption, age and sex, model 2 controlled for socio-economic indicators: self-reported ethnicity and educational attainment, and per cent working class in the 1990 census block group of residence. Model 3 included all the variables of model 2, plus clinical variables [duration of diabetes; obesity (body mass index  $\geq 30$ )]. Model 4 included all the variables of model 3, plus use of diabetes pharmacotherapies (oral glucose-lowering medications, insulin). Model 5 included all the variables of model 4, plus past chronic renal failure and cardiovascular disease (ischaemic heart disease, congestive heart failure, peripheral vascular disease, stroke). We included these variables in model 5 in order to control for the possibility that those with lower alcohol consumption might have decreased alcohol consumption because they already had complications of diabetes. We included these potential confounders based on preliminary analyses demonstrating that each was associated both with average alcohol consumption and with at least one of the self-care behaviours. Given that adherence to each self-care behaviour was a common outcome, odds ratios would be a biased measure of association [39]. We therefore relied on predicted probabilities of adherence at each level of alcohol consumption as our measure of effect.

## Results

### Evaluation of response bias

Over 93% of survey respondents answered both questions regarding alcohol consumption. Compared with the 61 511 subjects who answered both questions, the 4485 subjects who did not answer one or both alcohol consumption questions were older and more likely to be female, non-white, have no more than a high-school education, and to live in a working-class neighbourhood ( $P < 0.001$  for all comparisons). These 4485 were also more likely to have Type 1 diabetes, have had diabetes for a longer duration, have hypertension and use anti-hypertensive medication ( $P < 0.001$ ); have peripheral neuropathy ( $P = 0.03$ ); and less likely to be obese ( $P < 0.001$ ) or use medications to treat dyslipidaemia ( $P = 0.02$ ). The prevalence of current smoking was not significantly different between those who did and did not answer the alcohol questions.

### Study subject characteristics

Selected characteristics of study subjects are presented in Table 1. Approximately half consumed alcohol during the past year. Twenty-eight per cent were former drinkers and 21% lifetime abstainers. Forty-three per cent consumed less than one alcohol-containing drink per day, 4.6% consumed 1–1.9 drinks/day, 1.5% consumed 2–2.9 drinks/day, and only 1.6% consumed three or more drinks per day. Non-drinkers were older, more likely to live in predominantly working-class neighbourhoods, and more likely to have no more than a high-school education than those who consumed any quantity of alcohol. Heavy alcohol drinkers ( $\geq 3$  drinks/day) had the highest prevalence of hypertension and peripheral neuropathy; the lowest frequency of long-standing ( $> 20$  years) diabetes; the lowest percentage of women; and the lowest frequency of use of insulin, lipid-lowering medications, and anti-hypertensive agents (among those with hypertension).

### Self-care behaviours

Predicted probability of adherence to recommended self-care behaviours by level of alcohol consumption are presented in Fig. 1. For each of the self-care behaviours, we present predicted probabilities for the age- and sex-adjusted model (model 1) and the most saturated model (model 5). There was very little confounding, and thus model adjustment resulted in only trivially different results. For each of the six self-care behaviours we examined, we found a gradient of compliance across level of alcohol consumption: those who consumed greater quantities of alcohol were less likely to comply with recommended self-care behaviours than

those who consumed less. Former drinkers were the most likely to be compliant with each of the recommended self-care behaviours, except use of exercise to treat diabetes (consumers of < 1 drink/day were most likely to exercise) and current smoking (lifetime alcohol abstainers were least likely to smoke). The behaviour pattern of lifetime alcohol abstainers was similar to that of consumers of low levels of alcohol (< 1 drink/day).

## Discussion

We found that people with diabetes in this insured population reported lower levels of current alcohol consumption than those that have been reported by the general US adult population. The prevalence of any alcohol consumption in the past year was 50.8% in adults with diabetes, compared with 61.9% reported in the 2002 National Health Interview Survey [40]. This difference appeared to be as a result of the higher prevalence of former drinkers among people with diabetes compared with the general population (28.0 and 15.0%, respectively), as the prevalence of lifetime abstainers was nearly identical (21.2 and 22.1%, respectively). This suggests that people with diabetes may have curtailed their alcohol consumption because of declining health, perceived risk of alcohol on diabetes course [41,42] or because of physician advice to limit alcohol intake [43–46].

Alcohol use was associated with key self-care behaviours that are important for the health of patients with diabetes. We observed a gradient of increasing risk for poor adherence to diabetes self-care behaviours with increasing alcohol consumption, starting with those who consume even one drink a day. For use of exercise and smoking abstinence, we found statistically significant differences between lifetime abstainers and consumers of less than one drink a day and, for SMBG adherence, we found statistically significant differences between former drinkers and consumers of less than one drink a day. Former drinkers had the greatest compliance with each self-care behaviour, except current smoking. Our findings confirm those of previous investigators that former drinkers and lifetime abstainers have a different profile of risk behaviours [47]. Former drinkers may include those who stopped drinking as a result of a perceived or actual worsening of diabetes disease course.

Our findings might be explained by alcohol consumption being a marker for a set of disadvantageous health-related behaviours. Alcohol use has been shown to be inversely associated with frequency of outpatient visits in the insured population from which the patients in our study were drawn [48]. Alternatively, the disinhibitory effects or expectations of alcohol might explain poor adherence among regular, heavy drinkers. However, dis-inhibition would be less likely to explain differences among patients with low vs. moderate levels of alcohol consumption.

This is the largest study to date to examine the association of alcohol consumption with self-care behaviours within an ethnically diverse cohort of patients with diabetes. Because we had a high survey response rate of 83% and the demographic composition of our study population was representative of the general population, our findings are likely to reflect general patterns in insured patients with diabetes. Our findings extend those of past studies that found alcohol consumption was related to poorer compliance with diabetes self-care behaviours in more limited populations, including 154 older men treated at a Veterans Administration clinic [49], 176 patients treated in a tertiary-care clinic in Mexico City [50], and 392 minority patients at inner-city primary care clinics [51]. The finding that alcohol consumption was consistently associated with poorer adherence with each of six diabetes self-care behaviours strengthens our conclusion that excess alcohol consumption may be detrimental to the health-care behaviours that improve control of diabetes.

Our study had several limitations. This cross-sectional study was designed to assess associations, not causation. Our study was not designed to determine the prevalence of alcohol use disorders. As with all human studies of the relationship between alcohol consumption and behaviours, randomization was not possible. Heavy alcohol consumption is likely to be a marker for a larger set of adverse health-care behaviours and risk factors. We relied on self report of alcohol consumption. If some of the heavy drinkers underreported their levels of alcohol consumption, this would have created a conservative bias (i.e. an underestimate of the gradient of association).

Our study findings have methodological implications for epidemiological studies of the effects of alcohol consumption on physiological outcomes such as glycaemic control, dyslipidaemia, and cardiovascular events. As an example, moderately increased alcohol consumption has been associated with lower risk of cardiovascular events, despite its associations with lower adherence to self-care behaviours. Thus, the estimates of the effect of alcohol consumption on cardiovascular events will be conservatively biased unless they control for confounding as a result of self-care behaviours, given that increasing alcohol consumption is associated with lower adherence to self-care behaviours, which in turn is associated with poorer glycaemic control, a predictor of diabetes complications.

We observed modestly reduced adherence to recommended self-care behaviours even in people with low to moderate alcohol consumption. Furthermore, this alcohol-behaviour gradient persisted even after adjustment for a wide variety of socio-economic, disease severity, and treatment variables. Our study highlights the importance of alcohol consumption as a marker and potential risk factor for poorer adherence to diabetes self-care behaviours. This suggests that diabetes health-care providers should routinely ask their patients about alcohol consumption and be aware that heavy consumption may be a marker for poor self-care behaviours, as well as for increased risk of alcohol use disorders.

Further study is warranted to assess whether physician advice to decrease alcohol consumption among heavy drinkers is associated with improved adherence to self-care recommendations and reduced risk for diabetes complications. Additionally, given the evidence that low to moderate alcohol intake may have cardiovascular benefits for patients with diabetes [52–57], examination of the trade-offs between cardiovascular benefits vs. risk of lower adherence with self-care behaviours is needed. Similarly, clinical recommendations for alcohol consumption among people with diabetes need to balance the clinical benefits of moderate consumption and the potential risks of lowered adherence to self-care behaviours.

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### Abbreviations

KP, Kaiser Permanente Northern California Medical Care Program; MSA, Metropolitan Statistical Area; SMBG, self-monitoring of blood glucose.

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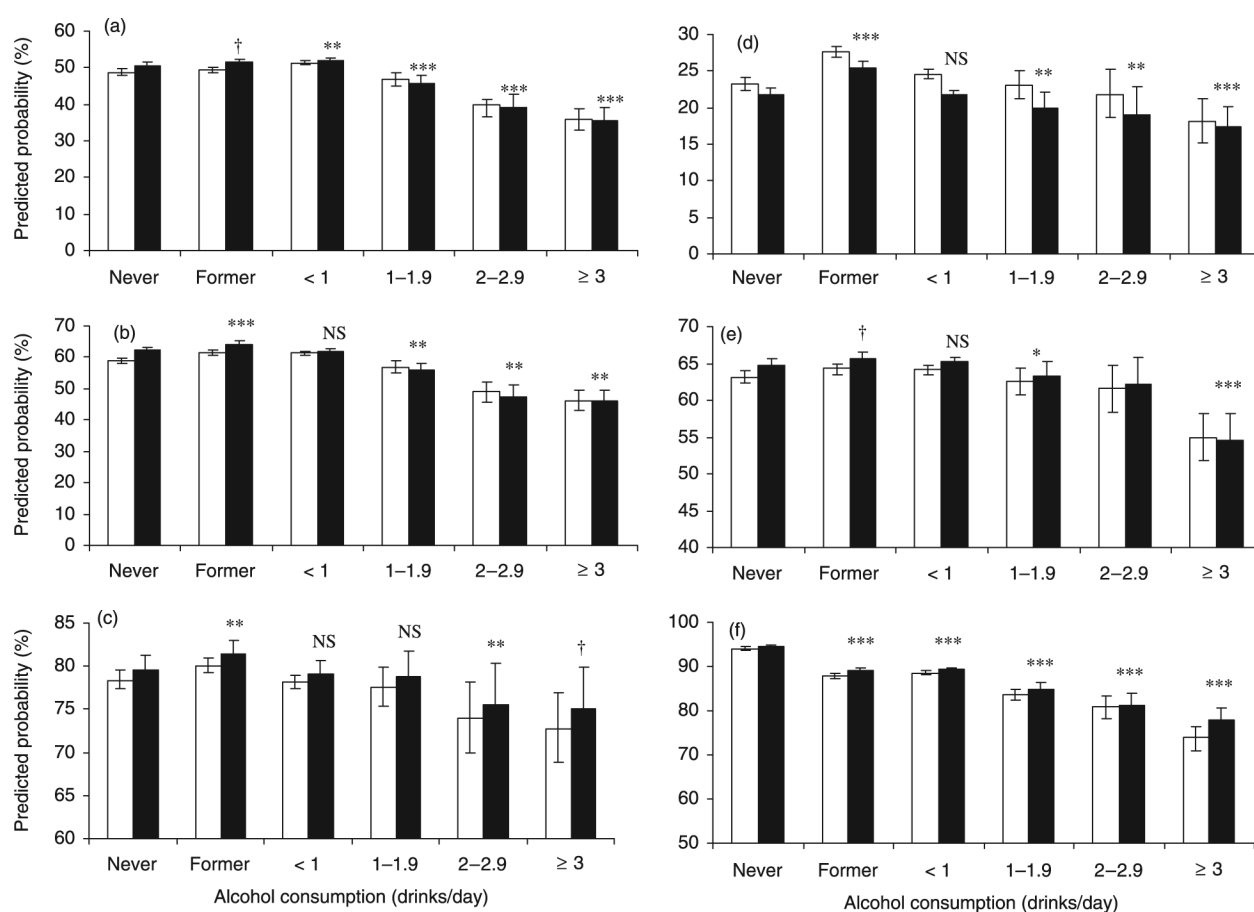


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**Figure 1.**

Predicted probability of adherence to each of six diabetes self-care behaviours, by average daily consumption of alcohol-containing drinks in the past year: (a) Use of exercise to treat diabetes; (b) use of diet to treat diabetes; (c) non-adherence to oral glucose-lowering medications; (d) adherence to self monitoring of blood glucose recommendations; (e) no HbA<sub>1c</sub> testing; (f) current smoking. Model 1 (white bar) is adjusted only for age and sex, model 5 (black bar) is adjusted for age, sex, ethnicity, education, per cent working class in census block group, obesity, duration of diabetes, use of insulin, use of oral glucose lowering medications, prior chronic renal failure, and prior hospital admission for cardiovascular disease. *P*-values: NS, *P* > 0.10, † *P* = 0.10, \* *P* = 0.05, \*\* *P* = 0.01, \*\*\* *P* < 0.001 for comparison with lifetime abstainers.

Table 1

Patient characteristics for Kaiser Permanente members with diabetes (1994–97 survey responders; 83% response rate), by self-reported average daily number of alcohol-containing drinks consumed in the past year

	Lifetime abstainer	Former drinker	Average daily number of alcohol-containing drinks consumed in the past year				Entire cohort
			<1	1–1.9	2–2.9	≥3	
<b>n</b>	13 067	17 219	26 553	2806	895	971	61 511
<b>Demographic and socio-economic characteristics</b>							
Mean age (SD; years)	60.8 (13.3)	60.8 (12.3)	57.1 (13.5)	59.6 (12.5)	59.4 (11.4)	56.5 (11.5)	59.1 (13.1)
Female (%)	69.6	47.2	41.1	20.3	12.4	8.6	47.0
Ethnicity (%)							
White	48.7	57.9	63.9	73.6	69.5	67.1	59.6
African-American	11.9	14.6	10.6	9.0	8.3	9.9	11.9
Latino	8.5	8.4	8.3	7.2	9.5	10.2	8.4
Asian	21.9	8.3	7.4	3.6	4.6	2.1	10.4
Other	9.0	10.8	9.9	6.6	8.1	10.7	9.7
> 66% working-class neighbourhood (%)	44.9	44.5	36.9	31.2	35.8	39.2	40.5
Education: high-school graduate or less (%)	51.7	51.5	37.7	34.2	36.8	48.7	44.5
<b>Clinical characteristics</b>							
Type of diabetes (%)							
Type 1	3.4	2.9	6.6	7.6	5.6	5.4	4.9
Type 2	94.2	94.9	90.1	88.1	91.3	91.1	92.2
Unsure	2.4	2.6	3.3	4.3	3.1	3.5	3.0
Duration of diabetes (%)							
< 10 years	59.1	61.2	66.8	62.7	62.9	69.3	63.4
10–19 years	25.0	24.1	20.7	22.5	22.7	22.0	22.7
≥ 20 years	15.9	14.7	12.5	14.8	14.4	10.7	13.9
Hypertension (self report, %)	64.3	64.5	58.5	61.3	65.3	68.8	61.8
Peripheral neuropathy (%)	30.8	34.3	28.4	26.5	33.3	35.9	30.6
Uses oral glucose-lowering agents (%)	56.7	58.2	54.5	52.3	56.2	57.0	55.4
Uses insulin (%)	32.2	31.7	28.9	26.6	23.2	22.9	29.5
Uses anti-hypertensive agents (%)	58.6	59.0	51.8	54.4	53.3	53.7	55.4
Uses lipid-lowering drugs (%)	13.1	13.3	13.4	13.6	13.7	10.4	13.2
Obesity, BMI ≥ 30 kg/m <sup>2</sup> (%)	39.5	43.3	42.2	29.1	30.4	33.7	41.0