

## Research Article

# Cell-Phone Use and Self-Reported Hypertension: National Health Interview Survey 2008

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**Background.** Cell-phone usage has increased dramatically over the last decade, along with a rising public concern over the health effects of using this device. The association between cell-phone usage and hypertension has not been examined before. **Methods.** We analysed data from 21,135 adults aged  $\geq 18$  years who participated in the 2008 National Health Interview Survey. Based on reported cell-phone use, participants were categorized as cell-phone nonusers, predominantly landline users, dual users of cell phone and landline, and predominantly cell-phone users. The main outcome of interest was self-reported physician-diagnosed hypertension ( $n = 6,793$ ). **Results.** 43.5% of the participants were cell-phone nonusers, while 13.8% were predominantly cell-phone users. We found that cell-phone use was inversely associated with hypertension, independent of age, sex, race/ethnicity, smoking, alcohol consumption, education, body mass index (BMI), and physical activity. Compared to cell-phone nonusers, the multivariable odds ratio (95% confidence interval) of hypertension was 0.86 (0.75–0.98,  $P$  trend = .005) among predominantly cell-phone users. This inverse association between cell-phone use and hypertension was stronger in women, those aged  $< 60$  years, whites, and those with BMI  $< 25$  kg/m<sup>2</sup>. **Conclusion.** We found that cell-phone usage was protectively associated with self-reported hypertension in a nationally representative sample of US adults.

## 1. Introduction

It has been reported that there are more than 285 million subscribers to cell-phone services in the US in 2009, which is more than a twofold increase from 110 million in 2000 [1]. This dramatic rise of cell-phone usage has also led to concerns over their possible adverse effects on human health. While cell phones may exert both thermal and nonthermal influences on the user, the latter has been under particular scrutiny. Cell phones transmit pulsed, radiofrequency radiation from their antennas and from circuit elements inside [2, 3]. Because cell phones are held against the head, many studies have examined the risk that these phones pose on the brain, including cognitive function [4, 5] and sleep [6]. Concerns over microwave radiation effects have mainly

spurred research into the relation between cell-phone usage and brain tumours, including acoustic neuroma, glioma, and meningioma. While some results have shown significant associations with several types of brain tumours [7, 8], most have shown a null association [9–11].

However, it is not clear if cell-phone usage is related to cardiovascular diseases (CVD). Some occupational studies have shown that chronic exposure to low-intensity electromagnetic field (EMF) is associated with increased risk of cardiac arrhythmias, acute myocardial infarction, cardiovascular mortality [12], and alteration of diurnal variation of blood pressure [13, 14], but others have not found such an association [15–18].

Hypertension is a common vascular condition [19] that is a strong and independent risk factor for CVD

[20]. A German study in 1998 found that cell-phone usage was associated with an increase in resting blood pressure [21]. The independent expert group on mobile phones hypothesized that radiation from the cell phone may possibly affect the cardiovascular centers of the brainstem or the carotid body receptors involved in the control of blood pressure [3]. In contrast, studies from former Soviet Union reported that exposure to radiofrequency radiation might reduce blood pressure and heart rate alterations and low-dose EMF therapy might be beneficial in treating hypertension and angina pectoris [22]. Given the dramatic increase in cell-phone usage in the past decade, it would be of interest to further investigate the effect of using cell phones on hypertension. In this context, we examined the association between mobile-phone usage and occurrence of hypertension in a large, representative sample of US adults.

## 2. Methods

The data for this study is derived from the 2008 National Health Interview Survey (NHIS). The details of the study design, questionnaire, and methods are available online [23]. In brief, NHIS is a multistage probability sample of the civilian, noninstitutionalized population of US adults. Blacks, Hispanics, and Asians were oversampled to provide stable estimates of these groups. Information on household telephone status was obtained for 12,597 households that include one civilian adult or child. The current study is based on the sample adult core component of the NHIS survey, administered by in-person interview to randomly selected civilian adults, aged  $\geq 18$  years. Of the 21,781 adults interviewed, after excluding participants who were pregnant ( $n = 221$ ), those with missing information on cell-phone status ( $n = 90$ ), and on certain other variables included in the multivariable analysis ( $n = 335$ ), 21,135 were available for the current analysis.

The main outcome of interest in the current study was physician-diagnosed hypertension ascertained by an affirmative response to the question, "have you ever been told by a doctor or other health professional that you had hypertension, also called high blood pressure?" Cell-phone use was assessed from the following question asked to the survey respondent from each family: "do you or anyone in your family have a working cell phone?" Participants who had no working cell phone in the family were classified as cell-phone nonusers. Of those living in a household with both landline and cell phone, those who received very few or no calls on cell phones and mostly on landlines, were classified as predominantly landline users; those who received some on cell phone and some on landline phones were classified as dual users of cell phone and landline; those who received all or almost all calls on cell phones were classified as predominantly cell-phone users. Information on demographic factors, socioeconomic characteristics, lifestyle characteristics, and health status were obtained through a standardized questionnaire.

We examined the association between cell-phone use and hypertension in two logistic regression models: (1) the

age- (years) sex-adjusted model and (2) the multivariable-adjusted model, additionally adjusting for race/ethnicity, cigarette smoking, alcohol intake, body mass index (BMI), physical activity, education, and landline use. We then examined the association between cell-phone use and hypertension in subgroups of age, gender, race/ethnicity and BMI categories. Linear trends were tested using categories of cell phone use as an ordinal variable in the corresponding logistic regression model. Interactions between cell-phone use and other covariates including age, gender, race/ethnicity, BMI were examined by introducing cross-product interaction terms between cell-phone use and the covariate examined, one at a time, in the corresponding multivariable model. Likelihood ratio tests were used to assess the statistical significance of an interaction between cell phone use and a covariate. All analyses were weighted to account for the complex survey design and survey nonresponse using SUDAAN (version 8.0; Research Triangle Institute, Research Triangle Park, NC) and SAS (version 9.2; SAS Institute, Cary, NC) software.

## 3. Results

Table 1 shows the characteristics of the study participants by cell-phone usage status. 43.5% of the participants were cell-phone nonusers and 13.8% were predominantly cell-phone users. Compared to subjects who were cell-phone nonusers, predominantly cell-phone users were younger, more likely to be current drinkers, or to be educated at a level higher than high school, less likely to be current smokers or physically active. Further, predominantly landline users were older, more likely to be females or non-Hispanic whites.

Figure 1 shows the prevalence of hypertension by categories of cell-phone use. The group with the highest prevalence was the predominantly landline users followed by cell-phone nonusers, dual users, and predominantly cell-phone users respectively. Table 2 shows the association between cell phone use and hypertension. Increasing categories of cell-phone usage was found to be inversely associated with hypertension in both the age-, sex-adjusted model ( $P$  trend  $< .0001$ ), and the multivariable-adjusted model ( $P$  trend = .005).

Tables 3, 4, 5, and 6 show the association between cell-phone use and hypertension in subgroups of age, gender, race/ethnicity, and BMI categories. Similar to the main findings in Table 2, an inverse association was observed between cell-phone use and hypertension within subgroups of age, gender, race/ethnicity, and BMI. Although there was no statistically significant interaction by age ( $P$  interaction = .99), gender ( $P$  interaction = .98), race/ethnicity ( $P$  interaction = .24), and BMI ( $P$  interaction = .07), the association was stronger in women, those aged  $< 60$  years, whites, and those with BMI  $< 25$  kg/m<sup>2</sup>.

## 4. Discussion

In a contemporary sample of US adults, we found that cell-phone usage was inversely associated with self-reported hypertension independent of age, sex, race/ethnicity,

TABLE 1: Characteristics of the participants by cell-phone use.

Characteristic	Cell-phone Nonusers (n = 9,190)	Predominantly landline users (n = 3,606)	Dual users of cell phone and landline (n = 5,420)	Predominantly Cell-phone users (n = 2,919)	P value
Age, years	44.52 ± 0.34	53.89 ± 0.42	45.98 ± 0.27	40.80 ± 0.43	<.0001
Female, %	49.90 ± 0.68	54.34 ± 1.01	51.44 ± 0.80	50.90 ± 1.15	.004
Smoking categories,%					<.0001
Never smoker	55.86 ± 0.70	54.23 ± 1.05	60.80 ± 0.86	60.51 ± 1.06	
Current smoker	25.79 ± 0.62	18.47 ± 0.82	16.46 ± 0.64	19.05 ± 0.91	
Former smoker	18.34 ± 0.51	27.29 ± 0.87	22.74 ± 0.73	20.44 ± 0.88	
Alcohol intake, %					<.0001
Never drinker	23.53 ± 0.64	20.68 ± 0.89	19.90 ± 0.70	15.67 ± 0.84	
Former drinker	15.55 ± 0.53	17.93 ± 0.69	12.56 ± 0.56	10.49 ± 0.68	
Current light drinker	38.75 ± 0.70	41.55 ± 1.01	45.58 ± 0.82	49.11 ± 1.13	
Current moderate drinker	14.62 ± 0.47	13.71 ± 0.70	15.84 ± 0.65	16.53 ± 0.77	
Current heavy drinker	6.21 ± 0.33	5.05 ± 0.45	4.70 ± 0.36	6.91 ± 0.65	
Unknown drinking status	1.34 ± 0.14	1.09 ± 0.19	1.41 ± 0.22	1.29 ± 0.28	
Race/ethnicity, %					<.001
Non-Hispanic whites	63.54 ± 0.82	76.24 ± 0.85	71.61 ± 0.85	66.01 ± 1.15	
Non-Hispanic blacks	13.86 ± 0.59	8.72 ± 0.48	10.36 ± 0.56	11.48 ± 0.77	
Mexican Americans	16.45 ± 0.59	9.92 ± 0.59	11.35 ± 0.59	15.43 ± 0.82	
Others	6.16 ± 0.35	5.13 ± 0.43	6.68 ± 0.40	7.08 ± 0.57	
Education categories					<.0001
<high school	21.43 ± 0.64	14.39 ± 0.76	11.16 ± 0.59	9.74 ± 0.79	
high school	29.35 ± 0.68	31.23 ± 0.99	25.43 ± 0.74	22.39 ± 1.02	
>High school	49.22 ± 0.82	54.38 ± 1.03	63.42 ± 0.87	67.87 ± 1.18	
Physical activity, %	53.18 ± 0.78	45.08 ± 1.05	42.57 ± 1.09	38.74 ± 1.30	<.0001
Body mass index, kg/m <sup>2</sup>	29.65 ± 0.20	30.12 ± 0.29	29.78 ± 0.21	28.92 ± 0.25	.2

Data presented are row percentages or mean values ± SE.

\*P value represents differences in means (SD) or proportions, using analysis of variance or Chi-square test.

TABLE 2: Association between cell-phone use and hypertension.

Cell-phone use	Sample size	Weighted prevalence, % <sup>†</sup>	Age-adjusted OR (95% CI)	Multivariable OR (95% CI)*
Hypertension				
Cell-phone nonusers	9190	32.71	1 (Referent)	1 (Referent)
Predominantly landline users	3606	43.01	0.99 (0.89–1.09)	1.05 (0.92–1.19)
Dual users of cell phone and landline	5420	29.48	0.85 (0.78–0.94)	0.92 (0.82–1.04)
Predominantly cell-phone users	2919	21.86	0.78 (0.69–0.88)	0.86 (0.75–0.98)
P (trend)			<.0001	.005

\* Adjusted for age (years), sex (female or male), ethnicity (non-Hispanic white, non-Hispanic blacks, Mexican Americans, or others), smoking categories (never, former, or current), alcohol intake (never drinker, former drinker, current light drinker, current moderate drinker, current heavy drinker, or unknown drinking status), body mass index (kg/m<sup>2</sup>), education (<high school, high school, or >high school), landline use (absent or present), and moderate physical activity (times/week).

<sup>†</sup>All estimates were weighted to account for the complex survey design and survey nonresponse, using the sample adult record weight, to represent the U.S. civilian noninstitutionalized population aged ≥18 years.

smoking, alcohol consumption, BMI, education, physical activity, and landline use. This inverse association between cell-phone usage and hypertension was found to be stronger in women, those aged <60 years, whites, and those with BMI < 25 kg/m<sup>2</sup>. This is the first study to examine the association between cell-phone use and hypertension in a population-based sample of US adults.

In the current study, we used self-reported hypertension to define the presence of hypertension, since NHIS did not have measured blood pressure. We believe that this is an important study limitation, since recent estimates from the US National Health and Nutritional Examination Surveys suggest that nearly 22% of truly hypertensive subjects are unaware of their condition [24]. This lack of

TABLE 3: Association between cell-phone use and hypertension by age groups.

Cell-phone use	Sample size	Weighted prevalence, %	Age-adjusted OR (95% CI)	Multivariable OR (95% CI)*
Age < 60 years ( <i>n</i> = 15336)				
Cell-phone nonusers	6600	20.55	1 (Referent)	1 (Referent)
Predominantly landline users	1938	26.83	0.93 (0.80–1.07)	0.98 (0.84–1.16)
Dual users of cell phone and landline	4183	21.04	0.77 (0.68–0.88)	0.85 (0.74–0.99)
Predominantly cell-phone users	2615	18.05	0.73 (0.63–0.84)	0.82 (0.70–0.96)
<i>P</i> (trend)			<.0001	.004
Age ≥ 60 years ( <i>n</i> = 5799)				
Cell-phone nonusers	2590	63.71	1 (Referent)	1 (Referent)
Predominantly landline users	1668	61.81	1.00 (0.86–1.16)	1.16 (0.88–1.53)
Dual users of cell phone and landline	1237	58.04	0.87 (0.74–1.01)	0.99 (0.75–1.32)
Predominantly cell-phone users	304	54.61	0.77 (0.58–1.02)	0.88 (0.61–1.27)
<i>P</i> (trend)			.02	.1

\* Adjusted for sex (female or male), ethnicity (non-Hispanic white, non-Hispanic blacks, Mexican Americans, or others), smoking categories (never, former, or current), alcohol intake (never drinker, former drinker, current light drinker, current moderate drinker, current heavy drinker, or unknown drinking status), body mass index (kg/m<sup>2</sup>), education (<high school, high school, or >high school), landline use (absent or present), and moderate physical activity (times/week); *P* interaction = 0.99.

† All estimates were weighted to account for the complex survey design and survey nonresponse, using the sample adult record weight, to represent the U.S. civilian noninstitutionalized population aged ≥18 years.<sup>1</sup>

TABLE 4: Association between cell-phone use and hypertension by gender.

Cell-phone use	Sample size	Weighted prevalence, %	Age-adjusted OR (95% CI)	Multivariable OR (95% CI)*
Men ( <i>n</i> = 9,310)				
Cell-phone nonusers	4218	28.92	1 (Referent)	1 (Referent)
Predominantly landline users	1444	42.31	1.12 (0.94–1.33)	1.07 (0.87–1.31)
Dual users of cell phone and landline	2343	30.35	0.98 (0.86–1.11)	0.95 (0.81–1.12)
Predominantly cell-phone users	1305	23.22	0.88 (0.74–1.04)	0.87 (0.72–1.06)
<i>P</i> (trend)			.1	.09
Women ( <i>n</i> = 11,825)				
Cell-phone nonusers	4972	35.92	1 (Referent)	1 (Referent)
Predominantly landline users	2162	43.48	0.88 (0.78–1.00)	1.05 (0.87–1.26)
Dual users of cell phone and landline	3077	28.83	0.75 (0.66–0.86)	0.90 (0.75–1.08)
Predominantly cell-phone users	1614	20.76	0.70 (0.59–0.83)	0.84 (0.68–1.04)
<i>P</i> (trend)			<.0001	.03

\* Adjusted for age (years), ethnicity (non-Hispanic white, non-Hispanic blacks, Mexican Americans, or others), smoking categories (never, former, or current), alcohol intake (never drinker, former drinker, current light drinker, current moderate drinker, current heavy drinker, or unknown drinking status), body mass index (kg/m<sup>2</sup>), education (<high school, high school, or >high school), landline use (absent or present), and moderate physical activity (times/week); *P* interaction = .98.

† All estimates were weighted to account for the complex survey design and survey nonresponse, using the sample adult record weight, to represent the U.S. civilian noninstitutionalized population aged ≥18 years.

blood pressure measurement may have resulted in outcome misclassification. Since hypertension status was assessed independently of a person's cell-phone use, we believe that this misclassification is more likely to be nondifferential and likely to underestimate a true association. However, we cannot entirely rule out the possibility that our findings are overestimate; that is, there is actually no protective association between cell-phone use and hypertension if there were no bias.

Few experimental studies have examined the association between cell-phone usage and blood pressure [21, 25]. Braune et al. noted a significant increase in systolic and diastolic BP in a small group of ten healthy volunteers exposed to EMF from a global system for satellite communications (GSM) cell phone compared with placebo exposure [21]. Vangelova et al. reported significantly higher levels of systolic and diastolic blood pressure in a group of 100 broadcasting and TV station operators exposed to EMF [25].

TABLE 5: Association between cell-phone use and hypertension by race/ethnicity.

Cell-phone use	Sample size	Weighted prevalence, %	Age-adjusted OR (95% CI)	Multivariable OR (95% CI)*
Whites ( <i>n</i> = 12,796)				
Cell-phone nonusers	5100	34.61	1 (Referent)	1 (Referent)
Predominantly landline users	2498	43.88	1.02 (0.91–1.15)	1.08 (0.92–1.26)
Dual users of cell phone and landline	3480	29.83	0.87 (0.78–0.97)	0.93 (0.80–1.09)
Predominantly cell-phone users	1718	21.42	0.73 (0.63–0.85)	0.81 (0.68–0.96)
<i>P</i> (trend)			<.0001	.003
Others ( <i>n</i> = 8,339)				
Cell-phone nonusers	4090	30.34	1 (Referent)	1 (Referent)
Predominantly landline users	1108	41.06	0.97 (0.81–1.17)	0.97 (0.78–1.20)
Dual users of cell phone and landline	1940	28.87	0.83 (0.70–0.98)	0.86 (0.71–1.04)
Predominantly cell-phone users	1201	22.48	0.88 (0.72–1.09)	0.93 (0.74–1.18)
<i>P</i> (trend)			.05	.3

\* Adjusted for age (years), sex (female or male), smoking categories (never, former, or current), alcohol intake (never drinker, former drinker, current light drinker, current moderate drinker, current heavy drinker, or unknown drinking status), body mass index (kg/m<sup>2</sup>), education (<high school, high school, or >high school), landline use (absent or present), and moderate physical activity (times/week); *P* interaction = .24.

† All estimates were weighted to account for the complex survey design and survey nonresponse, using the sample adult record weight, to represent the U.S. civilian noninstitutionalized population aged ≥18 years.

TABLE 6: Association between cell-phone use and hypertension by body mass index (BMI) categories.

Cell-phone use	Sample size	Weighted prevalence, %	Age-adjusted OR (95% CI)	Multivariable OR (95% CI)*
BMI < 25 kg/m <sup>2</sup> ( <i>n</i> = 7,691)				
Cell-phone nonusers	3540	23.39	1 (Referent)	1 (Referent)
Predominantly landline users	1136	31.78	0.95 (0.77–1.16)	1.05 (0.80–1.37)
Dual users of cell phone and landline	1889	17.95	0.79 (0.64–0.97)	0.86 (0.67–1.12)
Predominantly cell-phone users	1126	11.55	0.62 (0.48–0.81)	0.69 (0.51–0.94)
<i>P</i> (trend)			.0002	.007
BMI ≥ 25 kg/m <sup>2</sup> ( <i>n</i> = 13,444)				
Cell phone nonusers	5650	38.55	1 (Referent)	1 (Referent)
Predominantly landline users	2470	48.18	0.94 (0.83–1.06)	0.98 (0.85–1.14)
Dual users of cell phone and landline	3531	35.66	0.84 (0.75–0.94)	0.89 (0.77–1.03)
Predominantly cell-phone users	1793	28.33	0.84 (0.73–0.97)	0.89 (0.76–1.04)
<i>P</i> (trend)			.0007	.05

\* Adjusted for age (years), sex (female or male), ethnicity (non-Hispanic white, non-Hispanic blacks, Mexican Americans, or others), smoking categories (never, former, or current), alcohol intake (never drinker, former drinker, current light drinker, current moderate drinker, current heavy drinker, or unknown drinking status), education (<high school, high school, or >high school), landline use (absent or present), and moderate physical activity (times/week); *P* interaction = .07.

† All estimates were weighted to account for the complex survey design and survey nonresponse, using the sample adult record weight, to represent the U.S. civilian noninstitutionalized population aged ≥18 years.

Previous studies examining the relation between occupational EMF exposure and cardiovascular diseases have shown mixed results. While majority of the studies have shown a null association [11, 15–18], some have shown a positive association [12, 26], and one has shown a protective association [27]. Savitz et al. reported a positive association between occupational EMF exposure and cardiovascular mortality in a large cohort of 138,903 male electric utility workers from five US companies [12]. Sastre et al. found that exposure to intermittent 60-Hz magnetic fields reversibly reduces the normal variability of the heart rate in laboratory studies of volunteers [26]. Solenova et al. reported lower levels

of all-cause and cardiovascular mortality in TV workers exposed to EMF [27].

In the current study, cell-phone usage was found to be protectively associated with hypertension. It is possible that the effects of cell-phone usage could reduce BP due to an increase in parasympathetic activity and reduction in sympathetic activity originating in the brainstem [28]. Another possibility is that cell phones increase and sustain the social networks of the users, reducing stress and establishing greater connectedness of the users with their communities. This has been previously reported to be protectively associated with cardiovascular disease mortality [29, 30], and following this,



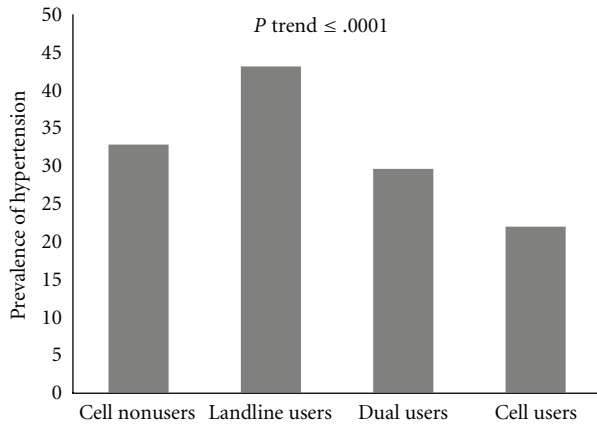


FIGURE 1: Prevalence of self-reported hypertension by cell-phone use categories.

we hypothesize that it may reduce the risk of hypertension as well. Finally, it is possible that our findings are due to chance. There is a need for longitudinal studies to examine the effect of cell-phone usage on longitudinal changes in blood pressure and hypertension development to refute or validate our findings. Future studies should also examine if there are differential effects for different mobile technologies such as GSM and code division multiple access (CDMA) phones.

The strengths of our study include a large sample size and availability of information on potential confounders. Our study has several limitations. First, as discussed above, our assessment of cell-phone usage and hypertension through self-reported questionnaire data may have resulted in misclassification bias. Second, a measure of blood pressure as a continuous variable would have greatly increased the impact of this study. We recommend that future studies examining the association between cell-phone use and hypertension should include measured blood pressure in addition to self-reported hypertension diagnosis to confirm if our findings are true. Third, we do not have information on EMF exposure from other sources (including cordless phones, radio, television, and microwave oven) that could potentially confound the association between cell phone and hypertension. Fourth, the lack of information on frequency and duration of calls limits any “dose response” to be evaluated. Fifth, while the large sample size allows for correction of potential confounders, it is possible that cell-phone use is different in categories of age, gender, race/ethnicity, and physical activity all of which are known to influence the prevalence of hypertension. Finally, the cross-sectional nature of the study limits any temporal relationship to be ascertained.

In conclusion, we found that cell-phone usage was inversely associated with self-reported hypertension in a nationally representative sample of US adults. Future research should investigate this relationship in prospective studies to provide more insight into the association.

### Conflict of Interests

There are no conflict of interests related to this paper.

### Guarantor Statement

“The guarantor, A. Shankar, accepts full responsibility for the work and/or the conduct of the study, had access to the data, and controlled the decision to publish”.

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