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Cognitive function and blood pressure control in elderly hypertensive individuals

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Abstract *This article aims to estimate the prevalence of cognitive impairment and analyze its association with blood pressure control in elderly hypertensive individuals. Cross-sectional study of 383 elderly hypertensive individuals in the state of Piauí, Brazil. The authors collected sociodemographic and clinical data, performed blood pressure measurement, and assessed cognitive function using the Montreal Cognitive Assessment (MoCA) test. Poisson regression with robust variance was used. Overall prevalence of cognitive impairment was 74.4%, higher in the age group 80 years and over and among older persons with less schooling. Prevalence of uncontrolled blood pressure was 61.6%, with a higher proportion in the elderly with cognitive impairment. An association was observed between cognitive impairment and uncontrolled blood pressure (aPR: 3.98; 95%CI = 2.51-6.33). The significant association between cognitive function and blood pressure control suggest that cognitive impairment is an important risk factor for uncontrolled blood pressure in older persons. The inclusion of screening measures for possible cognitive deficits may be useful for better monitoring blood pressure levels among elderly hypertensive individuals.*

Key words *Elderly, Cognition, Aging, Hypertension, Family Health Strategy Primary healthcare*

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Introduction

High blood pressure (HBP) is a chronic non-communicable disease, considered one of the leading mortality risks in the world[1]. Prevalence of hypertension increases significantly with age, and HBP is more prevalent among the elderly than in the young and middle-aged population[2]. In Brazil, HBP affect 36 million adults (32.5%) and more than 60% of the elderly, contributing directly or indirectly to 50% of cardiovascular deaths[3].

Although HBP is a major public health problem, leading to high costs for the health system due to complications, it still displays low control rates, thus increasing the risk of cardiovascular morbidity and mortality[4].

A recent study of hypertensive individuals 60 years or older found that 58.8% of participants were aware of their clinical condition, and that 96.5% of these were in treatment. Among treated participants, only 24.5% had their blood pressure (BP) adequately controlled, thus emphasizing the importance of strengthening primary care[5]. Brazilian studies have also shown low levels of blood pressure control in the elderly, varying from 27% to 50.8%[6,7].

Adequate control of BP levels is related to various factors such as sociodemographic characteristics (sex, age, schooling, income), health behavior (sedentary lifestyle), and treatment adherence[8]. In addition, cognitive impairment (CI) has been described as an important risk factor associated with inadequate blood pressure control[9]. CI poses a risk for daily activities of self-care[10], which are indispensable for maintaining BP within adequate levels. Since memory (the capacity to retrieve information) influences various aspects of life, and communication is the key element for wellbeing and survival[11], its impairment can compromise adherence to medication and selfcare and thus BP control in hypertensive patients.

In this context, although some studies have shown that cognitive deficit is associated with uncontrolled BP[9,12], there is still little information on the association between CI and BP control, especially in the elderly population. The current study thus aimed to estimate the prevalence of CI and analyze its association with BP control in a sample of elderly hypertensive Brazilians.

Method

Study design, population, and sample

This cross-sectional epidemiological study was conducted in the city of Picos, Piauí, Brazil, from June to November 2019. The municipality lies in the central-south region of the state of Piauí, 314 kilometers from the state capital Teresina, and has 36 family health teams (25 in the urban area and 11 in the rural area), with 100% population coverage by the Family Health Strategy.

Inclusion criteria for participation in the study were the following: age 60 years or older, coverage by the Family Health Strategy in the urban area of Picos, medical diagnosis of HBP, and use of antihypertensive medication. Exclusion criteria were elderly with prior diagnosis of dementia, history of stroke, severe visual and/or hearing impairment preventing cognitive assessment, psychiatric disorders, and institutionalized or hospitalized elderly.

To obtain the total number of elderly persons with HBP in the municipality of Picos, a list was first organized by the Family Health Strategy with the names and contact information of the nurses (team coordinators) and their respective community health workers. Next, the total number of 3,524 elderly with HBP was obtained from the Family Health Strategy, based on a survey of all the Family Health Strategy teams in the municipality (100% coverage).

Estimation of the sample size used the following parameters: estimated prevalence of 50%[8] to obtain the largest sample size, population size of 3,524 elderly with HBP monitored by the Family Health Strategy in the urban area, 5% estimation error, 95% confidence interval, and an additional 10% for possible losses and refusals. The estimated minimum sample was 382 elderly hypertensive individuals. Participants were selected by random sampling with distribution proportional to the sample size among elderly hypertensive individuals registered with each Family Health Strategy team.

After losses and refusals, the study´s final sample consisted of 383 elderly persons. Losses were defined as participants not located after three visits, change of address, or death. Contact with the selected elderly was done by the respective community health workers under the reference Family Health Strategy, who explained the study´s objectives and participation to the elderly. All participants signed a free and informed consent form.

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Data collection

Data collection used a face-to-face interview through a previously scheduled home visit. Data were collected by a trained team, consisting of 39 interviewers (undergraduate nursing students) under the supervision of two registered nurses.

The questionnaires were carefully drafted, pretested, and accompanied by a detailed instructions manual on the questions and orientation on how to proceed in case of doubts. Data quality control was reinforced by regular meetings with all interviewers and supervisors.

The interviewers were properly trained and certified, and the same care was maintained weekly when the questionnaires were turned in, with careful review by the data collection team supervisors.

Since the fieldwork involved participation by a large number of interviewers and was thus subject to wide margin of error, all procedures were accompanied by an instruction manual for proper completion of the questionnaire, standardization of anthropometric assessment techniques, and blood pressure measurement. Interviewers and supervisors also participated in regular meetings to clarify doubts concerning the data collection instrument and the approach to the elderly individuals.

The following variables were included in the study:

Sociodemographic and occupational: sex (female/male); age group in three categories (60-69/70-79/80 years and older); family arrangement (living alone versus with family or spouse); schooling (incomplete or complete elementary/incomplete or complete secondary/university or more); occupation (employed/unemployed/on leave/retired); health plan (yes/no);

Health status and aspects related to HBP: cognitive impairment (yes/no), BP control (yes/no), BMI (normal weight, underweight, and overweight/obesity); self-rated health (very good/good, fair, and very bad/bad); time since diagnosis of HBP (≤ 10 years and > 10 years), and treatment adherence for HBP (adherent/nonadherent);

Use of health services: time since last appointment for follow-up of HBP (≤ 3 months and > 3 months); participation in hypertension support group in primary care (yes/no); assessment of treatment received from the Family Health Strategy (very good/good, fair, and very bad/bad).

Cognitive function was assessed with the Montreal Cognitive Assessment test (MoCA), developed specifically for screening milder forms of CI and taking approximately ten minutes to administer[13]. The domains comprising the MoCA are visuospatial skills; executive functions, attention and concentration, language, memory, visuoconstructional abilities, calculation, abstraction, and orientation. The maximum score on the MoCA is 30 points, and higher scores reflect better performance[13]. The current study used a cutoff of ≤ 24 points for presence of CI, based on sensitivity and specificity of 81% and 77%, respectively, in screening CI in elderly Brazilians[14].

The study´s dependent variable was uncontrolled BP, defined as systolic blood pressure (SBP) ≥ 140 mmHg and diastolic blood pressure (DBP) ≥ 90 mmHg. BP measurements were performed with automatic BP monitors (OMROM model HEM-7130), properly calibrated, with an OMROM universal HEM-RML31 cuff (22-42 cm), appropriate for arm circumference, according to the protocol of the 7th Brazilian Guidelines on Systemic Arterial Hypertension[3].

For BP measurement, the elderly individual remained seated in a quiet setting, arm resting on the table at the level the heart, having rested previously for at least 5 minutes, besides absence of effort or physical exercise, alcohol use, or smoking in the 30 minutes prior to the measurements, and with an empty bladder.

Three BP measurements were taken on the left arm at 2-minute intervals, and the average of the last two measurements was recorded as final. Arm circumference was measured at the midpoint between the left shoulder and left elbow, at the level of the heart (fourth intercostal space) with the patient seated for the BP measurement.

All participants were asked about the medication they were taking for hypertension and to show the prescriptions and/or medications at the time of the interview.

Adherence to antihypertensive medication was assessed with the Brief Medication Questionnaire (BMQ), an instrument validated for the hypertensive population[15], consisting of three domains that identify barriers to adherence, beliefs, and recall in relation to drug treatment. The BMQ was dichotomized, and nonadherence was defined as a score ≥ 2 points.

Nutritional status was assessed by body mass index (BMI), obtained by dividing weight in kilograms by height in meters squared, with the Lipschitz classification[16]: underweight (BMI < 22.0 kg/m^2), normal weight (22.0 ≥ BMI < 27.0 kg/m^2), and excess weight (BMI ≥ 27.0 kg/m^2), with specific cutoff points for the elderly.

Weight (kg) was measured with a portable digital scale (Kikos ISON brand), with a capacity of 150 kg and precision of 0.1 kg, with an automatic display activated by the participant´s feet at the time of weighing, positioned in the center of the scale, barefoot, and wearing light clothing. Height (cm) was measured with an inelastic tape measure attached to the wall, with a maximum height of 2 m and precision of 1mm, with the participant standing erect, barefoot, heels together, and arms hanging by the sides.

Statistical analysis

A descriptive analysis was performed (absolute frequencies and percentages, means and standard deviations [SD], medians and interquartile ranges [IQR]) to present the distribution of the sociodemographic data, clinical characteristics, and BP control. Shapiro-Wilk test was used to assess data normality. Due to the nonnormal distribution of the MoCA domains, the cognitive performance in each MoCA domain between the groups with controlled and uncontrolled BP was compared with the Mann-Whitney test. Pearson chi-square and linear trend were used to test associations between categorical variables.

Poisson regression with robust variance was used to analyze the association between CI and blood pressure control. Variables that presented p-value < 0.20 in the crude model (sex, age group, schooling, BMI, self-rated health, treatment adherence, and time since last appointment) were included in the multivariate regression model.

The model was adjusted for possible confounding factors (control variables), based on the literature. Model 1 included the sociodemographic variables (sex, age group, and schooling); in model 2, variables related to health status and HBP were added (BMI, self-rated health, and treatment adherence); and model 3 also included variables on use of health services (time since last appointment).

Adjusted analysis used stepwise variable selection with backward elimination. Sex, age, and schooling were considered control variables and were thus present in all the models. In the adjusted analysis, the final model only retained the variables with p-value < 0.05.

Data were keyed in twice, corrected, and their consistency was assessed with *Epi Info* version 3.4.3. All statistical analyses used the R software version 3.6.1, and the results were expressed by prevalence ratios (PR) and their respective 95% confidence intervals (CI).

Ethical aspects

The study was approved by the Institutional Review Board of the Sergio Arouca National School of Public Health (ENSP-FIOCRUZ) under review no. 3.307.403 on May 12, 2019, complying with the ethical principles in Resolution 466/2012 of the Brazilian National Health Council.

Results

Most of the elderly hypertensive individuals were females (64.2%), 60 to 69 years of age (46.5%). The majority reported time since last appointment greater than three months (54.3%) and did not participate in hypertension support groups in the health unit (77.5%) (Table 1).

Prevalence of CI increased linearly with age and inversely to schooling. Prevalence of uncontrolled BP was 70.8% in men and 56.7% in women. Among elderly with "very bad/bad" self-rated health, prevalence of uncontrolled BP was higher (78.9%) than in elderly with "very good/good" self-rated health (65.8%), as shown in Table 1.

Prevalence of uncontrolled BP was 61.6%. Elderly with CI showed higher mean SBP (144.3 [SD = 16.50] mmHg) and DBP (85.66 [SD = 10.12] mmHg) than elderly without CI (SBP: 124.9 [SD = 14.43] mmHg; DBP: 77.38 [SD = 9.40] mmHg; $p < 0.001$). Cognitive impairment was seen in most of the participants (74.4%), and 77.5% of these presented uncontrolled BP ($p < 0.001$) (data not shown in the Table).

Elderly hypertensive individuals with controlled BP scored higher on performance in most of the cognitive domains, except for visuospatial/executive function, compared to elderly with uncontrolled BP. Among elderly hypertensive individuals with controlled BP, median score on the MoCA was higher (25; IQR = 19-25 points) than in those with uncontrolled BP (20; IQR = 17-23 points), as shown in Table 2.

Crude regression analysis showed that elderly hypertensive individuals with CI presented 5.07 times higher prevalence (95%CI = 3.17-8.10) of uncontrolled BP compared to elderly without CI. Cognitive impairment remained strongly associated with uncontrolled BP (RP = 5.13; 95%CI = 3.25-8.09) after adjusting for confounding factors (Table 3).

Table 1. Description of sample according to prevalence of cognitive impairment and uncontrolled blood pressure in hypertensive elderly. Picos. PI. Brazil. 2019.

Variables	Total n = 383	CI* n = 285	p	Uncontrolled BP†	p
	n (%)	n (%)		n (%)	
Sex					
Female	246 (64.2)	180 (73.2)	0.455	140 (56.7)	0.006¶
Male	137 (35.8)	105 (76.6)		97 (70.8)	
Age group					
60-69	178 (46.5)	115 (64.6)	< 0.001	105 (59.0)	0.138¶
70-79	138 (36.0)	110 (79.7)		85 (61.2)	
80 and older	67 (17.5)	60 (89.6)		47 (70.1)	
Family arrangement					
Living alone	41	30 (73.2)	0.847	24 (58.5)	0.657
With family or spouse	342	255 (74.6)		213 (62.1)	
Schooling					
Complete/incomplete elementary	257 (67.1)	206 (80.2)	< 0.001	168 (65.1)	0.065¶
Complete/incomplete secondary	102 (26.6)	66 (64.7)		56 (54.9)	
University and higher	24 (6.3)	13 (54.2)		13 (54.2)	
Occupation					
Employed	20 (5.2)	14 (70.7)	0.751	12 (60.0)	0.478
Unemployed	41 (10.7)	28 (68.3)		23 (56.1)	
On leave	17 (4.4)	13 (76.5)		8 (47.1)	
Retired	305 (79.7)	230 (75.4)		194 (63.4)	
Health plan					
Yes	106(27.7)	73 (68.9)	0.124	68 (64.2)	0.544
No	277(72.3)	212 (76.5)		169 (60.8)	
BMI‡					
Normal weight	177 (46.2)	129 (72.9)	0.591	114 (64.0)	0.012¶
Underweight	45 (11.7)	32 (71.1)		23 (51.1)	
Overweight/obesity	161 (42.1)	124 (77.0)		100 (62.1)	
Self-rated health					
Very good/good	192 (50.2)	144 (75.0)	0.456	127 (65.8)	0.002¶
Fair	153 (39.9)	110 (71.9)		80 (52.3)	
Very bad/bad	38 (9.9)	31 (81.6)		30 (78.9)	
Time since HBP diagnosis§					
≤ 10 years	169 (44.1)	127 (75.1)	0.769	110 (64.7)	0.283
> 10 years	214 (55.9)	158 (73.8)		127 (59.3)	
Treatment adherence					
Adherent	184 (48.1)	56 (59.6)	< 0. 001	37 (39.4)	< 0. 001¶
Nonadherent	199 (51.9)	229 (79.2)		200 (69.0)	
Time since last appointment					
≤ 3 months	175 (45.7)	132 (75.4)	0.676	102 (58.0)	0.162¶
> 3 months	208 (54.3)	153 (73.6)		135 (64.9)	
Participates in HBP group					
Yes	86 (22.5)	62 (72.1)	0.575	56 (65.1)	0.461
No	297 (77.5)	223 (75.1)		181 (60.7)	
Assessment of care from Family Health team‖					
Very good	318 (83.0)	238 (74.8)	0.822	199 (62.4)	0.409
Fair	48 (12.5)	34 (70.8)		26 (54.2)	
Very bad/bad	17 (4.5)	13 (76.5)		12 (70.6)	

* CI = cognitive impairment; † BP = blood pressure; ‡ BMI = body mass index; § HBP = high blood pressure; ¶ Variables with $p < 0.20$ in the association with the outcome (uncontrolled BP) were included in the multivariate model.

Source: Authors.

Discussion

This study, as in the few international studies identified in the literature[9,12], indicates that cognitive impairment is heavily associated with uncontrolled BP in the elderly. The study expands the knowledge on hypertension, particularly related to blood pressure control in elderly persons, and the results support the understanding of cognitive deficit as an important factor associated with uncontrolled BP.

Populations are aging worldwide, and HBP is one of the most common chronic noncommunicable conditions in the elderly[17], acknowledged as a risk factor for cardiovascular diseases[18]. Given this scenario, there is evidence that HBP can play a role in cognitive dysfunction, increasing the risk of related diseases such as Alzheimer´s disease and vascular dementia[19].

A study by Piotrowicz et al.[9] (2016) in 1,988 elderly hypertensive individuals in use of antihypertensive medication for at least one year showed that CI was associated with a 15% higher risk of inadequate BP control. The authors highlighted the high impact of these findings for patients´ health and the importance of geriatric assessment, including instruments to assess cognition, as alternatives for screening individuals with increased risk of low adherence to drug treatment and to help improve the low rates of BP control in the elderly population. The authors further emphasized that patients with CI should be monitored regularly for their mental health status. Caregivers or family members may also need orientation to supervise the patients' antihypertensive treatment or all drug treatments in the case of cognitive deficit, however subtle.

The study's results showed that elderly hypertensive individuals with uncontrolled BP performed worse on their total cognitive score and in most cognitive domains. The findings are consistent with studies that identified low cognitive performance in elderly hypertensive individuals or with increased BP[21,22].

Contrary to other studies that found significant differences for all cognitive domains of MoCa[21,22], the current study did not show a statistically significant difference in scores in the visuospatial and executive domains between participants with controlled and uncontrolled BP.

Performance in cognitive skills is dependent on executive functions, and their decline can compromise planning capacity, mental flexibility, and performance of strategic actions[23]. These are important functions for decision-making and selfcare. Evidence shows that cognitive alterations can appear early and may go unnoticed[24], especially in memory and executive functions. Executive function also involves multiple brain processes, and the cognitive domain is therefore more difficult to assess and with greater heterogeneity in the ways studies measure it[25].

Some additional factors may explain the heterogeneity in the results on impairment of visuospatial and executive skills and their relationship to blood pressure control, such as time and se-

Table 2. Cognitive domains and total MoCA score according to blood pressure control. Picos, PI, Brazil, 2019.

Domains	Score (total)	Controlled BP (n = 146)		Uncontrolled BP (n = 237)		p
		Mean (SD)*	Median (IQR) †	Mean (SD)	Median (IQR)	
Visuo espac/exec.	(0-5)	3.3 (1.3)	4.0 (3.0-4.0)	3.2 (1.3)	3.0 (2.0-4.0)	0. 240
Nomeação	(0-3)	1.8 (0.9)	2.0 (2.0-2.0)	1.7 (0.9)	2.0 (1.0-2.0)	0.001
Atenção	(0-6)	3.7 (1.6)	4.0 (3.0-5.0)	3.5 (1.7)	4.0 (2.0-5.0)	< 0.001
Linguagem	(0-3)	1.5 (0.9)	2.0 (1.0-2.0)	1.4 (0.9)	1.5 (1.0-2.0)	< 0.001
Abstração	(0-2)	1.6 (0.7)	2.0 (1.0-2.0)	1.4 (0.7)	2.0 (1.0-2.0)	0.027
Evocação tardia	(0-5)	2.2 (1.4)	3.0 (2.0-4.0)	1.8 (1.3)	2.0 (1.0-3.0)	< 0.001
Orientação	(0-6)	5.6 (0.7)	6.0 (6.0-6.0)	5.5 (0.8)	6.0 (5.0-6.0)	0.014
MoCA						
Total	(0-30)	20.6 (4.3)	25.0 (19.00-25.00)	19.5 (4.1)	20.0 (17.0-23.0)	< 0.001

* SD = standard deviation; † IQR: interquartile ranges.

Source: Authors.

Table 3. Crude and adjusted prevalence ratios for association between cognitive impairment and uncontrolled blood pressure. Picos, PI, Brazil, 2019.

Variables	Crude model PR* (95%CI†)	Model 1 PR* (95%CI†)	Model 2 PR* (95%CI†)	Model 3 PR* (95%CI†)
Cognitive function				
Without CI	1.00	1.00	1.0	1.0
With CI	5.07 (3.17-8.10)	5.16 (3.24-8.22)	3.94 (2.48-6.29)	3.98 (2.51-6.33)

* PR: prevalence ratio; † CI: 95% confidence interval.
Model 1: adjusted for sex, age, and schooling.
Model 2: model 1 + adjusted for BMI, self-rated health, and treatment adherence.
Model 3: model 2 + adjusted for time since last appointment.

Source: Authors.

verity of the disease, type of medication for HBP, and SBP levels, especially among the older elderly individuals.

There is little information on cognitive function and BP control in middle-income countries. In Brazil, the epidemiological data are scarce on the influence of CI on blood pressure control, thus limiting the management of patient care and action in evidence-based information programs to allow better management of HBP.

The current study´s results have important clinical implications because elderly hypertensive individuals with CI can have their selfcare and activities of daily living compromised. CI can lead to unintentional errors with dosage or amounts of medications, forgetting the days, hours, or types of medications used, thereby interrupting treatment continuity and compromising adequate control of BP levels.

Screening instruments have their limitations. Although findings in the literature suggest that MoCA is a rapid and precise screening tool for the identification and diagnosis of cognitive impairment, when compared to other instruments such as the Mini-Mental State Examination[21], a test battery may be more effective in the identification of deficits in specific cognitive domains.

Many studies have been performed for validation of the MoCA in diverse populations, and various cutoff points have been proposed[26]. As in our study, using a cutoff in MoCA of 25 points and correction of 1 point in patients with less than 12 years of schooling, Muela et al.[21] (2017) conducted a sub-analysis of cognitive performance in patients with high levels of education (≥ 9 years of schooling), and even in this subgroup of patients in whom schooling might have a protective effect, they found that worse cognitive performance was associated with severity of BP levels.

The low schooling observed in most of the elderly individuals in the current study is frequently found in current research[27]. The number of years of schooling, considered a neuronal protective factor, is also a diagnostic confounding element, since individuals´ performance on cognitive assessment instruments is heavily influenced by schooling[28].

Thus, the education variable is complex and individual and may be reflected in adulthood and contribute to intellectual decline in old age[29]. Differences in the proposed cutoff points and the influence of schooling in many studies highlight the importance of conducting validations of MoCA in specific populations, to maintain its efficacy as a screening tool.

The study's strengths and limitations

The study provides evidence that cognitive impairment can be a key element for understanding inadequate blood pressure control in elderly hypertensive individuals, expanding the existing literature on this topic, which has received relatively little research attention. In addition, the adjustment for possible confounding factors such as age to avoid overestimating or underestimating the results was important for understanding the association between CI and uncontrolled BP.

However, the study presents some limitations when interpreting the results. The cross-sectional design does not allow establishing a causal relationship between CI and uncontrolled BP. There was also a possible reverse causality bias, which limits inferences on the association's direction (CI influencing BP control).

The sample of elderly restricted to only one municipality in the interior of Brazil limits the results' generalization to other populations. Fu-

ture studies are thus needed for a more comprehensive and in-depth approach to the topic to elucidate the associations.

Measurement of BP on a single visit also hinders knowing whether the BP levels were stable at other moments and may thus not reflect the individuals' usual BP levels. In addition, although we used the cutoff point proposed by Memória et al. (2013) for the Brazilian population, the low schooling in most of the participants may have caused difficulties in understanding the MoCA content.

Conclusion

The significant association between cognitive function and blood pressure control in elderly persons with hypertension in the Family Health Strategy in Picos, Piauí, Brazil, indicates that the inclusion of screening measures for possible cognitive deficits may be important allies in the assessment of high blood pressure levels in hypertensive elderly persons in primary healthcare.

The findings emphasizing the high prevalence of CI and uncontrolled BP can support studies that assess the possible effects of CI on BP levels in elderly hypertensive individuals. The results can also help improve the approach to and care for this population, helping plan interventions according to individual and contextual characteristics and with the assistance of elderly persons´ caregivers to determine better control of high blood pressure and thereby prevent future complications.

Collaborations

ALA Luz: research conception and design, data collection, data analysis and interpretation, article writing, critical review and article writing. A Silva-Costa and RH Griep: research design, data analysis and interpretation, article writing, review critical: statistical analysis and interpretation of data, critical review. EL Barbosa, LP Marques and EP Souto: statistical analysis and interpretation of data, critical review. All authors approved the final version of the manuscript.

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