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Original Communication

Cooking with shea butter is associated with lower blood pressure in the Ghanaian population

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Abstract: The cardiovascular health benefits of shea butter, an edible off-white or ivory-colored fat native to West Africans has never been investigated. This is in spite of anecdotal evidence, which suggests that shea butter may have medicinal properties and its bioactive constituents lower certain cardiovascular risk markers. We hypothesized that cooking with shea butter would be associated with lower blood pressure (BP) in the Ghanaian population. Data from the 2014 Ghana Demographic and Health Survey, a nationally representative population-based survey was analyzed. A total of 9396 women aged 15-49 years and 4388 men aged 15-59 years selected from 12,831 sampled households were included in the study. Respondents with average systolic BP of ≥140 mmHg or average diastolic BP of ≥90 mmHg were classified as hypertensive. Multivariable linear and logistic regression adjusting for gender, age, area of residence, religion, ethnic group, marital status, education and wealth index was used to establish the association between shea butter consumption and BP. Overall prevalence of hypertension in the population was 15.1%. Shea butter consumption was associated with 2.43 mmHg (95% CI: −3.54, −1.31) and 1.78 mmHg (95% CI: −2.71, −0.86) decrease in systolic BP and diastolic BP, respectively, and 25% (AOR = 0.75, 95% CI: 0.55, 1.04) reduced odds of hypertension, compared to use of vegetable oils. Region of residence appeared to modify the relationship. We found an association of shea butter consumption with lower BP, which provides the rationale for investigation through rigorous study designs to evaluate the benefits of shea butter consumption for prevention of hypertension and improved cardiovascular health.

Keywords: blood pressure, cooking oil, cross-sectional, Ghana, hypertension, shea butter

Introduction

Hypertension is a major public health problem worldwide, contributing significantly to the global burden of heart disease, stroke, kidney failure, premature mortality and disability [1]. Of the total global deaths, hypertension is estimated to cause about 12.8% representing 7.5 million deaths, and accounts for 57 million disability adjusted life years [2]. Hypertension also accounts for 9.4 million of the 17 million cardiovascular deaths worldwide every year [3]. Hypertension has also being estimated to be responsible for over 45% and 51% of deaths due to heart disease and stroke, respectively [4]. In spite of their enormous medical and economic burden, hypertension has not been given the needed attention and priority especially in low-resource settings [5].

Africa records the highest prevalence of hypertension worldwide with 46% of adults estimated to have the condition [2]. In Ghana, the prevalence of adult hypertension continues to rise with estimates ranging from 19% to 48% [6]. Hypertension ranks as the third most common newly diagnosed outpatient disease among adults [7]. Hypertension has ranked in the top five outpatient diseases in Ghana for more than 15 years, accounting for 3-5% of all new outpatient diseases across all ages [7, 8]. Reported outpatient cases of hypertension in public and mission facilities in Ghana excluding teaching hospitals increased more than ten-folds from about 60,000 in 1990 to about 700,000 in 2010 [7, 8].

Increasing urbanization with its associated changing lifestyle habits including unhealthy dietary habits, increased alcohol use, smoking and low physical activity drives hypertension levels in Africa and other developing regions. Besides the consumption of foods high in sodium, use of cooking oils high in saturated fat and trans-fat is also well

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documented as an important dietary risk factor. Vegetable oils is an integral ingredient of the daily diet of many people worldwide. According to Rosillo-Calle et al. [9], about 80% of the market share for edible vegetable oils are for food preparation with the remaining 20% for industrial purposes. The most commonly used vegetable oils globally for food preparation are palm oil, soybean oil, sunflower oil and rapeseed oil. In developing countries, the commonly used vegetable oils are palm oil, palm kernel oil, coconut oil, and their refined, bleached and deodorized products and are known to be high in saturated and trans fatty acids [10–12].

Shea butter, an edible off-white or ivory-colored fat is extracted from the nut of shea tree (*Vitellaria paradoxa*) and is native to the dry savanna belt of West Africa. Anecdotal evidence suggests that, shea butter has medicinal properties. The medicinal properties of shea butter has been attributed to its unsaponifiable fraction which is composed of bioactive substances including triterpene alcohols, some hydrocarbons, sterols and vitamin E [13]. The saponifiable fraction of shea butter which constitutes about 90% of the mass of the butter [14] and composed primarily of stearic (42%) and oleic (45%) acid, and small amounts of palmitic (4%) and linoleic (6%) acids [15] have also been documented to confer cardiovascular benefits. Stearic acid, a saturated fatty acid (SFA) and the bulk (83%) of the SFA fraction of shea butter is the least harmful of all SFAs and found to lower LDL cholesterol levels [16]. Oleic acid, a monounsaturated fatty acid, has BP lowering effect [17]. Linoleic acid, a polyunsaturated fatty acid (PUFA), lowers total and LDL cholesterol, improve insulin sensitivity and protects against coronary heart disease [18, 19].

Yet, to date, no epidemiological study has been conducted to ascertain whether consumption of shea butter confers cardiovascular health benefits. We hypothesized that cooking with shea butter would be associated with lower BP in the Ghanaian population. With Ghana and other West African countries experiencing a high burden of hypertension and other cardiovascular diseases owing to the ongoing epidemiological and nutrition transition in these countries, it is important to identify and promote healthy eating habits for addressing the problem.

Materials and Methods

The study was conducted in Ghana. Ghana is located in West Africa along the Gulf of Guinea and Atlantic Ocean and covers an area of 238,535 square kilometers with a population of approximately 28 million people. Ghana is divided into 10 administrative regions and 254 administrative districts with very diverse ethnic, linguistic and religious groups.

Data from the 2014 Ghana Demographic and Health Survey (GDHS) [20], a nationally representative population-based survey was obtained from the DHS Program and analyzed for this study. A two-stage sample design was adopted by the 2014 GDHS and first involved the selection of 427 clusters consisting of enumeration areas delineated for the 2010 Population and Housing Census. These clusters were selected from the 10 administrative regions of the country and across urban (n = 216) and rural (n = 211) areas. The second stage involved the selection of about 30 households from each cluster constituting total sample size of 12,831 households.

Data collection was carried out using three questionnaires; household questionnaire, woman's questionnaire, and man's questionnaire. The household questionnaire was used to list all the members of and visitors to the selected households with the information gathered used to identify women and men eligible for individual interviews. Eligible participants had to be permanent residents of the selected households or visitors who stayed in the household the night before the survey. The woman's questionnaire was used to collect information from all eligible women aged 15-49 years. In half of the selected households, the man's questionnaire was administered to all eligible men aged 15-59 years. A total of 9396 women (response rate, 97.3%) and 4388 men (response rate, 95.2%) were interviewed for the survey.

A flow chart of the survey sampling procedure and the data collected from the study participants is depicted in Figure 1.

Ascertainment of Outcome

Three BP measurements were taken at intervals of 10 minutes or more from consenting women and men during the interviews using the LIFE SOURCE® UA-767 Plus digital oscillometric blood pressure monitor (A&D Medical, San Jose, CA, USA). The average of the second and third measurements was used to classify the respondents with respect to hypertension according to American College of Cardiology (ACC)/American Heart Association (AHA) high blood pressure guidelines. Respondents with average systolic blood pressure (SBP) of $\geq$140 mmHg or average diastolic blood pressure (DBP) of $\geq$90 mmHg were classified as hypertensive. At the time of the survey, respondents who had normal BP measurement but indicated that they have previously been diagnosed by a physician as hypertensive were also categorized as hypertensive.

Cooking Oil Choices of Participants

Information on the cooking oil choices of participants was obtained from the household questionnaire. In this

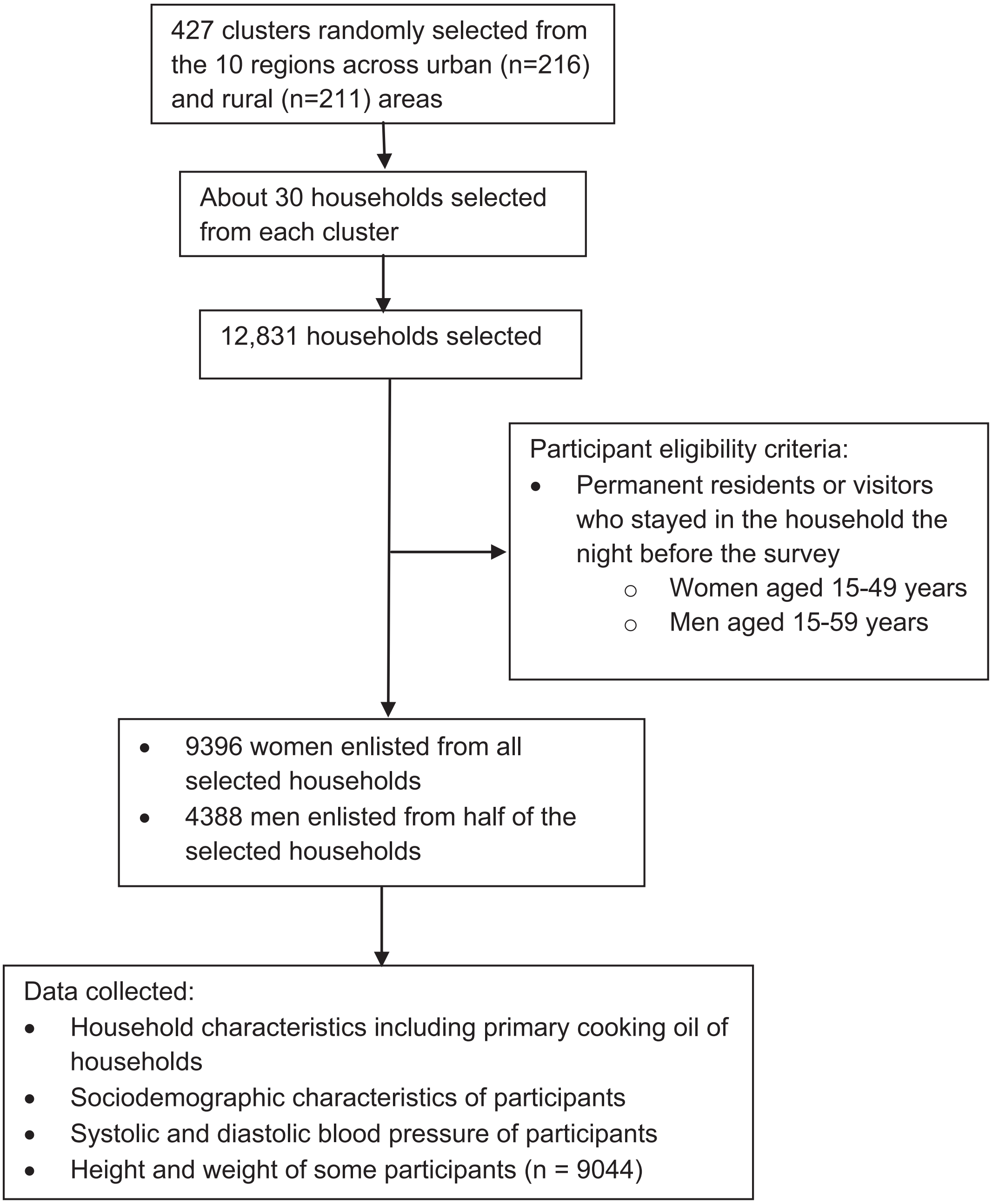

Figure 1. Flow chart of the survey sampling procedure and the data collected from the study participants

questionnaire, household heads were asked, *"What type of oil does your household mainly use for cooking?"* Participants whose households used frytol/fortified vegetable oil and other vegetable oil for cooking served as the reference category and were compared to participants whose households used red and yellow palm oil, and shea butter for cooking. Participants whose households used other cooking oils were excluded from the analysis.

Covariates

The potential confounders adjusted in the analysis were sex, age, area of residence, ethnic group, marital status, religion, education and wealth index of respondents, and body mass index (BMI).

Body mass index (BMI) was available for only a subset of the study population. The survey collected anthropometric data (height and weight) for only respondents who were eligible for providing blood samples for anemia, malaria and HIV testing. Also, among female respondents, those who were pregnant and those who had given birth in the two months preceding the survey were excluded from the BMI estimation.

Statistical Analysis

Linear regression modelling was used to estimate the effect of type of oil used for cooking on SBP and DBP. Models were adjusted for potential confounders. Multivariable logistic regression adjusting for potential confounders was used to estimate the effects of type of oil used for cooking on the risk of elevated BP. We further restricted the analysis to respondents who had information on BMI to assess the robustness of the findings. Stratified analysis was conducted to elaborate the effect modifying role of region of residence of the study participants.

We accounted for the two-stage sampling design in the analyses using the svyset function available in Stata 12.0 software to identify the survey design characteristics and prefixing all descriptive and estimation commands with svy. Stata 12.0 (Stata Corporation, College Station, TX, USA) was used to perform all the analysis.

Ethical Approval

The 2014 GDHS was conducted under the scientific and technical supervision of the Ghana Statistical Service, Ghana Health Service (GHS), National Public Health Reference Laboratory of the GHS and Noguchi Memorial Institute for Medical Research. All the survey methods and procedures were carried out in accordance with relevant guidelines and regulations of these organizations. The survey protocols were approved by ICF International through The DHS Program. Written informed consent was obtained from all subjects before the interview.

Results

The characteristics of the study population are presented in Table 1. Females constituted about two-thirds (68%) of the respondents. Mean age of the population was 30.7 years (SD: 10.6) with almost half of the respondents (49.2%) found to be within the age group 15-29 years. More than two-thirds (78%) of the respondents were Christians with Moslems constituting 16%. Half of the respondents were Akans. The proportion of the respondents who reported being married and never being married was 43% and 36%, respectively. About 16% of the respondents had no formal education with respondents educated up to the university/tertiary level or higher constituting 8%. The proportion of respondents who were unemployed was 20%. About 46% of the participants were classified as rich with 34% classified as poor.

Table 2 presents households cooking oil choices and body mass index of the study participants according to hypertensive status. Red/Yellow palm oil (48%), and frytol and other vegetable oil (42%) were the main cooking oils used by respondents' households. Shea butter was used for cooking in 9% of the respondents' households. Of the participants that provided BMI information (n = 9044), about 29% were either overweight or obese with 8% found to be underweight. The overall prevalence of elevated BP in the study area was found to be low (15.1%). The lowest proportion of elevated BP was recorded among shea butter users (4.2%).

The mean SBP and DBP (in mmHg) in the population was low; 113.60 (SD = 16.93) and 74.50 (SD = 11.84), respectively. Use of shea butter resulted in 2.43 mmHg (95% CI: −3.54, −1.31) and 1.78 mmHg (95% CI: −2.71, −0.86) decrease in SBP and DBP, respectively (Table 3). Use of red/yellow palm oil also resulted in a small decrease in DBP ($\beta = -0.69$; 95% CI: −1.33, −0.04) (Table 3). In the analysis restricted to respondents with data on BMI, the decrease in SBP and DBP with use of shea butter was slightly attenuated (Table 4).

Shea butter users were found to have 25% (Adjusted OR [AOR] = 0.75, 95% CI: 0.55, 1.04) reduced odds of elevated BP compared to their counterparts using frytol and other vegetable oils (Table 5). The confidence interval, however, included the null value. Use of palm oil was also not associated with reduced odds of elevated BP (OR = 0.88; 95% CI: 0.75, 1.04). In the analysis restricted to respondents with data on BMI (Table 6), the reduced odds of elevated BP observed among shea butter users was slightly attenuated (AOR = 0.79, 95% CI: 0.60, 1.04). Again, the confidence interval included the null value.

The cooking oil - BP relationship appears to be modified by region of residence of the respondents (Tables 7 and 8). Shea butter users residing in the three northern regions (Northern, Upper East and Upper West) were found to have decreased SBP and DBP (Table 7). Shea butter users residing in the Brong Ahafo and Upper East regions recorded statistically significant decreased odds of elevated BP (Table 8). Shea butter users residing in the Volta and Brong Ahafo regions recorded much higher decreased SBP and DBP compared to their counterparts in the northern regions. Whereas shea butter users residing in Ashanti and Western regions recorded elevated SBP and DBP (Table 7).

Table 1. Demographic and background characteristics of respondents according to hypertensive status (N = 13784)

Characteristic	Total Weighted N (%)	Hypertensive Weighted n (%) n = 2083 (15.1%)	Not hypertensive Weighted n (%) n = 11701 (84.9%)
Gender[1]			
Male	4388 (31.8)	711 (16.2)	3677 (83.8)
Female	9396 (68.2)	1372 (14.6)	8024 (85.4)
Age group (years)[2]			
15–19	2480 (18.0)	56 (2.3)	2424 (97.7)
20–29	4394 (31.2)	342 (7.8)	4052 (92.2)
30–39	3692 (26.8)	671 (18.2)	3021 (81.8)
40–49	2698 (19.6)	829 (30.7)	1870 (69.3)
50–59	519 (3.8)	185 (35.6)	335 (64.4)
Region of residence			
Western	1540 (11.2)	201 (13.0)	1339 (87.0)
Central	1358 (9.9)	177 (13.0)	1181 (87.0)
Greater Accra	2820 (20.5)	571 (20.2)	2249 (79.8)
Volta	1057 (7.7)	180 (17.0)	877 (83.0)
Eastern	1307 (9.5)	196 (15.0)	1110 (85.0)
Ashanti	2588 (18.8)	445 (17.2)	2143 (82.8)
Brong Ahafo	1133 (8.2)	139 (12.3)	993 (87.7)
Northern	1142 (8.3)	104 (9.1)	1038 (90.9)
Upper East	526 (3.8)	46 (8.8)	479 (91.2)
Upper West	314 (2.3)	24 (7.6)	291 (92.4)
Area of residence[3]			
Urban	6448 (46.8)	724 (11.2)	5724 (88.8)
Rural	7336 (53.2)	1359 (18.5)	5977 (81.5)
Religion[4]			
Christian	10714 (77.7)	1674 (15.6)	9040 (84.5)
Moslem	2194 (15.9)	285 (13.0)	1910 (87.0)
Traditional/Spiritualist	350 (2.5)	40 (11.5)	310 (88.5)
Other	4 (0.03)	0 (0.0)	4 (100.0)
No religion	521 (3.8)	84 (16.1)	437 (83.9)
Missing	1 (0.0001)		
Ethnic group[5]			
Akan	6856 (49.7)	1121 (16.4)	5735 (83.7)
Ga/Dangbe	1122 (8.1)	194 (17.2)	929 (82.8)
Ewe	1861 (13.5)	341 (18.3)	1520 (81.7)
Guan	303 (2.2)	46 (15.1)	257 (84.9)
Mole – Dagbani	2019 (14.7)	217 (10.7)	1802 (89.3)
Grussi	382 (2.8)	34 (8.8)	349 (91.2)
Gurma	800 (5.8)	60 (7.5)	740 (92.5)
Mande	133 (1.0)	10 (7.9)	123 (92.2)
Other	307 (2.2)	61 (19.9)	246 (80.1)
Missing	1 (0.0001)		
Marital status[6]			
Never married	4958 (36.0)	293 (5.9)	4665 (94.1)
Married	5861 (42.5)	1244 (21.3)	4617 (78.8)
Cohabitation	1751 (12.7)	233 (13.3)	1518 (86.7)
Widowed	283 (2.1)	80 (28.2)	204 (71.8)
Divorced	391 (2.8)	118 (30.3)	272 (69.7)
Separated	540 (3.9)	114 (21.2)	426 (78.8)

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Table 1. (Continued)

Characteristic	Total Weighted N (%)	Hypertensive Weighted n (%) n = 1911 (13.9%)	Not hypertensive Weighted n (%) n = 11873 (86.1%)
Education[7]			
None	2261 (16.4)	313 (13.8)	1949 (86.2)
Primary (1–6 years of schooling)	2262 (16.4)	307 (13.6)	1956 (86.5)
Secondary/SHS (6–13 years of schooling)	8147 (59.1)	1227 (15.1)	6920 (84.9)
Higher (≥14 years of schooling)	1114 (8.1)	237 (21.3)	877 (78.8)
Occupation			
Unemployed	2801 (20.4)	201 (7.2)	2600 (92.8)
Professional/Technical/Managerial	1053 (7.7)	233 (22.1)	820 (77.9)
Clerical	194 (1.4)	47 (24.3)	147 (75.7)
Sales	3833 (27.9)	762 (19.9)	3071 (80.1)
Agriculture – Self employed	3041 (22.1)	355 (11.7)	2686 (88.3)
Agriculture – Employed	99 (0.7)	9 (8.8)	90 (91.2)
Services	300 (2.2)	55 (18.4)	245 (81.7)
Skilled manual	1737 (12.6)	282 (16.2)	1455 (83.8)
Unskilled manual	695 (5.1)	136 (19.5)	560 (80.5)
Missing	31 (0.002)		
Wealth index[8]			
Poorest	2263 (16.4)	192 (8.5)	2072 (91.5)
Poorer	2415 (17.5)	264 (10.9)	2152 (89.1)
Middle	2773 (20.1)	395 (14.2)	2378 (85.8)
Richer	3077 (22.3)	553 (18.0)	2524 (82.0)
Richest	3255 (23.6)	680 (20.9)	2575 (79.1)

Covariates: [1]Female, [2]15-29 years, [3]Rural, [4]Christian, [5]Northern tribe (Mole – Dagbani, Grussi, Gurma and Mande), [6]Never married, [7]None/Primary and [8]Poorest served as reference category

Table 2. Households cooking oil choices and body mass index of respondents according to hypertensive status

	Total Weighted N (%)	Hypertensive Weighted n (%) n = 1911 (13.9%)	Not hypertensive Weighted n (%) n = 11873 (86.1%)
Type of cooking oil used by household			
Red/Yellow palm oil	6549 (47.5)	956 (14.6)	5593 (85.4)
Frytol/Fortified/Other vegetable oil	5781 (41.9)	997 (17.3)	4784 (82.8)
Shea butter	1183 (8.6)	81 (6.9)	1102 (93.1)
Other	59 (0.4)	4 (6.9)	55 (93.1)
Don't know	1 (0.01)	0 (0.0)	1 (100.0)
Missing	211 (1.5)		
Body Mass Index (kg/m^2, n = 9044)[1]*			
Underweight (<18.5)	711 (7.9)	52 (7.3)	659 (92.7)
Normal (18.5–24.9)	5646 (62.4)	624 (11.1)	5021 (88.9)
Overweight (25.0–29.9)	1762 (19.5)	396 (22.5)	1366 (77.5)
Obese (≥30)	864 (9.6)	321 (37.2)	543 (62.9)

Covariates: [1]Normal as reference category.
*Population size is 8983.

Discussion

Use of shea butter was associated with 2.43 mmHg (95% CI: −3.54, −1.31) and 1.78 mmHg (95% CI: −2.71, −0.86) decrease in SBP and DBP, respectively, and 25% (AOR = 0.75, 95% CI: 0.55, 1.04) reduced odds of hypertension. In sensitivity analysis, the decrease in SBP and DBP, and reduced odds of hypertension with shea butter intake was

Table 3. Linear regression of systolic and diastolic BP on cooking oil type (N = 13784)

Type of cooking oil	Systolic BP (mmHg)		Diastolic BP (mmHg)	
	Unadjusted β (95% CI)	Adjusted β (95% CI)	Unadjusted β (95% CI)	Adjusted β (95% CI)
Red/Yellow palm oil	−0.19 (−0.96, 0.58)	0.23 (−0.53, 0.99)	−1.11 (−1.63, −0.59)	−0.60 (−1.14, −0.06)
Shea butter	−5.90 (−6.74, −5.07)	−2.43 (−3.54, −1.31)	−5.23 (−5.97, −4.48)	−1.78 (−2.71, −0.86)
Frytol/Fortified/Other vegetable oil	Reference	Reference	Reference	Reference

Covariates adjusted in the analysis were gender, age, area of residence, religion, ethnic group, marital status, education and wealth index

Table 4. Linear regression of systolic and diastolic BP on cooking oil type among participants with information on BMI (n = 9044)

Type of cooking oil	Systolic BP (mmHg)		Diastolic BP (mmHg)	
	Unadjusted β (95% CI)	Adjusted β (95% CI)	Unadjusted β (95% CI)	Adjusted β (95% CI)
Red/Yellow palm oil	−0.28 (−1.12, 0.56)	0.25 (−0.66, 1.17)	−1.37 (−1.99, −0.74)	−0.69 (−1.33, −0.04)
Shea butter	−5.99 (−6.95, −5.04)	−2.12 (−3.49, −0.76)	−5.42 (−6.31, −4.54)	−1.53 (−2.63, −0.43)
Frytol/Fortified/Other vegetable oil	Reference	Reference	Reference	Reference

Covariates adjusted in the analysis were gender, age, area of residence, religion, ethnic group, marital status, education and wealth index

Table 5. Binary logistic regression of elevated BP risk on cooking oil type (N = 13784)

	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Red/Yellow palm oil	0.82 (0.71, 0.94)	0.88 (0.75, 1.04)
Shea butter	0.35 (0.27, 0.46)	0.75 (0.55, 1.04)
Frytol/Fortified/Other vegetable oil	1.00	1.00

Covariates adjusted in the analysis were gender, age, area of residence, religion, ethnic group, marital status, education and wealth index.

Table 6. Binary logistic regression of elevated BP risk on cooking oil type among participants with information on BMI (n = 9044)

	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Red/Yellow palm oil	0.82 (0.69, 0.97)	0.93 (0.80, 1.07)
Shea butter	0.39 (0.28, 0.55)	0.79 (0.60, 1.04)
Frytol/Fortified/Other vegetable oil	1.00	1.00

Covariates adjusted in the analysis were gender, age, area of residence, religion, ethnic group, marital status, education, wealth index and BMI.

slightly attenuated. Region of residence of the participant appeared to modify the relationship with shea butter users in the Brong Ahafo and three northern regions recording decreased SBP and DBP, and decreased odds of hypertension.

Validity Issues

The sampling strategy of the 2014 GDHS survey together with the high response rate (97.3% and 95.2% for women and men, respectively) minimizes selection bias. Also the standardized data collection instruments and procedures of DHS surveys including the present and the extensive training of interviewers guarantees the collection of reliable information from survey participants. Missing data was not a concern in this study. Of the variables of interest, only area of residence and ethnic group recorded one missing information.

Cooking oil choices of the participants was assessed based on cooking oils primarily used by households. There are limitations with this approach. Firstly, it was impossible to ascertain whether cooking oil choices of the households remained relatively stable throughout the lifetime of the participants. Secondly, there was no information on households using multiple cooking oils as is the situation in majority of Ghanaian households. Misclassification bias is therefore possible in the study with the direction of bias unclear. However, in Ghana, anecdotal evidence suggests that in households that use shea butter for cooking, often this is the only cooking oil. Lack of information on the frequency of shea butter use and the amount consumed is also a limitation of the study. Availability of this information will have enabled an assessment of dose-response relations and strengthen the evidence.

The outcome of interest was measured three times at intervals of 10 minutes of more using the same BP monitor across all households and with the average of the second and third measurements used for our analysis. Interviewers were trained to use the device according to the manufacturer's recommended protocol and as a result, the potential for measurements errors is likely to be minimized. In classifying respondents with hypertension, the BP measurement was complemented with information on respondents who indicated at the time of the survey that they have previously being diagnosed by a physician as being hypertensive and

Table 7. Linear regression of systolic and diastolic BP on cooking oil type stratified by region of residence (N = 13784)

Region of residence	Type of cooking oil	Systolic BP (mmHg) Unadjusted β (95% CI)	Diastolic BP (mmHg) Unadjusted β (95% CI)
Western	Red/Yellow palm oil	0.62 (−1.25, 2.48)	−0.70 (−1.94, 0.55)
	Shea butter	8.00 (6.70, 9.30)	7.39 (6.45, 8.33)
	Frytol/Fortified/Other vegetable oil	Reference	Reference
Central	Red/Yellow palm oil	−0.23 (−1.78, 1.32)	−0.70 (−1.83, 0.44)
	Shea butter		
	Frytol/Fortified/Other vegetable oil	Reference	Reference
Greater Accra	Red/Yellow palm oil	0.06 (−1.96, 2.08)	−0.83 (−2.31, 0.65)
	Shea butter		
	Frytol/Fortified/Other vegetable oil	Reference	Reference
Volta	Red/Yellow palm oil	−2.17 (−4.46, 0.11)	−1.61 (−2.93, −0.30)
	Shea butter	−4.41 (−6.42, −2.40)	−5.02 (−6.05, −3.98)
	Frytol/Fortified/Other vegetable oil	Reference	Reference
Eastern	Red/Yellow palm oil	0.24 (−1.64, 2.11)	−0.89 (−2.25, 0.46)
	Shea butter		
	Frytol/Fortified/Other vegetable oil	Reference	Reference
Ashanti	Red/Yellow palm oil	0.01 (−2.41, 2.44)	−1.00 (−2.50, 0.49)
	Shea butter	11.26 (1.98, 20.53)	7.92 (3.38, 12.47)
	Frytol/Fortified/Other vegetable oil	Reference	Reference
Brong Ahafo	Red/Yellow palm oil	−0.25 (−1.93, 1.43)	−1.20 (−2.55, 0.14)
	Shea butter	−6.06 (−9.35, −2.78)	−6.06 (−8.19, −3.92)
	Frytol/Fortified/Other vegetable oil	Reference	Reference
Northern	Red/Yellow palm oil	1.75 (−1.57, 5.08)	1.02 (−1.70, 3.76)
	Shea butter	−2.51 (−3.90, −1.11)	−2.32 (−3.69, −0.94)
	Frytol/Fortified/Other vegetable oil	Reference	Reference
Upper East	Red/Yellow palm oil	−1.27 (−6.39, 3.85)	1.54 (−0.66, 3.73)
	Shea butter	−1.50 (−3.38, 0.39)	−2.76 (−4.26, −1.26)
	Frytol/Fortified/Other vegetable oil	Reference	Reference
Upper West	Red/Yellow palm oil	−2.07 (−4.98, 0.84)	−5.99 (−9.42, −2.57)
	Shea butter	−4.74 (−7.19, −2.29)	−3.37 (−5.40, −1.34)
	Frytol/Fortified/Other vegetable oil	Reference	Reference

Rows with no estimates had either no or limited data for the analyses to converge.

were lowering their BP by one or more of the following measures; taking medication, controlling weight, decreasing salt intake, exercise, decreasing alcohol intake, and stopping smoking. This approach enabled a better estimation of prevalence of hypertension in the population. However, there are likely to be some hypertensive cases within the population who were diagnosed by people other than physicians notably herbalists, chemical sellers, pharmacists and pharmacy shop attendants, and possibly managing the condition with either orthodox or herbal medicines. Unfortunately, the DHS survey do not capture these cases and could possibly lead to underestimation of hypertension in this population.

The study was not able to control for the confounding effect of physical activity, alcohol intake and consumption of salty foods, owing to the DHS survey not collecting information on these covariates. The inability to control for these important potential confounders in the models is a threat to validity of the study results. However, the survey collected information on BMI for a subset of the study population, another important potential confounder, and with this information we further restricted the analysis to this subsample to assess the robustness of the study findings. The consistent results produced from the analysis adjusting further for BMI strengthen the study findings, albeit the confidence interval included the null value.

Plausible Mechanistic Explanations

A systematic literature search identified a large population-based incident case-control study conducted in Costa Rica [21] as the only study to have investigated the relationship between cooking oil and CVD endpoint. The study found consumption of palm oil relative to soybean oil and other unsaturated oils (predominantly sunflower) to be associated with myocardial infarction. Palm oil users were more

Table 8. Binary logistic regression of elevated BP risk on cooking oil type stratified by region of residence (N = 13784)

Region of residence	Type of cooking oil	Unadjusted OR (95% CI)
Western	Red/Yellow palm oil	1.09 (0.73, 1.63)
	Shea butter	
	Frytol/Fortified/Other vegetable oil	1.00
Central	Red/Yellow palm oil	0.66 (0.42, 1.04)
	Shea butter	
	Frytol/Fortified/Other vegetable oil	1.00
Greater Accra	Red/Yellow palm oil	0.86 (0.60, 1.22)
	Shea butter	
	Frytol/Fortified/Other vegetable oil	1.00
Volta	Red/Yellow palm oil	0.83 (0.54, 1.27)
	Shea butter	
	Frytol/Fortified/Other vegetable oil	1.00
Eastern	Red/Yellow palm oil	0.81 (0.60, 1.08)
	Shea butter	
	Frytol/Fortified/Other vegetable oil	1.00
Ashanti	Red/Yellow palm oil	0.93 (0.66, 1.32)
	Shea butter	
	Frytol/Fortified/Other vegetable oil	1.00
Brong Ahafo	Red/Yellow palm oil	0.73 (0.53, 1.02)
	Shea butter	0.38 (0.16, 0.96)
	Frytol/Fortified/Other vegetable oil	1.00
Northern	Red/Yellow palm oil	1.03 (0.44, 2.39)
	Shea butter	0.65 (0.39, 1.09)
	Frytol/Fortified/Other vegetable oil	1.00
Upper East	Red/Yellow palm oil	1.25 (0.53, 2.92)
	Shea butter	0.48 (0.30, 0.78)
	Frytol/Fortified/Other vegetable oil	1.00
Upper West	Red/Yellow palm oil	0.86 (0.29, 2.55)
	Shea butter	0.56 (0.31, 0.90)
	Frytol/Fortified/Other vegetable oil	1.00

Rows with no estimates had either no or limited data for the analyses to converge.

likely to have a myocardial infarction compared to users of soybean oil (OR = 1.33; 95% CI: 1.08-1.63) or other cooking oils (OR = 1.23; CI: 0.99-1.52). However, there is consistent observational evidence linking consumption of fried foods with risk of hypertension and CVDs [22]. Our findings add up to the limited evidence on the adverse effects of use of vegetable oil and palm oil for BP and cardiovascular health.

Vegetable oil which is produced from legumes, nuts, oilseeds and flesh of some fruits is made up of different kinds of fatty acids of varied compositions [23] with trans-fatty acids (TFA) which is produced by hydrogenation of unsaturated oils, common to most vegetable oils. TFA have been reported to increase LDL cholesterol and by so doing decreases HDL cholesterol [24]. Palm oil has atherogenic potential because of its low levels of PUFA and high levels of saturated fat (36-50%), predominantly palmitic acid [25–27]. Studies in humans and animals have shown palm oil to increase plasma total and LDL cholesterol compared with safflower oil or sunflower oil [28–32], and also caused atherosclerosis in monkeys [33].

The study is the first epidemiological report on the benefits of shea butter for BP. Shea butter is composed primarily of polyphenols, vitamin E, sterols, and stearic and oleic acid, all of which are known to have the potential to reduce BP either directly (polyphenols, vitamin E, oleic acid) [17, 34, 35] or indirectly (sterols, stearic acid) through lowering of LDL cholesterol levels [17, 36, 37]. Oleic acid, a monounsaturated fatty acids, has been documented to have hypotensive effect by regulating membrane lipid structure (H_{II} phase propensity) in such a way as to control G protein-mediated signaling thereby causing a reduction in BP [17]. According to the authors [17], this effect is in part caused by its regulatory action on G protein-associated cascades that regulate adenylyl cyclase and phospholipase C. The well-documented hypotensive effect of olive oil has been reported by Teres et al. [17] to be induced through the action of its high oleic acid content and not its minor components (vitamin E, polyphenols and other phenolic compounds). Stearic acid is a SFA but according to Baer et al. [38] it does not increase LDL cholesterol like other SFAs. A systemic review of clinical and epidemiological studies [16] reported dietary stearic acid to be associated with lower LDL levels and directionally lower total cholesterol/HDL cholesterol ratio compared to any other SFA. Teres et al. [17], however, found stearic acid to have no significant BP lowering effect in spite of their chemical similarity with oleic acid. It has been suggested that, even though palm oil also has high oleic acid content (39%), it is not sufficient to compensate for the deleterious effects of its attendant high saturated fat and low concentrations of linoleic acid and α-linolenic acid [21].

Polyphenols are found in shea butter, albeit in relatively low concentrations, and are known to improve vascular health and significantly reduce risk of hypertension and CVD [34]. Ten phenolic compounds have been identified in shea butter, of which eight are catechins (flavan-3-ol) [39]. The phenolic profile of shea butter has been reported to be similar to that of green tea [40]. The concentration of catechins in shea butter has been found to compare favorably to the polyphenolic content of olives [41, 42]. A systematic review and meta-analysis found green tea catechins to lower blood pressure and reduce LDL and total cholesterol [43]. Vitamin E is an antioxidant and protects unsaturated fatty acids and other lipid components of the cell membrane from oxidative damage. Oxidative stress has been implicated in the pathogenesis of hypertension [44–47]. Consumption of foods rich in vitamin E such as shea butter can thus reduce one's risk of hypertension. A triple-blind clinical trial reported vitamin E supplementation to reduce BP among mild hypertensive patients [35]. Sterols which constitutes 8% of the unsaponifiable fraction of shea butter [48] are well known for lowering LDL cholesterol levels [36, 37]. Animal models [49–51] have shown shea butter to reduce circulatory cholesterol concentrations. However, there is lack of consistent evidence supporting intake of plant sterols (β-sitosterol and campesterol) and decreased risk of hypertension and CVD [52, 53]. β-sitosterol (61.5%) and campesterol (16.5%), the two commonly occurring plant sterols in foods, and stigmasterol (16.1%) constitutes about 94% of sterols in shea butter [48, 54].

Region of residence was found to be modifying the relationship. Decreased SBP and DBP, and decreased odds of hypertension was noted among shea butter users in the three northern regions where shea butter is commonly used. However, the increased odds of hypertension observed in the southern regions of Ashanti and Western possibly means shea butter consumption should be complemented with other healthy eating habits as prevails in northern Ghana to realize the full cardiovascular benefits.

Conclusion

In conclusion, we found an association of shea butter consumption with lower BP with region of residence appearing to modify the relationship. The findings of the study provide the rationale for investigation through rigorous study designs in this and other populations to evaluate the benefits of shea butter consumption for prevention of hypertension and improved cardiovascular health. Should our findings be confirmed in future studies, consumption of shea butter can be an important alternative to the expensive PUFA-rich cooking oils, the mainstay of Mediterranean diets, for curbing the rising incidence of hypertension in Ghana and other sub-Saharan African countries.

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Conflict of interest
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