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Abstract

Objective: To determine whether long-term and increased intake of baked or boiled potatoes, French fries or potato chips is associated with the incidence of hypertension. This association is important, especially with recent changes lifting the restriction on starchy vegetables serving in school lunches and allowing white potatoes in food packages of nutrition programs for women and children (up to 5 years of age).

Design: Prospective longitudinal cohort studies.

Setting: Healthcare providers in the United States.

Participants: 62,175 women in Nurses' Health Study, 88,475 women in Nurses' Health Study II and 36,803 men in Health Professionals Follow-up Study who were non-hypertensive at baseline.

Main Outcome Measures: Incident cases of hypertension. A healthcare provider diagnosis of hypertension is self-reported.

Results: Compared with consumption of <1 serving/month, the pooled hazard ratios for ≥4 serving/week were 1.11 (95% CI: 1.04-1.19) for baked, boiled or mashed potatoes, 1.17 (1.07-1.27) for French fries, and 0.98 (0.95-1.02) for potato chips. In substitution analyses, replacing one serving/day of baked, boiled or mashed potatoes with one serving/day of non-starchy vegetables was associated with decreased hypertension risk (hazard ratio=0.93 [0.89-0.96]).

Conclusion:

Higher intake of baked, boiled or mashed potatoes and French fries was independently and prospectively associated with an increased risk of developing hypertension in three large cohorts of adult men and women.

Introduction:

Government agencies within the United States have established several programs in the last decade to provide healthy meals to children and to low-income populations [1 2], including the Healthy, Hunger-Free Act of 2010 (a school lunch program) and the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) [3]. The Healthy, Hunger-Free Act initially restricted the provision of starchy vegetables to one cup/week; in 2009,the WIC program offered a monthly fruit and vegetable cash-value voucher that excluded white potatoes [4].

However, opposition from several state and local school lunch operators led to a removal of the restriction on starchy vegetables (including French fries) in school lunches in 2012 [5] and, based upon an Institute of Medicine report requested by Congress [6], the restriction on white potatoes in the WIC fruit and vegetable cash-voucher was lifted in 2015. The rationale for removing these limitations on potatoes included their high potassium content and insufficient evidence on their health effects [6].
On the international front, the World Health Organization (WHO) does not include potatoes as vegetables[7].

Although potassium supplementation may be beneficial for chronic disease prevention, in particular prevention of hypertension[8], a 6 week feeding trial of 164 prehypertensive and hypertensive individuals found that diets rich in protein or monounsaturated fat reduced blood pressure (BP) compared with diets rich in carbohydrates[9]. Because potatoes are high in both glycemic carbohydrates and potassium, their impact on hypertension risk is unclear; the long-term association of high potato intake with the risk of developing hypertension has not been examined. We therefore examined the prospective, independent association of baked, boiled or mashed potatoes, French fries and potato chips consumption with incident hypertension in three large cohort studies that included 187,453 participants with more than 20 years of follow-up.

Methods:

Study Population

We used data from the Nurses' Health Study (NHS, N=121,700 women, aged 30-55 at the time of cohort inception in 1976), the Nurses' Health Study II (NHS II, N=116,430 women, aged 25-42 at cohort inception in 1989), and the Health Professionals Follow-up Study (HPFS, N =51,529 men, aged 40-75 at cohort inception in 1986). Participants returned a questionnaire every two years with health status updates, including information about hypertension diagnosed by a health-care provider. Also, participants of NHS answered an extensive semi-quantitative food frequency questionnaire (FFQ) in 1984, 1986, and then every four years thereafter; participants of NHS II and HPFS answered similar FFQs every four years starting in 1991 (in NHS II) and 1986 (HPFS). The validity and reproducibility of these FFQs, which ascertain intake of more than 130 foods and beverages, has been detailed previously [10 11]. After excluding participants who did not provide dietary information and those who reported a diagnosis of hypertension at the baseline FFQ (1984, 1991, and 1986 for NHS, NHS II, and HPFS, respectively), the study population consisted of 62,175 women in NHS, 88,475 women in NHS II and 36,803 men in HPFS.

The Institutional Review Board of Brigham and Women's Hospital approved the study. Participants provided implied consent by voluntarily returning their questionnaires.

Assessment of Hypertension

A diagnosis of hypertension by a health professional was self-reported on the baseline and biennial questionnaires. Studies in the three cohorts were performed to validate this method of hypertension diagnosis [12-14]. In NHS, 77% of 51 cases of self-reported hypertension had a BP >160/95 mmHg and a 100% had a BP >140/90 mmHg; none of the women who did not report a diagnosis of hypertension were found to be hypertensive by medical record review. In HPFS, out of 114 participants without a self-report of hypertension, only two were found to have hypertension[14]. In a review of randomly chosen participants who self-reported a diagnosis of hypertension in NHS II and HPFS, 94% and 100% were confirmed to have hypertension,

respectively [12-14]. As this analysis was prospective, participants with self-reported hypertension at baseline questionnaire were excluded from our study. Incident cases of hypertension were included those who reported a diagnosis of hypertension on subsequent questionnaires with a date of diagnosis that was after the baseline questionnaire.

Assessment of Potato Intake

In 1984, 1991 and 1986, a detailed FFQ was sent to all participants in NHS, NHS II and HPFS, respectively. Approximately every four years thereafter, similar FFQs were sent out to update habitual dietary intake. Participants answered how often, on average over the past year, they consumed each food in a standard portion size. Nine different response categories could be selected, ranging from "never or less than once a month" to "6 or more a day". Three questions on the FFQ ascertained potatoes: baked, boiled potatoes (1) or mashed (1 cup), French fries (4 oz. or 1 serving) and potato or corn chips (small bag or 1 oz.). In previous validation studies, the deattenuated Pearson correlations between potato intake reported on FFQs and on multiple one-week dietary records (considered the gold-standard) were 0.69 for baked, boiled or mashed potatoes, 0.56 for French fries and 0.55 for potato chips [15 16].

Assessment of Covariates

Updated information about weight, smoking status, physical activity (estimated as metabolic equivalent tasks [METs]) was obtained on biennial questionnaires. Body mass index (BMI) was calculated as weight (in kg) divided by height squared (in m). Potential dietary confounders were also ascertained on the FFQs, such as alcohol, whole grains, total caloric intake, total whole fruit and vegetable intake, and consumption of sugar-sweetened and artificially-sweetened beverages and animal flesh (red and processed meat, poultry, and fish). These covariates have been validated with correlation coefficients of, for example, 0.97 for weight, 0.79 for physical activity and 0.90 for alcohol [17 18]. Race was self-reported.

Statistical Analysis

As the month and year of the hypertension diagnosis by a health professional was provided by participants, we used an interval-censoring model by calculating each participant's person-time (in months) from the date of the baseline questionnaire to the date of hypertension diagnosis, date of death, or end of follow-up (2010 for NHS and HPFS, and 2011 for NHS II), whichever came first.

We used a cumulative average of a participant's intake to decrease within-person variation. Consumption of baked, broiled or mashed potatoes, French fries, and potato chips were grouped into 4 categories, from "≤1 serving/month" to "≥ 4 servings/week". We also analyzed a variable that combined intake of baked, broiled or mashed potatoes and French fries, which we grouped into 5 categories: "<1 serving/month", "1-3 servings/month", "1-3 servings/week", "4-6 servings/week", and "≥1 serving/day".

We then used Cox proportional hazards regression to calculate the hazard ratios (HRs) and 95% confidence intervals for incident hypertension, using "<1 serving/month" as the reference group for all analyses. We adjusted for the following potential confounders, updating them as time-varying covariates using information from successive questionnaires: age; BMI; change in weight; race/ethnicity (white, African-American, Asian, Hispanic, other); family history of hypertension; smoking status (current/past); physical activity (METs per week); post-menopausal status; oral contraceptive use (in NHS II); use of non-narcotic analgesics (nonsteroidal antiinflammatory drugs, acetaminophen, and aspirin); total energy intake (kcal/day); intakes of alcohol (g/day), total whole fruits and total vegetables, animal flesh, whole grains, and sugar-sweetened and artificially-sweetened beverages. Adjusted multivariable HRs for the three cohorts were pooled using fixed effects meta-analysis. We then calculated the attributable fraction of hypertension in NHS II (the cohort closest in age to participants of the WIC program) using the following formula:

$$\mathrm{AF}\,\% = \left[\frac{\mathrm{HR}-1}{\mathrm{HR}}\right] pd \times 100$$

where *pd* is the proportion of cases exposed the risk factor, which here represents potatoes consumption[19].

We then performed substitution analyses to determine whether replacing one serving/day of baked, broiled or mashed potatoes with other starchy vegetables (peas, lima beans, corn and sweet potatoes), non-starchy vegetables, or French fries, was associated with an increased or decreased risk of developing hypertension. In these analyses, the HRs for starchy vegetables, non-starchy vegetables, or French fries represents the "effect" of replacing one serving per day of baked, boiled or mashed potatoes with one of these foods.

Several secondary analyses were then performed. First, we added intake of micronutrients (potassium, calcium, magnesium, sodium, and fiber) to our multivariable models. Second, we repeated our analyses excluding BMI and weight changes from our models. Third, we introduced trans and saturated fat into our multivariable models; polyunsaturated fat was added only into the multivariable model analyzing potato chips and hypertension. Fourth, we created a stratified model and introduced multiplicative interaction terms to our unstratified multivariable models to analyze whether the associations of potato intake with hypertension varied significantly according to age and BMI. Fifth, we repeated our analyses without cumulatively averaging participants' potato intake (ie, using simple updating). Finally, we reanalyzed the pooled HRs using random effect models. All analyses were performed with SAS software (version 9.4; SAS Institute Inc, Cary, NC). All *P* values were two-sided.

Patient Involvement

No patients were involved in setting the research question or the outcome measures, nor were they involved in developing plans for recruitment, design or implementation of the study. No patients were asked to advise on interpretation or writing up of results. There are no plans to disseminate the results of the research to study participants or the relevant patient community.

Results:

During 2,938,961 person-years of follow-up, 77,726 participants reported a diagnosis of hypertension (35,728 cases/1,034,257 person-years in NHS, 25,246 cases/1,344,475 person-years in NHS II and 16,752 cases/560,229 person-years in HPFS). Baseline characteristics for each cohort are reported in **Table 1** according to the lowest and highest intake category of baked, boiled or mashed potatoes, French fries and potato chips. Participants who consumed ≥4 servings/week of any type of potatoes were, in general, less physically active and smoked more than participants whose consumption was <1 serving/week.

In pooled analyses, participants who consumed ≥1 serving/day of either baked, boiled or mashed potatoes or French fries had an independently increased risk of incident hypertension compared with those who ate <1 serving/month of these foods with a multivariable HR of 1.12 (1.02-1.24; p-trend <0.001) (**Table 2**). The multivariable HRs for these comparisons in NHS, NHS II, and HPFS were 1.07(0.92-1.24), 1.42 (1.18-1.72), and 0.96 (0.79-1.16), respectively.

Baked, boiled or mashed potatoes were associated with an increased adjusted risk of developing hypertension when intake of ≥4 servings/week was compared with <1 serving/month in NHS (HR=1.13 [1.02-1.26]; p-trend=0.01) and NHS II (HR=1.25 [1.11-1.41]; p-trend<0.001), but not in HPFS (HR=0.95 [0.84-1.08]; p-trend=0.46). The pooled HR comparing extreme categories in all three cohorts was 1.11(1.04-1.19; **Table 3**).

Increasing consumption of French fries (≥4 servings/week as compared with <1 serving/month) was associated with an increased risk of hypertension in all three cohorts (**Table 4**) with multivariable HRs of 1.17(0.92-1.50) in NHS, 1.17 (1.04-1.33) in NHS II, 1.16(1.00-1.33) in HPFS, and a pooled HR of 1.17(1.07-1.27; p-trend<0.001). Potato chips were not associated with an increased risk of hypertension in NHS and NHS II; in HPFS however, participants consuming ≥4 servings/week of potato chips had a lower risk of developing hypertension (HR = 0.86 [0.79-0.93]; p-trend=0.004) (**Table 5**). Also, increased consumption of potato chips was associated with an increased risk of hypertension in NHS II (HR=1.24 [1.16-1.32]; p-trend<0.001) when age-adjusted, but not when a multivariate model was used (HR=1.02 [0.96-1.09]; p-trend=0.61). This loss of significance was primarily due to confounding by BMI (**Table 5**).

In the younger women (NHS II), the hypothetical fraction of new-onset hypertension attributable to the consumption of >1 serving/month of total potatoes was 12.8%, suggesting that this proportion of hypertension incidence might have been prevented had these young women not consumed baked, boiled or mashed potatoes or French fries.

Adjusting for sodium intake and other micronutrients, such as potassium, magnesium, calcium and fiber, did not materially alter our results. Removing BMI and weight change from the multivariable models did not change our results, nor did adding trans, saturated, and polyunsaturated fat. There were no consistent interactions between any type of potato intake and either BMI or age. Using simple updating rather than cumulative averaging to analyze the association of potato intake with hypertension yielded similar findings. Pooled HRs did not materially change when using random effect models as compared with fixed effect models.

Substitution analyses are reported in **Table 6**. Replacing one serving/day of baked, boiled or mashed potatoes with one serving/day of a non-starchy vegetable was associated with a lower adjusted pooled HR of 0.93([0.89-0.96]; p-value<0.001).

Discussion:

In three prospective cohorts of US women and men, we found that higher long term intake of baked, boiled or mashed potatoes was significantly associated with an increased risk of hypertension in women, independent of numerous other hypertension risk predictors including dietary factors such as whole grain, and whole fruit and vegetable intake. In addition, higher consumption of French fries was associated with incident hypertension in all three cohorts, whereas potato chip intake was associated with no increased risk. To our knowledge, this study is the first to examine potato consumption and the incidence of hypertension.

The association of potato intake with hypertension is a critical public health issue in the United States, in large part because potatoes have recently been inserted into government sponsored food programs[6]. The primary, the justification for their inclusion into food programs is the potential cardiovascular benefits generated by their high potassium content, which in turn is primarily justified by beneficial effects on blood pressure. Specifically, the IOM and the USDA recommended white potatoes to be allowed as part of the fruit and vegetable cash-voucher WIC program, and most states have already implemented this regulation. The IOM report emphasized potatoes' high potassium, which are desired features of foods for the WIC population [6], and high potassium intake has been associated with a lower blood pressure. In a meta-analysis of 22 randomized controlled trials, for example, increased potassium intake (as a supplement) produced a 3.5 mmHg reduction in systolic blood pressure and 2.0 mmHg reduction in diastolic blood pressure in hypertensive individuals [8].

However, we found that higher potato intake was associated with an increased, rather than decreased risk of developing hypertension. One potential mechanism that could explain our findings is the high glycemic load (GL) associated with potatoes. Boiled white potatoes have a high GL of 21 [20]. The GL is a measurement that reflects how a serving of a specific food affects glucose level in the human body. It is obtained from multiplying the grams of carbohydrates in a food times the glycemic load of the food, divided by 100 (glycemic index compares 50 grams of a specific food to 50 grams of glucose is reported on a scale of 0 to 100, with higher scores given to a food with the most rapid glucose rise)[21 22]. The subsequent postprandial

hyperglycemia that follows a high glycemic load meal has been associated with endothelial dysfunction, oxidative stress and inflammation, all potentially important mechanisms in the development of hypertension [23-25]. The potential adverse consequence of a high carbohydrate intake, and therefore a higher glycemic load, on blood pressure in prehypertensive and hypertensive individuals was examined in the OMNIHEART trial [9]. Compared with a carbohydrate-rich diet, both a protein-rich diet and a diet rich in unsaturated fat lowered systolic and diastolic blood pressure by 1.4/3.5 mmHg and 1.3/2.9 mmHg, respectively, at 6 weeks.

Weight gain associated with potato intake is another potential mechanism for the development of hypertension [26 27]. As an example, in a prospective analysis of diet with weight change in the NHS, NHS II, and HPFS, each additional daily serving of potato chips and potatoes was strongly associated with 4-year weight change (1.7 and 1.3 lbs, respectively) [28]. However, we controlled for both weight change and BMI in our multivariable models, reducing the likelihood that our findings are explained simply by changes in adiposity (we also removed weight change and BMI from our models and our results were mostly unchanged). Because excess adiposity is a strong risk factor for hypertension, our analyses that adjusted for adiposity likely underestimated the long term adverse effects of potatoes on risk of hypertension.

We found a few differences between the women and the men cohorts. There was an increased risk of hypertension with increasing consumption of boiled, baked or mashed potatoes in both female cohorts, but not in the male cohort. These findings, as well as the lack of association of potato chips with the incidence of hypertension in HPFS were unexpected. While there was a nonsignificant trend towards a higher risk of developing hypertension in women with increased consumption, men had a lower hypertension incidence with greater long-term potato chips intake. Men who consumed more potato chips were slightly younger and leaner, although we adjusted for these variables in our analysis. Most brands of potato chips are currently produced using monounsaturated and polyunsaturated fats instead of trans and saturated fats, which could be considered healthier [29]. In a randomized double-blind 4-week/3-week crossover trial, for example, participants consuming potato chips fried in highly oleic sunflower oil (which is very high in monounsaturated fat) had reduced low-density-lipoprotein cholesterol (LDL)

compared with participants who consumed potato chips fried in palmolein, an oil high in saturated fats [30]. However, controlling for polyunsaturated fat in secondary analyses did not eliminate the inverse association of potato chips with hypertension in men.

The present study has several limitations. First, random misclassification of potato intake could have taken because all dietary assessment methods are imperfect; however, this type of random error in exposure assessment would tend to attenuate our findings and therefore underestimate the true association. Second, participants self-reported a diagnosis of hypertension and direct blood pressure measurements were not obtained. Yet our method of hypertension ascertainment (self-report by trained health professionals of similar educational backgrounds) has been extensively validated in all three cohorts[12-14]. Third, our population consists mostly of non-Hispanic white individuals of a relatively uniform socioeconomic status. However, there is no reason to suspect that the biological response to diet is qualitatively different across ethnic groups. Fourth, as with any observational study, our findings could be explained by residual confounding; for example, potatoes are often consumed with salt and added fat (such as butter or margarine). The increased sodium content could explain the association of boiled/baked potatoes with hypertension. However, our results did not materially change after we adjusted for sodium intake or trans and saturated fat.

We also controlled for numerous known and proposed hypertension risk factors that were collected in a prospective fashion. Further, the relative uniformity of socioeconomic status reduces the likelihood of confounding by unmeasured variables.

In conclusion, we found independent prospective associations of higher intake of baked, broiled potatoes and French fries with an increased risk of hypertension. These findings have potentially important public health ramifications, since they do not support a potential benefit from the inclusion of potatoes as vegetables in government food programs, but instead support a harmful impact that is consistent with adverse effects of high carbohydrate intakes in controlled feeding studies.

Footnotes

We thank participants and staff of the Nurses' Health Study, the Nurses' Health Study II and the Health Professionals Follow-up Study for their valuable contributions.

Contributors: LB and JFP designed this study. LB was involved in data collection. WCW, ERB and JFP provided statistical expertise. LB analyzed the data and wrote the first draft of the manuscript. All authors helped with the interpretation of the results and approved the final version of the manuscript. LB had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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Competing interests: all authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years, no other relationships or activities that could appear to have influenced the submitted work.

Ethical approval: The study protocol was approved by the institutional review boards of the Brigham and Women's Hospital, and the Harvard School of Public Health. By virtue of voluntarily returning their questionnaires, participants provided implied consent.

Data sharing: No additional data available.

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Transparency Declaration: Dr. Borgi confirms that the manuscript is an honest, accurate and transparent account of the reported study.

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Table 1: Baseline characteristics of participants in the Nurses' Health Study, Nurses' Health Study II and the Health Professionals Follow-up Study. Values are median (interquartile range) or percentages unless stated otherwise.

Nurses' Health Study†	Baked, boiled or mashed potatoes		French Fries		Potato Chips	
	<1 per month	≥4 per week	<1 per month	≥4 per week	<1 per month	≥4 per week
Age (years)	51 (45-57)	51 (45-57)	52 (47-58)	46 (41-53)	53 (47-58)	45 (41-51)
White (%)	90	96	95	94	94	96
Body Mass Index	23.5 (21.2-25.8)	23.2 (21.4-26.1)	23.3 (21.4-25.8)	24.3 (21.5-27.4)	23.4 (21.5-25.8)	23.0 (20.9-26.1)
Physical Activity (METs/w)	9.1 (2.9-21.7)	6.5 (2.4-16.5)	9.3 (3.2-21.0)	7.1 (1.9-17.4)	8.8 (20.9-3.0)	6.1 (2.1-15.9)
Current Smokers (%)	24	25	21	29	23	32
Family History of HTN (%)	40	42	41	39	40	46
Nurses' Health Study 2¥	**Baked, boiled or mashed potatoes**		**French Fries**		**Potato Chips**	
	<1 per month	≥4 per week	<1 per month	≥4 per week	<1 per month	≥4 per week
Age (years)	40 (35-45)	44 (39-49)	44 (39-50)	40 (36-45)	43 (38-49)	43 (38-48)
White (%)	83	96	94	93	93	94
Body Mass Index	23.0 (21.0-26.2)	24.7 (21.9-28.9)	23.3 (21.1-26.5)	26.1 (22.6-31.8)	23.4 (21.3-26.9)	24.0 (21.5-28.3)
Physical Activity (METs/w)	14.2 (4.8-31.5)	12.0 (4.5-26.3)	17.5 (7.4-34.7)	7.7 (2.3-19.6)	15.9 (6.4-33.1)	22.4 (9.9-41.5)
Current Smokers (%)	10	11	8	15	9	13
Family History of HTN (%)	48	49	49	50	49	48

	Baked, boiled or mashed potatoes		French Fries		Potato Chips	
Health Professionals Follow-up Study[§]	<1 per month	≥4 per week	<1 per month	≥4 per week	<1 per month	≥4 per week
Age (years)	53 (45-61)	55 (47-63)	56 (48-64)	45 (41-53)	57 (49-64)	46 (42-55)
White (%)	82	94	91	92	91	93
Body Mass Index	24.8 (23.2-26.6)	24.4 (23.0-26.5)	24.4 (23.0-26.4)	25.1 (23.5-27.3)	24.7 (23.1-26.5)	24.4 (22.9-26.2)
Physical Activity (METs/w)	12.6 (3.3-30.1)	12.1 (4.1-29.6)	15.3 (5.0-33.4)	7.5 (1.9-20.1)	13.9 (4.5-31.3)	10.4 (3.1-27.1)
Current Smokers (%)	10	9	7	17	8	11
Family History of HTN (%)	30	30	31	32	33	35

† Baseline for Nurses' Health Study is 1984.

¥ Baseline for Nurses' Health Study II is 1991.

§ Baseline for Health Professionals Follow-up Study is 1986.

Table 2: Pooled hazard ratios (95% confidence intervals) for incident hypertension for total potatoes (baked, boiled or mashed potatoes and French fries) consumption in Nurses' Health Study, Nurses' Health Study II and Health Professional Follow-up Study

	Consumption Levels					
	<1 per month	**1-3 per month**	**1-3 per week**	**4-6 per week**	**≥ 1 per day**	**Linear P Trend**
NHS * (cases/persons-years)	291/10,480	4,527/143,881	18,286/516,243	12,085/344,911	539/18,743	
Age-adjusted HR	1.00(reference)	1.02(0.90-1.14)	1.08(0.96-1.22)	1.13(1.00-1.27)	1.09(0.94-1.25)	<0.001
Multivariate-adjusted HR§	1.00	1.00(0.89-1.13)	1.05(0.93-1.18)	1.09(0.97-1.23)	1.07(0.92-1.24)	<0.001
NHS II † (cases/persons-years)	156/13,108	2,065/127,696	13,635/752,459	8,947/430,729	443/20,484	
Age-adjusted HR	1.00	1.03(0.87-1.21)	1.24(1.05-1.45)	1.49(1.27-1.75)	1.90(1.58-2.28)	<0.001
Multivariate-adjusted HR§	1.00	1.04(0.88-1.22)	1.13(0.96-1.32)	1.23(1.04-1.44)	1.42(1.18-1.72)	<0.001
HPFS‡ (cases/persons-years)	156/6004	1918/67,267	7958/261,776	6,304/209,045	416/16,138	
Age-adjusted HR	1.00	0.93(0.79-1.10)	0.94(0.80-1.10)	0.96(0.82-1.13)	0.89(0.74-1.07)	0.49
Multivariate-adjusted HR§	1.00	0.96(0.81-1.13)	0.99(0.84-1.16)	1.01(0.86-1.19)	0.96(0.79-1.16)	0.20
Pooled Results¶						
Age-adjusted pooled HR	1.00	1.00(0.91-1.08)	1.08(1.00-1.17)	1.17(1.08-1.27)	1.20(1.09-1.33)	<0.001
Multivariate-adjusted pooled HR	1.00	1.00(0.92-1.09)	1.05(0.97-1.14)	1.10(1.02-1.20)	1.12(1.02-1.24)	<0.001

* Follow-up in Nurses' Health Study was from 1984 to 2012.

† Follow-up in Nurses' Health Study II was from 1991-2011.

‡ Follow-up in Health Professionals Follow-up study was from 1986 to 2012.

§ Adjusted for age, race/ethnicity (white, African-American, Asian, Hispanic, other), body mass index, current smoking status, physical activity, weight change per food frequency questionnaire cycle, menopausal status (in NHS and NHS II), alcohol intake, current oral contraceptive use (in NHS II), analgesic use (nonsteroidal antiinflammatory drugs, acetaminophen, aspirin), family history of hypertension, total energy intake, animal flesh intake (combination of processed and unprocessed red meat, poultry and seafood), whole grains (quintiles), sugar-sweetened beverage intake, artificially-sweetened diet beverage intake, total fruit, total vegetables.

¶Pooled hazard ratios of the three cohorts using a fixed effects model.

Table 3: Pooled hazard ratios (95% confidence intervals) for incident hypertension for potatoes consumption (baked, boiled or mashed) in Nurses' Health Study, Nurses' Health Study II and Health Professional Follow-up Study

	Consumption Levels				
	<1 per month	**1-3 per month**	**1-3 per week**	**≥4 per week**	**P Trend**
NHS * (cases/persons-years)	406/14,882	6,233/189,737	22,353/648,475	6,736/181,163	
Age-adjusted HR	1.00(reference)	1.07(0.97-1.19)	1.12(1.02-1.24)	1.11(1.01-1.23)	0.06
Multivariate-adjusted HR§	1.00	1.07(0.97-1.19)	1.12(1.01-1.24)	1.13(1.02-1.26)	0.01
NHS II † (cases/persons-years)	333/25,721	5,673/327,099	16,338/867,668	2,902/123,987	
Age-adjusted HR	1.00	1.07(0.96-1.20)	1.23(1.10-1.37)	1.39(1.24-1.56)	<0.001
Multivariate-adjusted HR§	1.00	1.08(0.97-1.21)	1.17(1.04-1.31)	1.25(1.11-1.41)	<0.001
HPFS‡ (cases/persons-years)	308/11,050	3,088/102,773	10,668/361,971	2,688/84,435	
Age-adjusted HR	1.00	0.90(0.80-1.01)	0.90(0.80-1.01)	0.86(0.77-0.97)	0.04
Multivariate-adjusted HR§	1.00	0.92(0.82-1.04)	0.95(0.84-1.07)	0.95(0.84-1.08)	0.46
Pooled Results¶					
Age-adjusted pooled HR	1.00	1.02(0.96-1.09)	1.08(1.02-1.15)	1.11(1.04-1.18)	<0.001
Multivariate-adjusted pooled HR	1.00	1.03(0.97-1.10)	1.08(1.02-1.15)	1.11(1.04-1.19)	<0.001

*Follow-up in Nurses' Health Study was from 1984 to 2012.
† Follow-up in Nurses' Health Study II was from 1991-2011.
‡ Follow-up in Health Professionals Follow-up study was from 1986 to 2012.
§ Adjusted for age, race/ethnicity (white, African-American, Asian, Hispanic, other), body mass index, current smoking status, physical activity, weight change per food frequency questionnaire cycle, menopausal status (in NHS and NHS II), alcohol intake, current oral contraceptive use (in NHS II), analgesic use (nonsteroidal antiinflammatory drugs, acetaminophen, aspirin), family history of hypertension, total energy intake, animal flesh intake (combination of processed and unprocessed red meat, poultry and seafood), whole grains (quintiles), sugar-sweetened beverage intake, artificially-sweetened diet beverage intake, total fruit, total vegetables.
¶Pooled hazard ratios of the three cohorts using a fixed effects model.

Table 4: Pooled hazard ratios (95% confidence intervals) for incident hypertension for French Fries consumption in Nurses' Health Study, Nurses' Health Study II and Health Professional Follow-up Study

	Consumption Levels				
	<1 per month	**1-3 per month**	**1-3 per week**	**≥4 per week**	**P Trend**
NHS * (cases/persons-years)	14,507/420,566	17,912/506,132	3,243/105,756	66/1,802	
Age-adjusted HR	1.00(reference)	1.17(1.14-1.19)	1.26(1.21-1.32)	1.42(1.11-1.81)	<0.001
Multivariate-adjusted HR§	1.00	1.08(1.06-1.11)	1.11(1.06-1.16)	1.17(0.92-1.50)	<0.001
NHS II † (cases/persons-years)	4,735/291,260	13,887/719,673	6,321/322,226	303/11,316	
Age-adjusted HR	1.00	1.23(1.19-1.27)	1.54(1.48-1.60)	2.03(1.81-2.28)	<0.001
Multivariate-adjusted HR§	1.00	1.04(1.00-1.08)	1.12(1.07-1.17)	1.17(1.04-1.33)	<0.001
HPFS ‡ (cases/persons-years)	4,723/165,247	7,994/256,288	3,817/131,730	218/6,964	
Age-adjusted HR	1.00	1.11(1.07-1.15)	1.20(1.14-1.25)	1.28(1.11-1.47)	<0.001
Multivariate-adjusted HR§	1.00	1.04(1.00-1.08)	1.08(1.02-1.14)	1.16(1.00-1.33)	0.002
Pooled Results¶					
Age-adjusted pooled HR	1.00	1.17(1.15-1.19)	1.34(1.31-1.37)	1.64(1.51-1.78)	<0.001
Multivariate-adjusted pooled HR	1.00	1.06(1.04-1.08)	1.11(1.08-1.13)	1.17(1.07-1.27)	<0.001

* Follow-up in Nurses' Health Study was from 1984 to 2012.

† Follow-up in Nurses' Health Study II was from 1991-2011.

‡ Follow-up in Health Professionals Follow-up study was from 1986 to 2012.

§ Adjusted for age, race/ethnicity (white, African-American, Asian, Hispanic, other), body mass index, current smoking status, physical activity, weight change per food frequency questionnaire cycle, menopausal status (in NHS and NHS II), alcohol intake, current oral contraceptive use (in NHS II), analgesic use (nonsteroidal antiinflammatory drugs, acetaminophen, aspirin), family history of hypertension, total energy intake, animal flesh intake (combination of processed and unprocessed red meat, poultry and seafood), whole grains (quintiles), sugar-sweetened beverage intake, artificially-sweetened diet beverage intake, total fruit, total vegetables.

¶Pooled hazard ratios of the three cohorts using a fixed effects model.

Table 5: Pooled hazard ratios (95% confidence intervals) for incident hypertension for potato chips consumption in Nurses' Health Study, Nurses' Health Study II and Health Professional Follow-up Study

	Consumption Levels				
	<1 per month	**1-3 per month**	**1-3 per week**	**≥4 per week**	**P Trend**
NHS * (cases/persons-years)	10,704/309,729	15,556/443,075	8,310/245,781	1,158/35,672	
Age-adjusted HR	1.00(reference)	1.07(1.04-1.10)	1.15(1.12-1.19)	1.11(1.04-1.18)	<0.001
Multivariate-adjusted HR§	1.00	1.02(0.99-1.04)	1.07(1.03-1.10)	1.03(0.97-1.10)	0.004
NHS II † (cases/persons-years)	3,988/242,232	11,367/581,659	8,612/457,599	1,279/62,985	
Age-adjusted HR	1.00	1.14(1.10-1.19)	1.22(1.17-1.26)	1.24(1.16-1.32)	<0.001
Multivariate-adjusted HR§	1.00	1.05(1.01-1.08)	1.05(1.01-1.09)	1.02(0.96-1.09)	0.61
HPFS ‡ (cases/persons-years)	4,533/149,730	6,730/218,121	4,747/164,415	742/27,964	
Age-adjusted HR	1.00	1.00(0.96-1.04)	1.03(0.99-1.07)	0.91(0.84-0.98)	0.19
Multivariate-adjusted HR§	1.00	0.96(0.92-0.99)	0.97(0.93-1.01)	0.86(0.79-0.93)	0.004
Pooled Results¶					
Age-adjusted pooled HR	1.00	1.07(1.05-1.09)	1.14(1.12-1.16)	1.10(1.06-1.14)	<0.001
Multivariate-adjusted pooled HR	1.00	1.01(0.99-1.03)	1.04(1.02-1.06)	0.98(0.95-1.02)	0.47

* Follow-up in Nurses' Health Study was from 1984 to 2012.

† Follow-up in Nurses' Health Study II was from 1991-2011.

‡ Follow-up in Health Professionals Follow-up study was from 1986 to 2012.

§ Adjusted for age, race/ethnicity (white, African-American, Asian, Hispanic, other), body mass index, current smoking status, physical activity, weight change per food frequency questionnaire cycle, menopausal status (in NHS and NHS II), alcohol intake, current oral contraceptive use (in NHS II), analgesic use (nonsteroidal antiinflammatory drugs, acetaminophen, aspirin), family history of hypertension, total energy intake, animal flesh intake (combination of processed and unprocessed red meat, poultry and seafood), whole grains (quintiles), sugar-sweetened beverage intake, artificially-sweetened diet beverage intake, total fruit, total vegetables.

¶Pooled hazard ratios of the three cohorts using a fixed effects model.

Table 6: Hazard ratio (95% CI) for substituting one serving of baked, boiled or mashed potato per day for starchy vegetables and non-starchy vegetables in the Nurses' Health Study I, Nurses' Health Study II and Health Professional Follow-up Study

Replacing one serving of Potato with one serving:				
	NHS	**NHS II**	**HPFS**	**Pooled HR ¶**
Starchy Vegetables §	0.99(0.91-1.07)	0.90(0.81-0.99)	1.05(0.94-1.16)	0.98(0.93-1.03) P 0.42
Non-starchy Vegetables §	0.95(0.90-1.00)	0.82(0.76-0.88)	1.01(0.94-1.09)	0.93(0.89-0.96) P<0.001

§ Adjusted for age, race/ethnicity (white, African-American, Asian, Hispanic, other), body mass index, current smoking status, physical activity, weight change per food frequency questionnaire cycle, menopausal status (in NHS and NHS II), alcohol intake, current oral contraceptive use (in NHS II), analgesic use (nonsteroidal antiinflammatory drugs, acetaminophen, aspirin), family history of hypertension, total energy intake, animal flesh intake (combination of processed and unprocessed red meat, poultry and seafood), whole grains (quintiles), sugar-sweetened beverage intake, artificially-sweetened diet beverage intake, total fruit, total vegetables.

¶Pooled hazard ratios of the three cohorts using a fixed effects model.