

# **The use of Medicinal Plants in the Management of Hypertension and Potential Concomitant use with Western Antihypertensive Drugs in Belize**

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## **Abstract**

*The world-wide increase in the use of plants for medicinal purposes, especially in developing countries, calls for evaluation of their concomitant use with Western medications. Hypertension is a major non communicable disease in Belize and to date, no studies have evaluated the concomitant use of medicinal plants with Western medications and its management of hypertension. This study examined the use of medicinal plants in the management of hypertension and the potential concomitant use of such plants with Western medications in the country of Belize with the goal of providing baseline data for regular pharmacovigilance. Using a cross-sectional descriptive research design, data was collected from 422 hypertensive patients with a questionnaire. Most respondents in the study were knowledgeable (85.5%) and used (77.5%) medicinal plant therapies to treat their diseases. In addition, the majority (55%) of the respondents had used medicinal plants to manage their hypertension, 23% combined their herbs with Western medications, and a few (6%) habitually combined herbs with Western medications in the management of their hypertension. There is a need to regularly monitor and evaluate concomitant drug-herb use to avert harmful interactions among the hypertensive population in Belize.*

**Keywords:** Indigenous therapies, Western medications, medicinal plants, interactions, hypertension, Belize

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## **Introduction**

Belize, being a developing nation, is experiencing a gradual transition in disease burden from communicable diseases to chronic non-communicable diseases. Presently diabetes and hypertension are the most common non-communicable diseases in Belize, with the highest rates of morbidity and mortality (PAHO 2009; Danladi et al., 2017). In 2009, the Pan American Organization (PAHO) survey on diabetes and hypertension reported an overall prevalence of hypertension to be 28.7%. The study reported an alcohol consumption rate of 31.7%, obesity 32.5%, overweight, 33.5%, cigarette smoking 19.8%, and 77.7% indicating less than 60 minutes of physical activity per week as the major risk factors in developing hypertension in Belize. With the global increase in morbidity and mortality due to non-communicable diseases, especially hypertension, people are looking for the best possible means of management in addition to Western medications and medicinal plants offers such alternatives (Cooper et al. 2017; Forouzanfar et al. 2017; Rojas et al. 2019; Husaini et al., 2023b). The World Health Organization [WHO] (2013) defines indigenous therapies as plants or plant products that possess medicinal properties that can be utilized for therapy and presently, many countries are widely embracing the use of medicinal plants for the treatment of various diseases and conditions (Ekor 2014; Mphuthi and Pienaar 2017; Shaikh et al. 2020; Mphuthi & Husaini, 2022). Additionally, medicinal plants for the management of hypertension have been studied by other researchers using animals as subjects (Al Disi et al. 2016; Meresa et al. 2017; Malik et al. 2018; Chan et al. 2020). The ancestral linkage of Belizeans to indigenous therapies in the management of various diseases coupled with vast rainforests in the country makes medicinal plants a viable option for hypertension management (Arnason et al. 1980; Ekor 2014; Balick and Arvigo 2015; Arzu & Thiagarajan, 2016; Mans et al. 2017).

A common practice with Western therapies is polypharmacy, described as the concurrent administration of more than one drug or substance for therapeutic purposes (Dookeeram et al. 2017). The practice of polypharmacy is carefully monitored in clinical settings. Although it is easier to monitor drug-drug interactions in clinical settings, monitoring herb-drug interactions is difficult because most of these interactions have not been scientifically proven (Kahraman et al. 2020; Onyeaghala et al., 2023). Many times, it becomes precarious when medicinal therapies are combined with other herbal therapies, or when herbal preparations are combined with Western therapies. These drug-herb or herb-herb interactions can precipitate toxic effects. Nevertheless, in some instances these interactions render the therapeutic effect of a conventional drug more potent, or the promising herbal preparation more effective (Mans et al. 2017; Shaikh et al. 2020). Unfortunately, in Latin America and the wider Caribbean, few studies have investigated the interactions between herbal remedies and Western drugs (Picking et al. 2011; Mans et al. 2017). For instance, in Belize, only a few studies on medicinal plants have been published (Arnason et al. 1980; Balick and Arvigo 2015; Husaini et al. 2020). Furthermore, to date no studies have investigated the concomitant use of medicinal plants with Western medications in Belize even though the practice exists and has been reported in the wider Caribbean (Picking et al. 2011). In Belize, there is a paucity of information on the use of medicinal plants, especially when concomitantly used with Western drugs in the management of hypertension. This study examined the use of medicinal plants in the management of hypertension and the potential concomitant use of such plants with Western medications. The results of this study will inform the design, development and implementation of educational and prevention programs aimed at building public awareness on the use of herbal-western therapies in the country of Belize. The study will also provide baseline data for healthcare professionals to see the need for routine patient evaluation of medicinal plants use. The study seeks to further provide data on the need for patients to share accurate information with their physicians on medicinal plants use. Finally, the study might stimulate the need for concerted research on the rich medicinal forest of Belize with a view to identify new sources of drugs or discover synergistic effects of medicinal plants with Western therapies.

## **Research Setting**

The current study on the use of medicinal plants in the management of hypertension and the potential concomitant use of herbal remedies with Western medications was conducted in the country of Belize. Belize (formerly British Honduras) is the only commonwealth and English-speaking country in Central America. By virtue of its geographical location and historical background, Belize is part of both Central America and the Caribbean. The country therefore participates in the activities of the Central American Integration System (SICA) and the Caribbean Community (CARICOM). According to the Statistical Institute of Belize (SIB), the country has a total area of about 8,867 square miles (23,000 km<sup>2</sup>) and shares borders with Guatemala (266 km) to the south and west, and Mexico (250 km) to the north. It is bordered by the Caribbean Sea to the east, with 386 km of coastline. The postcensal population estimate for the year 2020 was reported to be 419,199 (SIB 2021). The main ethnic groups in the country are Creole, Garifuna, Mestizo and Maya. The literacy rate was 79.7%, with an unemployment rate of 14.2%. Belize is a parliamentary democracy, a member of the Commonwealth, and is divided into 6 administrative regions called districts. As of 2022, the country has a GDP of USD \$2.5 billion, and a per capita GDP of \$6049 (World Bank, 2024) Belize's total exports total for 2018 were estimated at US\$200 million annually. The principal sectors of the economy are agriculture, agro-processing, and services primarily consisting of tourism (Martin and Manzano 2010). The main exports are sugar and molasses (30%), bananas (18.5%), citrus (15.7%), marine products (10.7%), and crude petroleum (6.3%).

## **Materials and Methods**

### **Research design**

The study utilized a cross-sectional quantitative research design to describe the use of medicinal plants used in the management of hypertension and the potential concomitant use with Western medications in the country of Belize.

### **Population of the study**

The participants in this study comprised all hypertensive adult patient's currently accessing antihypertensive medications from government-owned hospitals, private clinics, and pharmacies in the country of Belize.

### **Sample and sampling techniques**

The sample was computed using Open Epi (Epi Info™), Version 3, open-source online software. Using this data, a sample size of 422 was obtained at 95% confidence level. To obtain proportionate samples from the 6 districts in the country, the 422 total sample size was further stratified proportionately. Samples were collected from the Belize district (128), Cayo district (102), Orange Walk district (55), Corozal district (51), Stann Creek district (46), and Toledo district (40). The strategy to stratify the sample size was to provide even selection of participants from each district based on the population of the district. The study employed a random sampling technique to obtain data from diagnosed hypertensive patients in the country of Belize.

### **Data collection**

A questionnaire was developed after reviewing relevant literature. Some questions were adapted and modified from previously developed research instruments in line with the current study (Picking et al. 2011; TRAMIL 2017). The questionnaire was divided into three sections and consisted of 38 items. This was piloted in 25 participants in the city of Belmopan to check for errors. Some spelling and grammatical errors were identified and corrected. The skip option was further added for individuals who indicated that they did not use medicinal plants for the management of their hypertension. The questionnaire was further validated. Reliability testing of the questionnaire showed a Cronbach's alpha value of 0.779. An exploratory factor analysis (EFA) using principle component analysis extraction and direct oblimin rotation with Kaiser Normalization was also employed, which extracted five components. The Kaiser Mayer Olkin (KMO) measure of sampling adequacy and Bartlett's test for sphericity was also employed, which reported a value of 0.6 and a *p*-value < 0.001. In this regard, the questionnaire was considered validated and used for data

collection. The questionnaire was then divided into 3 sections consisting of demographic information, medicinal plants usage, and concomitant use with Western therapies.

The participants were selected purposively from the public, the objectives and significance of the study were explained to them and any queries they had were addressed. After consent, the questionnaires were administered to the participants by the researcher using paper and pencils. Those who could complete the questionnaire without assistance were allowed to do so while the researcher assisted those who were not able to. Self-administered questionnaires were distributed at hospitals, pharmacies, and clinics throughout the country. Completed questionnaires were retrieved and stored in a secure and safe cabinet at the Faculty of Health Sciences, the University of Belize. The confidentiality of respondents' information was always maintained. A total of 422 questionnaires were completed from October 2018 to April 2019.

## **Data analysis**

Collected data were analyzed using descriptive statistics. Prior to being analysed, coding of the data was done using Statistical Package for Social Sciences (SPSS) version 21.0 software. Coded data were then cross-checked by two other reviewers for the purpose of consistency, readability and completeness. Mistakes from respondents were checked and corrections made. Descriptive statistics were primarily used to describe demographic data and research questions.

## **Ethical consideration**

The study was approved by the Faculty of Health Sciences, University of Belize as part of faculty research, and the University of South Africa research ethics committee (HSHDC/761/2017). Participant's informed consent was obtained before the administration of the questionnaire. The research was conducted according to the principles of the World Medical Association Declaration of Helsinki "Ethical Principles for Medical Research Involving Human Subjects", as amended in October 2013.

## **Results**

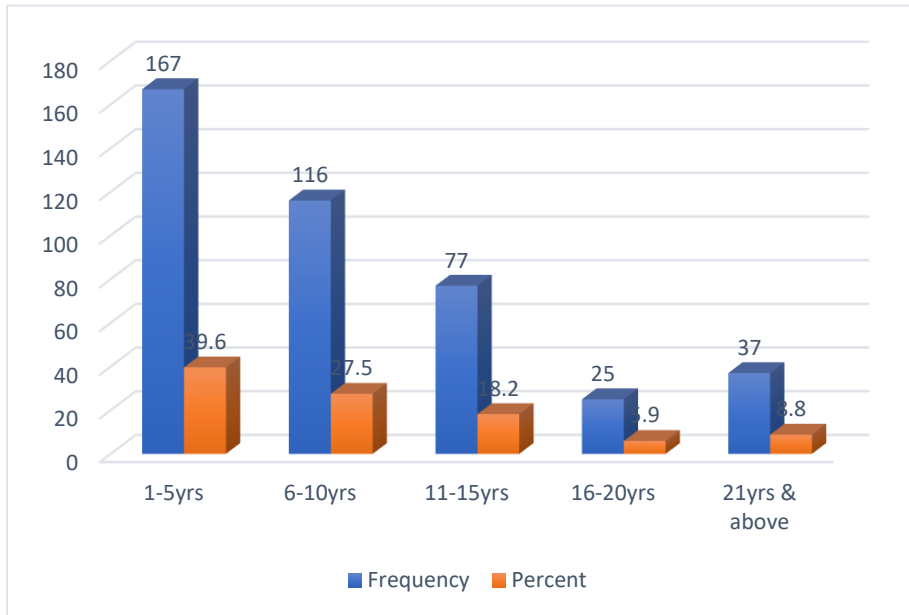
### **Biographical data**

All 422 questionnaires were received, giving a cumulative response rate (RR) of 100%. The mean age of the respondents was  $43 \pm 3.65$ , with the age class 41 and 50 years having the highest number of respondents ( $n=116$ ; 27.5%). The distribution based on gender showed that approximately 54% ( $n=227$ ) of the respondents were female and 46% ( $n=195$ ) were male. Regarding marital status, the majority ( $n=131$ ; 31.0%) of the respondents were married, while 16.8% ( $n=71$ ) were in a common law relationship. Data on religious affiliation indicated that the highest number of hypertensive participants in this study was Catholics ( $n=151$ ; 35.8%) followed by the evangelicals ( $n=116$ ; 27.5%), while Mestizo ( $n=98$ ; 23.2%) and Creole ( $n=97$ ; 23%) ethnicities were the highest in the study. In addition, data on educational status indicated that the majority attended secondary school (35.1%,  $n=148$ ), employment status showed that those who were gainfully employed with a regular income to be the majority (54%  $n=228$ ) with ( $n=144$ ; 34.1%) having a monthly income between \$1001 and \$2000 Belize dollars.

### **Hypertension diagnosis and Western medication use.**

Most of the respondents were diagnosed with hypertension within the last 10 years, with those diagnosed within 1 – 5 years having the highest proportion ( $n=167$ ; 39.6%) of reported cases, followed by those diagnosed within 6 – 10 years ( $n=116$ ; 27.5%). Furthermore, the majority ( $n=173$ ; 41.0%) of the respondents reported being on Western medications for 1-5 years, while 25.5% ( $n=107$ ) reported using western medications for 6 – 10 years, with 84% ( $n=353$ ) reporting a once daily dose regimen (Fig. 1). Although hydrochlorothiazide ( $n=335$ ; 33.7%) was the most reported antihypertensive medication, other

medications such as captopril (12.3%), amlodipine (9%), Olmesartan (9%), and lisinopril (8%), were reported (Fig. 1).



**Fig. 1** Number of years diagnosed with hypertension.

**Use of herbal remedies with Western medications**

The majority (85.5%) of the respondents knew about medicinal plants used in the management of hypertension, 77.5% used herbal remedies to treat other diseases, and more than half (55%) of the respondents used herbal remedies to manage their hypertension (Table 1).

**Table 1.** Knowledge and practice of herbal remedies

	Frequency (n=422)	Percent (%)
<b>Knew about herbal remedies used for hypertension</b>		
Yes	361	85.5
No	61	14.5
<b>Use of herbal remedies to treat other diseases</b>		
Yes	327	77.5
No	95	22.5

<b>Use herbal remedies to manage hypertension</b>		
Yes	232	55
No	190	45
<b>Knew someone using herbal remedies to manage hypertension</b>		
Yes	336	79.6
No	86	20.4

**Table 2. Medicinal plants used to manage hypertension as reported by participants.**

Medicinal plants used by respondents for the management of hypertension.	Family	Frequency	Percent (%)
Garlic ( <i>Allium Sativum</i> )	<a href="#">Amaryllidaceae</a>	227	19.4
Lime ( <i>Citrus aurantiifolia</i> )	Rutaceae	105	9.0
Aloe Vera ( <i>Aloe barbadensis miller</i> )	Asphodelaceae	78	6.7
Soursop ( <i>Annona muricata Linnaeus</i> )	Annonaceae	72	6.2
Celery ( <i>Apium graveolens</i> )	Apiaceae	72	6.2
Beetroots ( <i>Beta vulgaris</i> )	Chenopodiaceae	71	6.1
Lettuce ( <i>Lactuca sativa</i> )	<a href="#">Asteraceae</a>	51	4.4
Sorrel ( <i>Hibiscus sabdariffa</i> )	Malvaceae	45	3.9
Eggplant ( <i>Solanum Molongena</i> )	Solanaceae	45	3.9
Trumpet Tree ( <i>Cecropia peltata</i> )	Cecropiaceae	43	3.7
Moringa ( <i>Moringa oleifera</i> )	<a href="#">Moringaceae</a>	40	3.4
Serosi [Ceraceae] ( <i>Momondica charantia</i> )	Cucurbitaceae	30	2.6
Jackass Bitter ( <i>Neurolaena lobata</i> )	Asteraceae	27	2.3
Almond/hammon ( <i>Terminalia catapp</i> )	Rosaceae	27	2.3
Chayote [Choko] ( <i>Sechium edule</i> )	Cucurbitaceae	25	2.1
Lemon grass ( <i>Cymbopogon citratus</i> )	<a href="#">Poaceae</a>	24	2.1
Avocado leaves ( <i>Persea americana</i> )	<a href="#">Lauraceae</a>	23	2.0
Susumba ( <i>Solanum Turvum</i> )	Solanaceae	15	1.3
Noni ( <i>Morinda citrifolia</i> )	Rubiaceae	15	1.3
Bay Leaves ( <i>Laurus nobilis</i> )	<a href="#">Lauraceae</a>	14	1.2
Calabash Tree ( <i>Crescentia cujeta</i> )	<a href="#">Cucurbitaceae</a>	14	1.2
Neem ( <i>Azadirachta indica</i> )	Meliaceae	13	1.1
Wild Tamarind/Jumbie plant ( <i>Tamarindus Indica</i> )	Fabaceae	11	0.9
Periwinkle/ Ram goat ( <i>Catharanthus roseus</i> )	<a href="#">Apocynaceae</a>	11	0.9
Cat's claw ( <i>Uncaria tomentosa/ U. guianensis</i> )	Rubiaceae	11	0.9
Cascarilla ( <i>Croton eluteria</i> )	Euphorbiaceae	9	0.8
Scoggineal ( <i>Opuntia cochenillifera</i> )	Cactaceae	9	0.8
Pine bark ( <i>Pinus</i> )	Pinaceae	9	0.8
Mango ( <i>Mangifera indica</i> )	<a href="#">Anacardiaceae</a>	8	0.7
Guava ( <i>Psidium guajava</i> )	Myrtaceae	8	0.7
Papaya ( <i>Carica papaya</i> )	<a href="#">Caricaceae</a>	7	0.6
Breadfruit ( <i>Artocarpus Altilis</i> )	Moraceae	7	0.6

Chestnut ( <i>Pachina aquatica</i> )	<a href="#">Malvaceae</a>	2	0.2
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Over 30 medicinal plants belonging to 25 families are used for the management of hypertension, as reported by the respondents (Table 2). Respondents also reported Garlic (*Allium sativum*) 19.4% (n=227) and Lime (*Citrus aurantiifolia*) 9% (n=105), while aloe vera (*Aloe barbadensis miller*), as the most common indigenous therapies used for the management of hypertension. Cucurbitaceae and Rubiaceae had the highest number of reported plants family reported by the respondents for the management of hypertension (Table 2).

Furthermore, over 30 different medicinal plants and herbs were reported as popular remedies for the management of hypertension in Belize. Beetroot (n=56; 13.3%) and garlic (n=45; 10.7%) were among the highest reported medicinal plants used for the management of hypertension by the respondents, with most respondents indicating garlic (19.4%) and lime citrus (9%) as the most frequently used herbal remedies for the management of their hypertension.

**Table 3. Concomitant use of herbal remedies with Western medications**

<b>Do you combine herbal remedies with indigenous remedies?</b>	Frequency (n=422)	Percent (%)
Indigenous therapies alone	83	19.7
Indigenous therapies and western medications together	26	6.2
Sometimes indigenous therapies alone and sometimes in combination with western therapies.	98	23.2
I only use Western medications	215	51
<b>Combining indigenous and western therapies help lower blood pressure</b>		
No response	9	2.1
No	62	14.7
Yes	71	16.8
Sometimes	93	22.0
I don't know	74	17.5
I do not take indigenous therapies for my hypertension	113	26.8
<b>Awareness of probable interactions</b>		
No response	33	7.8
No	106	25.1
Yes	153	36.3
I don't know	38	9.0
I do not take indigenous therapies for my hypertension	92	21.8

The majority (51%) of the respondents did not combine their Western medications with herbal remedies, while a few (6.2%) indicated combining herbs with Western medications. Other respondents (23.2%) stated that they occasionally used herbs with Western medications (Table 3). The majority (41%, n=173) of the respondents indicated using medicinal plants for hypertension because they are natural (Table 3).

## **Discussion**

This study examined the use of medicinal plants in the management of hypertension and the potential concomitant use with Western drugs. Our study included participants from varying ages diagnosed with hypertension. Age-related increases in blood pressure are widely reported and accepted features of aging (Olivera et al. 2019; Muli et al. 2020). The risk of developing hypertension increases with age. For example, epidemiological studies have shown an increase in age-related systolic blood pressure that is progressive, reaching an average of approximately 140 mmHg in the 80<sup>th</sup> year (Mills et al. 2020). The age-related hypertension reported cases in this survey agree with previous studies on age-related hypertension in Belize (PAHO 2009; Danladi et al. 2016).

Regarding gender, females had the highest reported cases of hypertension in this study possibly because more female participated in the study compared to men. The general perception of gender-based hypertension is that hypertension is the most prevalent disease in men (Connelly et al., 2022). Contrary to this belief, most cardiovascular diseases inclusive of hypertension, are higher in women than in men (Ramirez et al. 2018; Alexander et al. 2020). Menopausal women have been reported to have a higher incidence of hypertension compared to other women. Furthermore, women have been reported to have uncontrolled hypertension and experience higher incidences of cardiovascular diseases later in life than men (Ramirez et al. 2018). In addition, the higher prevalence of hypertension in females has been attributed mostly to hormonal changes and longevity seen in women than in men (Rahman et al. 2017). A previous study in Belize reported more women with hypertension than men in at least 3 districts of the country (PAHO 2009). The results seen in this study corroborates previously reported studies on gender-based hypertension.

Data obtained on marital status indicated that the majority of the respondents were either married or in a common-law relationship. An important predictor of a wide range of health outcomes is the marital status of the individual (Lipowicz and Lopuszanska 2005; Birditt et al. 2014; Ramezankhani et al. 2019). It is a vital social factor that has also been associated with cardiovascular diseases, including hypertension. However, studies have presented conflicting evidence regarding the role of marital status in hypertension. For instance, a study in Ghana reported significantly higher odds of hypertension for married (OR=2.14, 95% CI=1.30-3.53), cohabiting (OR=1.94, 95% CI=1.16-3.23), and previously married (OR=2.23, 95% CI=1.29-3.84) women as compared to unmarried (Tuoyire and Ayetey 2019). Similarly, Manfredini et al. (2017) reviewed 13 studies on marriage and hypertension in 1,245,967 subjects and concluded that persons with spouses diagnosed with hypertension had better therapeutic outcomes to single persons. They further reported that being married was associated with lower risk factors and better health status were lower among married persons even in the presence of many confounding effects (Manfredini et al. 2017).

Data on religion were also presented in this study. Religion has been reported to have a protective role against hypertension (Meng et al. 2019). Some religions and beliefs do not eat animal-based food but depend on vegetarian diets such as nuts, fruits, and vegetables. These religion-related activities such as meditation, vegetarian diets, exercise, smoking abstinence, nut consumption, and social support, were mediators indicated to help protect against hypertension (Meng et al. 2019). Although we did not examine the correlation between religion and hypertension, most of the respondents in this study reported varying religious affiliations. Genetic factors, improper nutritional and dietary practices, and lack of adherence to strict religious meditation may contribute to higher levels of hypertension (Mills et al. 2020). The results of the current study are therefore predictive of the possibility that culture, environmental factors and religious beliefs could play a significant role in hypertension pathophysiology Belize. The results suggest a need to further explore marital status, culture, and religious beliefs and their role in hypertension epidemiology in Belize.

Regarding ethnicities, the Mestizo and Creole ethnicities had the highest ethnic respondents in this study. Ethnicity and ethnic variations have been reported to exist among hypertensive patients, leading to errors in hypertensive management and control (Thomas et al. 2019). For instance, it is a well-established fact that the black race is especially susceptible to hypertension and its associated organ-damage as compared to the white race (James et al. 2014; Lackland 2014). The results of the current study therefore corroborate previous studies on variations that exist between ethnicities of hypertensive patients. Further studies on ethnicities-specific biomarkers and their role in hypertension needs to be evaluated and characterized among different ethnicities in Belize.



Data on the educational status of respondents observed in this study indicated that most of the respondents attended secondary school (35.1%, n=148). Educational attainment has been reported to be associated with risk for cardiovascular diseases (CVD), presumably as a marker or mediator of other traditional risk factors (Kubota et al. 2017). For instance, lower educational status has been reported to be associated with a high prevalence of hypertension (Sarki et al. 2015). In this study, educational status was associated with higher levels of hypertension as compared to participants with no formal education. The association between hypertension and educational level seen in this study is likely to be mediated by other nonclinical or clinical factors. Nevertheless, awareness of a patient's education status could help improve overall clinical assessments and patient counseling (Kubota et al. 2017).

Finally, demographic data on employment status and monthly income obtained in this study represent data typically seen in most developing countries. Hypertension rates have been reported to be higher in upper middle-income countries than in lower-middle-income countries (Sarki et al. 2015). In addition, hypertension and reduced risks of heart diseases have been shown with higher job status (Amano et al. 2019). In this study, gainful employment was associated with higher levels of hypertension compared to participants without employment.

In relation to hypertension, most of the respondents were diagnosed with hypertension within the last 10 years (Fig. 1). The risk of developing cardiovascular complications, whether young or old, substantially increases by hypertension (James et al. 2014). Greater risks of adverse outcomes and heritable risk factors can be developed with early or late onset of hypertension, although the former premise has yet to be demonstrated (Niiranen et al. 2017). The results of this study indicated that the age class of the participants with the most reported hypertension fell within the age class of 41 and 50 years. Given that hypertension is multifaceted and heterogeneous, it is likely that the less common type of hypertension which develops earlier in life is genetically determined (James et al. 2014). On the other hand, the environmentally determined type of hypertension could develop later in life. Individuals with high blood pressure in the clinical setting should therefore be screened for heritable factors or at the onset, be administered pharmacological agents (James et al. 2014).

Prescribed Western medications reported by respondents in this study indicated a wide range of antihypertensive drugs. There is universal agreement among clinicians supporting combinational antihypertensive therapies to produce better hypertension therapeutic outcomes than single therapies (Guerrero-García and Rubio-Guerra 2018). Common combinations of antihypertensive medications that have been shown to be safe and effective in the management of hypertension include a calcium antagonist with a renin-angiotensin system inhibitor (RASI), whether an angiotensin-converting enzyme inhibitor (ACEI) or angiotensin receptor blocker (ARB). Regardless of whether a free combination or fixed doses type of antihypertensive medications are prescribed to patients, most will include a diuretic (Guerrero-García and Rubio-Guerra 2018). Furthermore, greater blood pressure control has always been reported with combinational therapies as compared to monotherapies. Guerrero-García and Rubio-Guerra (2018) reported that for most antihypertensive patients to reach the recommended goal, a combination of at least two antihypertensive medications should be given. Combination therapies are always recommended for patients with a systolic blood pressure reading of about 20mmHg above the target pressure or 10mmHg above the target diastolic pressure. Aside from providing greater hypertensive control, the use of multiple medications is also recommended in hypertensive patients with risks for cardiovascular complications (Husaini et al., 2023a). Lastly, combined therapies reduce the potential for adverse effects while providing superior protection to target organs as compared with monotherapy (Guerrero-García and Rubio-Guerra 2018). Patients who do not respond to dual therapies within 6-8 weeks will usually require triple therapy with renin angiotensin system inhibitors, a natriuretic and a calcium antagonist (Guerrero-García and Rubio-Guerra 2018).

Many of the respondents in this study were knowledgeable of herbal remedies used in the management of hypertension and many reported using herbal remedies to treat hypertension and other disease conditions (Table 1). The respondents reported *Beta vulgaris* (beetroot) juice as the most used antihypertensive medicinal plant in this study (Table 2). Nitrate-dietary supplementation with beetroot juice has been advanced as a nutritional approach for the control of arterial blood pressure in normotensive individuals, pre-hypertensive subjects, and diagnosed patients that are being managed with Western antihypertensive medications (Bonilla Ocampo et al 2018). Secondary metabolites found in *Beta vulgaris* probably act by utilizing nitrate/nitrite/nitric oxide (NO<sub>3</sub><sup>-</sup>/NO<sub>2</sub><sup>-</sup>/NO) pathway. Juice extracted from beetroot has been

reported to be a cost-effective approach to reducing blood pressure in several hypertensive populations (Bonilla Ocampo et al 2018). In addition, reduction in morbidity and mortality from complications of hypertension could be drastically reduced by using beetroot juice as a cheap and easily accessible dietary intervention in the management of cardiovascular complications (Bonilla Ocampo et al 2018). The use of beetroot reported by respondents in the management of hypertension in this study corroborated previous studies.

The medicinal plants used to manage hypertension and those used by the participants to manage their hypertension are presented in Table 2. Over 30 medicinal plants belonging to 25 families were used for the management of hypertension as reported by the respondents. Garlic was reported as a medicinal herb/spice used by the respondents in this study. This result of the study is in line with many previously reported studies on the health benefits of garlic, especially its use in the management of hypertension. For instance, garlic has been reported to have anti-inflammatory, hypocholesterolemic, anti-cancer, antibacterial, hypotensive and antioxidant properties and its healing abilities have been reported in various cultures and societies for over 1,000 years (Chan et al. 2020). Furthermore, in many developed and developing countries, physicians and clinical researchers are continuing their efforts to investigate the numerous claims made regarding the multi-fold healing powers of garlic (Qidwai and Ashfaq 2013; Chan et al. 2020). In relation to some of these claims, Ried et al. (2013) reported that individuals using garlic for medicinal purposes or as spices consume either the extract, powder, oil or in raw form. The strong smell of garlic limits raw consumption for some individuals; hence, many enteric-coated supplements that dissolve easily in the gastrointestinal tract are available for ease of consumption (Chan et al. 2020). Reports by Qidwai and Ashfaq (2013) and Chan et al. (2020) indicated that the number of people treating their hypertension with garlic is on the increase and interest in its use is on the rise. The major reported bioactive organo-sulfur substances that gives garlic its unique mechanism of action are diallyl disulfides (DADS), methyl thiosulfonate, S-allylcysteine (SAC), diallyl trisulfides (DATS), and Allicin (Qidwai and Ashfaq 2013). Although garlic is presented to be potentially effective in many health situations, and its use has found global acceptance, numerous pharmacologic mechanisms of action for hypotension have been reported based on the constituents identified. For instance, reduction in systolic blood pressure or diastolic blood pressure have only been reported in some studies, while no change in blood pressure or significant lowering of blood pressure has been reported in other studies (Chan et al. 2020). Despite the irregular reported effects of garlic and its constituents, the induction of its hypotensive abilities has been confirmed (Chan et al. 2020). In a recent review Chan et al. (2020) described various types of garlic reported to lower systolic, diastolic or both blood pressure. Furthermore, garlic was reported to have an efficacy of almost 80% as an antihypertensive herb (Qidwai and Ashfaq 2013; Chan et al. 2020). With over hundred active compounds scientifically identified as drugs from plants, an increasing amount of literature exists on medicinal plants and herbs used for the management of hypertension (Al Disi et al. 2016; Malik et al. 2017; Meresa et al. 2018; Chan et al. 2020). Some of the herbal therapies have gone through extensive studies with many reported discoveries about their bioactive metabolites, while others are still being studied with new information on their pharmacology and toxicities (Shaikh et al. 2020). This study agrees with the globally presented research on the use of medicinal plants in many communities. The potential to discover new drugs from Belize's rich rainforest is enormous if research is focussed on identifying their active metabolites and pharmacological benefits.

Responses on the rationale for the use of medicinal plants observed in this study corroborate previous studies where the motivation for the use of medicinal plants in the management of diseases was because they are natural, readily available, cheap, safe and effective. Numerous factors have led to a substantial global increase in medicinal plant usage (Ekor 2014; Mphuthi & Husaini, 2022). Foremost among them is that indigenous therapies are inexpensive when compared to conventional drugs and have fewer adverse effects. The World Health Organization (2013) reported that this increase in patronizing herbal remedies is not necessarily dependent on the country, region or economic status or the individuals, since complementary and alternative medicines are now used by over 70% of people in developed countries for the prevention or treatment of various ailments and diseases. The trend is not any less in developing countries where a more pronounced usage of alternative medicines is being recorded (WHO 2013; Ekor 2014). Despite international efforts to encourage collaboration between indigenous and Western healers, and the long ancestral history of medicinal therapies use in Belize, medicinal plant therapies are not recognized by Western healers, at least not publicly in Belize. Both indigenous and Western scientific knowledge have similar foundations and are built on the same philosophies (WHO, 2023). Since Western

science was given full and unreserved acceptance, indigenous science should be explored further with a view to identify the benefits that are inherent to such science in the country of Belize.

Finally, data on the concomitant use of medicinal plants with Western medicines were presented (Table 3). Approximately 23.2% reported occasional use of medicinal plants in combination with Western medications, while 6.2% reported frequent consumption of herbal therapies with Western medications (Table 3). The majority (28.3%) of the respondents reported that the combination of indigenous and Western medications for the management of hypertension is effective, while 36.3% reported being aware of potential interactions when herbal and Western therapies were taken together (Table 3). The low concomitant use of herbs with Western medications seen in this study could be attributed to increased awareness by the respondents of potential interactions between herbs and Western drugs (Table 3). There are a lot of uncharacterized compounds in medicinal plants that present many opportunities for drug-herb or herb-herb interactions. These drug-herb or herb-herb interactions can precipitate toxic effects or, in some instances, render the therapeutic effect of a conventional drug or herbal preparations more potent (Kahraman et al. 2020). Patient counseling on the potential interactions with drug-herb interactions could greatly help reduce the incidence of unwanted toxic events seen in herb-drug interactions (Kahraman et al. 2020). Participants in this study reported a low concomitant use of medicinal plants with Western medications in the management of hypertension.

## **Conclusions**

The results of this study indicate the majority of respondents are knowledgeable about medicinal plants used in the management of hypertension in Belize. Most of the respondents also reported being knowledgeable of medicinal plants and used them to treat hypertension and other diseases. Although many of the respondents have used herbs to manage their hypertension, a few of them from time to time combined their herbs with Western medications, with a few frequently combining herbs with Western medications in the management of their hypertension. Beetroot, garlic, lime, and aloe vera were the most reported medicinal plants and herbs used in the management of hypertension in Belize, while hydrochlorothiazide and captopril were the major Western medications used by respondents in the management of hypertension. Although an increased awareness and knowledge of herbs and medicinal plants was seen among respondents in this study, the majority did not combine their Western medications with herbal remedies, probably due to awareness of potential harmful interactions. The need to maintain consistency with prescribed medications and share herbal remedy practices with physicians is imperative in achieving better therapeutic outcomes. In addition, since herbal remedies have been in existence before Western medicines and have effectively been used in the treatment of various diseases with proven efficacy, both indigenous therapy and Western therapies can therefore co-exist to provide holistic healthcare to the Belizean population, especially that a few Western medications have been discovered from medicinal plants and the need to seek alternative therapies is on the rise.

## **Suggestions for Future Research**

The results of this study suggest a need to further explore cultural, educational status, religious beliefs, and socio-economic factors, and their role in hypertension epidemiology in Belize. Further studies on ethnicities-specific biomarkers and their role in hypertension needs to be evaluated and characterized among different ethnicities in Belize.

## **Limitations of the study**

Although the authors did their best to ensure a biased free study, purposive sampling poses limitations. In addition, since the study was self-reported by the respondents, recall bias may be a limitation.

## **Conflicts of interest**

The authors declare that they have no competing interests.

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