

# Nutrient Diversity and its Association with Type 2 Diabetes Mellitus in Urban Indian Population

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## ABSTRACT

**Background:** Nutrient diversity is one of the key factors of a balanced diet because of its correlation with macronutrients and micronutrients. **Aims and Objectives:** The objective of the study was to assess daily dietary intake and get urban Indian data based on the regional dietary intake of the subjects. **Materials and Methods:** Nutrient diversity was inferred using a food frequency questionnaire and 24-h dietary recall along with other variables such as demographic data, income, education, lifestyle, number of meals per day, and addictions. Average, mean, and standard deviation were calculated for all of these. **Results:** Results showed a positive correlation between nutrient diversity and its association with type 2 diabetes mellitus. The average dietary intake of the study showed that the subjects consumed a diet high in carbohydrates and fat while the protein and micronutrient intake was on the lower side. A large variation was observed in the average nutrient intake from different food groups. **Conclusion:** The current study concluded that the nutrient diversity amongst the subjects is an indicator to risk of diabetes and pre-diabetes.

**Keywords:** Dietary intake, Macronutrients, Micronutrients, Nutrient diversity, Type 2 Diabetes

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## INTRODUCTION

Diet is a combination of nutrients and chemical elements that play an important role in lowering the risk of developing any non-communicable diseases (NCDs). With the rise in industrialization and urbanization, there is a shift in eating patterns with diminished multifariousness in food. The growth in the food industry, increased use of poor-quality oils and beverages loaded with sugar or sugar substitutes is now becoming a trend among Indians.<sup>[1]</sup> Indians have started adapting the Western dietary patterns, i.e., increased consumption of bakery products, processed meat, fried foods, and ready to eat which are all linked to increase risk of NCDs.<sup>[2]</sup>

Nutrient diversity refers to variety in diet and opting for various healthier food options to get maximum benefits from the foods available, thereby increasing the availability of phytonutrients that are essential for good health and lowering the risk of NCDs.<sup>[3]</sup> There have been studies that show a positive association between mean nutrient adequacy with low risk of developing NCDs and the score of dietary diversity that have been used globally to assess the quality of diet.<sup>[4]</sup> Literature has shown that nutrient diversity is inversely associated with metabolic syndrome, obesity, and cardiovascular risk factors.<sup>[5]</sup>

## MATERIALS AND METHODS

This study is a cross-sectional study with a mixed-method research design. 240 diabetic subjects were selected using a purposive sampling technique. The subjects recruited were in the age group of 25–60 years, both males ( $n = 99$ ) and females ( $n = 141$ ). Patients fulfilling the inclusion criteria were selected. Data collection was done with the help of a questionnaire which was formulated considering all the aspects of the study.

The questionnaire included demographic data, information on social and financial background, physical activity, addictions if any, anthropometric data, recent biochemical values (blood sugar parameters—fasting and postprandial, lipid parameters—total

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cholesterol (TC), low-density lipoprotein-cholesterol (LDL-C), high-density lipoprotein-cholesterol (HDL-C), Triglycerides (TG) and very low-density lipoprotein-cholesterol (VLDL-C), bio-physiological values (blood pressure using a sphygmomanometer), food frequency table and 2-day dietary recall (1 weekday and 1 weekend), detailed history of past and present medical status for all the subjects.

The study protocol was explained to all participants and written informed consent was obtained in the local language of the participant. Signatures of the consent form were taken in the preference of language by the subject. This study was approved by a government-recognized independent Ethics Committee.

The inclusion criteria were as follows: Subjects who are clinically diagnosed with diabetes (pre-diabetes and newly detected), subjects who are otherwise healthy with no eating disorders, aged 25–60 years, and with otherwise normal mental health. The exclusion criteria were as follows: Patients suffering from a renal disorder or, liver disorders; patients who have undergone surgery

in the past 3 months, patients who have undergone bariatric surgery or have any existing diabetic complications, patients on alternative medication, children, pregnant or lactating women. The migrant population and people with variable work timings and shift duties were also excluded from the study.

## RESULTS

The mean age of male subjects in the study was  $48.78 \pm 8.65$  years and female subjects in the study were  $48.81 \pm 9.51$  years.

Among the study population, the majority of the male subjects had a monthly income of more than 30,000/- and a higher number of female subjects reported a monthly income between 15,000/- and 30,000/-.

Data reveals that the religions which dominated in the study were Hindu and Muslim.

Figure 1 reports that 50.50% of males and 46.80% of females consumed at least 4 meals a day.

Figure 2 indicates that a sedentary lifestyle was common across most male subjects

Figure 3 indicates that a sedentary lifestyle was common across most female subjects

Addictions such as chewing tobacco, smoking, and alcohol consumption were not commonly observed. However, among those who did consume, male subjects did report higher consumption than female subjects [Figure 4].

Table 1 indicates anthropometric measurements of the subjects

Figure 5 shows that the average body mass index (BMI) of male subjects was  $26.82 \pm 5.03$  kg/m<sup>2</sup> and that of female subjects

was  $29.21 \pm 5.77$  kg/m<sup>2</sup>. A higher percentage (37.37% of n) of male subjects were Grade I Obese and (47.51% of n) of females were Grade I Obese and 21.21% of male subjects and 33.33% of female subjects were in Grade II Obese category.

Table 2 shows that there was more variation in the fasting and post-prandial blood sugar (PPBS) levels among the subjects. The male subjects reported an average fasting blood sugar (FBS) of  $170.48 \pm 87.89$  mg/dL and PPBS of  $228.74 \pm 112.34$  mg/dL. The female subjects reported a lower blood sugar level compared to the male subjects, their FBS was  $154.86 \pm 74.78$  mg/dL and PPBS was  $198.93 \pm 89.15$  mg/dL.

Table 2 also portrays the average blood pressure levels and lipid profiles of both male and female subjects.

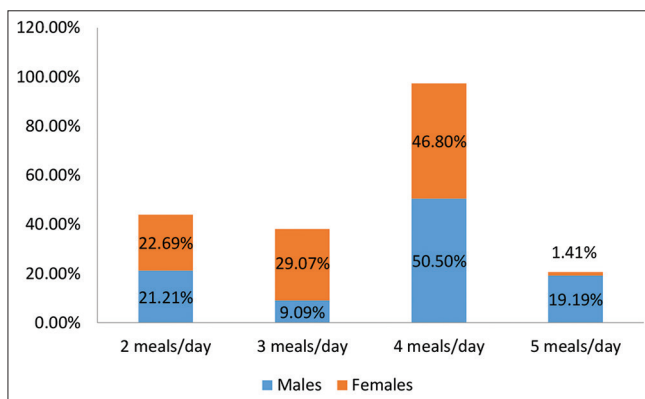
Figure 6 portrays that FBS values higher than 110 mg/dL were observed among 76.76% of male subjects and 69.50% of female subjects. PPBS values above 240 mg/dL were observed among 80.80% of male subjects and 70.92% of female subjects.

Table 3 estimates the average nutrient intake of macronutrients and micronutrients for the study population. These values were

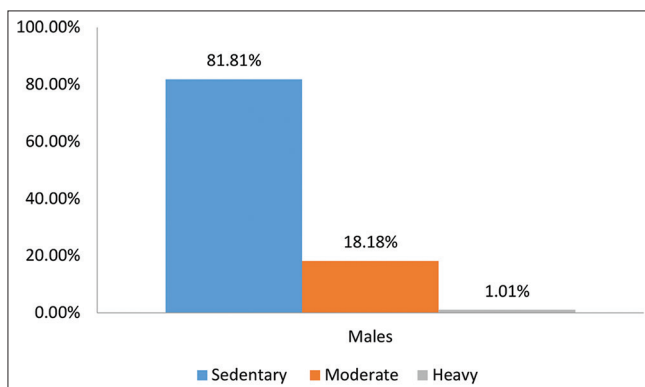
**Table 1:** Data on average mean of anthropometric measurements of subjects

Anthropometric measurements	Males (n=99)	Females (n=141)
Height (cm)	167.70±8.92	158.05±13.46
Weight (kg)	75.44±14.76	72.05±14.79
BMI (kg/m <sup>2</sup> )	26.82±5.03	29.21±5.77

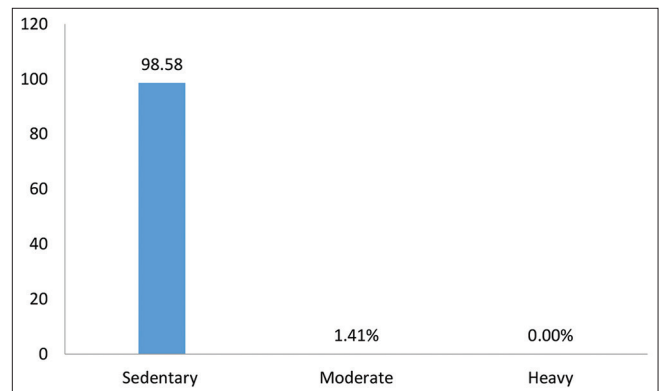
BMI: Body mass index



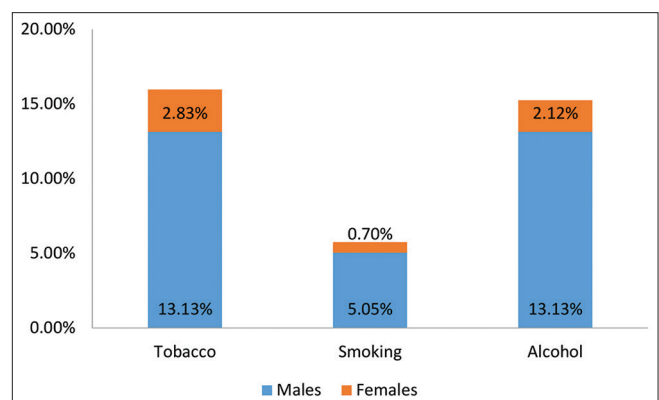
**Figure 1:** Number of meals per day of subjects



**Figure 2:** Activity pattern of male subjects



**Figure 3:** Activity pattern of female subjects



**Figure 4:** Subjects who responded "YES" to having some kind of addiction

**Table 2:** Mean biochemical and bio-physiological parameters of the subjects

Biochemical and bio-physiological parameters		
Blood sugar levels	Males (n=99)	Females (n=141)
Fasting Blood Sugars (mg/dL)	170.48±87.89	154.86±74.78
Post-prandial blood sugars (mg/dL)	228.74±112.34	198.93±89.15
BP		
BP-systolic (mmHg)	140.56±17.95	138.11±18.05
BP-diastolic (mmHg)	81.72±10.15	79.59±10.19
Lipid profile (mg/dL)		
Total cholesterol (mg/dL)	155.78±42.64	164.45±35.69
Triglycerides (mg/dL)	162.33±70.31	169.63±82.08
Low-density lipoproteins (mg/dL)	87.37±35.93	91.73±36.79
High-density lipoproteins (mg/dL)	37.36±4.82	45.79±8.81
Very-density lipoproteins (mg/dL)	32.28±15.57	33.34±17.72

BP: Blood pressure

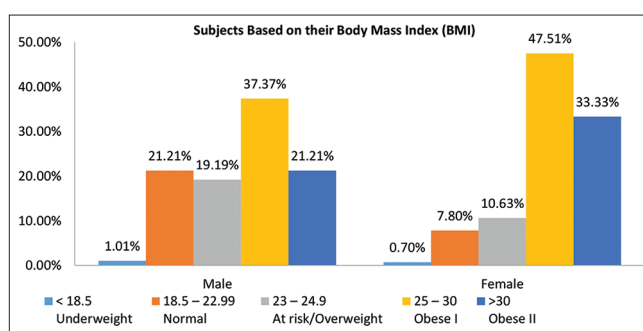
**Table 3:** Average mean and standard deviation of nutrient intake of subjects

Nutrients	Males (n=99)	Females (n=141)
Energy (kcal)	1292±584.87	1035±465.52
Protein (g)	47.62±21.21	38.50±18.95
Energy percentage of proteins	14	12
Carbohydrate (g)	179.86±87.51	183.77±57.68
Energy percentage of carbohydrates	56	57
Total available carbohydrate (g)	115.62±69.88	99.48±41.97
Total starch (g)	104.10±69.42	89.84±40.96
Total free sugar (g)	22.98±15.27	19.11±12.87
Total fiber (g)	27.92±11.30	22.49±8.58
Insoluble fiber (g)	21.50±8.29	17.34±6.86
Soluble fiber (g)	5.84±2.67	4.58±1.84
Fat (g)	40.18±27.65	43.52±25.54
Energy percentage of fat	30	31
Total saturated fat (mg)	10107.55±8032.25	7667.38±7791.43
Total monounsaturated fat (mg)	6924.69±6189.57	6180.31±6847.70
Total polyunsaturated fat (mg)	7205.66±7825.42	5311.13±5446.40
Total trans fat (g)	0.082±0.115	0.061±0.156
Vitamin C (mg)	103.12±75.32	65.12±54.33
Vitamin D3 (mcg)	1.55±1.11	1.50±1.04
Vitamin D2 (mcg)	23.35±11.11	18.75±12.84
Iron (mg)	11.35±5.11	9.03±3.81
Calcium (mg)	448.15±21339.42	396.54±249.24
Chromium (mg)	0.05±0.04	0.04±0.02
Selenium (mg)	80.51±38.39	66.19±35.46
Zinc (mg)	5.98±2.41	4.87±2.03

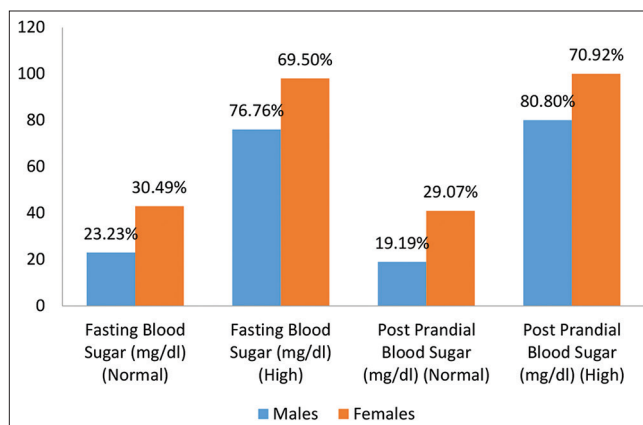
compared against the currently available recommendations for medical nutrition therapy for the management of diabetes mellitus. The average energy intake was 1292 ± 584.87 kcals and 1035 ± 465.52 kcals in males and females, respectively. The average diet of the study group was estimated to be high in CHO and fat intake while being low in protein and other micronutrients. However, it was observed that total fiber intake in the day was within the recommended range.

When questioned on the type of edible oil consumed, the study population varied in response. However, the most popular was sunflower oil (37.50%) followed by subjects preferring a rotation of oils (15%) and ground nut oil (13.33%) [Figure 7].

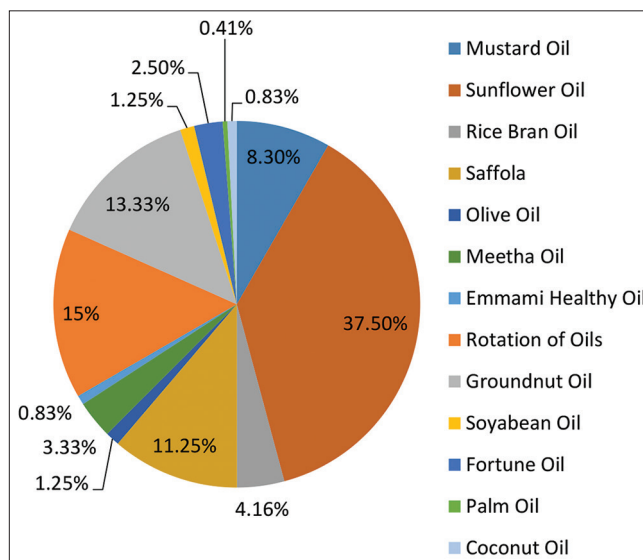
Table 4 explains the average nutrient intake from different food groups.



**Figure 5:** Body mass index of subjects



**Figure 6:** Subject distribution based on their blood sugar levels



**Figure 7:** Consumption of different edible oils by the subjects

The above table shows a negative correlation between the following food groups and lipid profiles respectively—other vegetables, fruits, nuts and oilseeds, sugar, and biscuits with TC levels; cereals and millets, fruits, nuts and oilseeds, sugar, egg and egg products, poultry, fresh water and shell water fish, bread and rolls and biscuits with triglyceride levels. A positive significant correlation at a 5% level of significance was observed between grain legumes, fruits, freshwater fish, and shellfish Table 6.

**Table 4:** Data on mean and standard deviation of food groups of subjects

Cereals and millets (g)	
Males (n=99)	141.16±95.05
Females (n=141)	121.49±54.66
Grain Legumes (g)	
Males (n=99)	20.23±27.90
Females (n=141)	18.25±19.93
Green leafy vegetables (g)	
Males (n=99)	20.23±27.90
Females (n=141)	18.25±19.93
Other Vegetables (g)	
Males (n=99)	220.79±309.66
Females (n=141)	154.01±131.20
Roots and Tubers (g)	
Males (n=99)	34.04±42.74
Females (n=141)	21.15±30.23
Fruits (numbers)	
Males (n=99)	77.83±66.99
Females (n=141)	61.88±44.86
Sugars (g)	
Males (n=99)	11.51±22.29
Females (n=141)	4.47±5.95
Nuts and Oilseeds (g)	
Males (n=99)	15.38±19.34
Females (n=141)	12.31±16.73
Spices and Condiments (g)	
Males (n=99)	24.08±22.63
Females (n=141)	18.53±24.94
Milk and Milk Products (g)	
Males (n=99)	173.53±99.17
Females (n=141)	160.51±151.83
Eggs (numbers)	
Males (n=99)	36.51±29.13
Females (n=141)	40.58±31.46
Poultry (g)	
Males (n=99)	67.46±61.68
Females (n=141)	48.16±44.48
Fresh Water Fish and Shellfish (g)	
Males (n=99)	64.70±82.35
Females (n=141)	50.77±50.69
Edible Oils (ml)	
Males (n=99)	11.05±16.13
Females (n=141)	6.56±8.59
Breads and Rolls (number)	
Males (n=99)	33.57±34.77
Females (n=141)	30.15±33.94
Biscuits (number)	
Males (n=99)	11.42±9.10
Females (n=141)	12.94±10.83
Sweets (number)	
Males (n=99)	33.33±21.82
Females (n=141)	17.87±19.93
Namkeen (g)	
Males (n=99)	85.45±77.23
Females (n=141)	61.69±19.93
Chips (g)	
Males (n=99)	34.71±39.22
Females (n=141)	39.73±46.82
Breakfast Cereals (g)	
Males (n=99)	36.66±11.54
Females (n=141)	27.00±6.70
Ice creams (bowls)	
Males (n=99)	8.21±2.32
Females (n=141)	38.18±44.35
Ready to Eat (g)	
Males (n=99)	45.90±68.00
Females (n=141)	28.79±39.90
Ready Mix (g)	
Males (n=99)	20.98±12.29
Females (n=141)	16.30±16.69
Sauces, spreads and dressings (g)	
Males (n=99)	25.87±47.54
Females (n=141)	10.17±15.03

The above table shows a positive correlation at a 5% level of significance between other vegetables, edible oils, and fats with FBS levels, and the latter shows a positive correlation between edible oils and fats with postprandial levels. HbA1c level shows a significant level at 5% with green leafy vegetables, freshwater fish, and shellfish. The current study shows a negative correlation at a 5% level of significance between roots and tubers and PPBS levels Table 5.

## DISCUSSION

Asian diets are carbohydrate-concentrated diets, therefore not only the quantity but also the quality has a major role in maintaining blood sugar levels. Foods high in glycemic index promote high glycemic as well as insulin response leading to insulin resistance and exhausting beta-cells thus causing type II diabetes mellitus.

There have been many cross-sectional as well as longitudinal studies over the years showing a strong link between type II diabetes mellitus and high carbohydrate diets and it is also connected with obesity, especially in Asian Indians.

The quality of carbohydrates consumed is also equally responsible for maintaining optimum blood sugar levels. Carbohydrates are divided into complex and simple carbohydrates. Most foods which are rich in fiber such as brown rice, pulses, lentils, and green leafy vegetables are complex carbohydrates, and foods which are refined, processed and high in sugar such as bakery, fruit juices, aerated drinks, and sports drinks. Are simple carbohydrates. The famous saying "Moderation is Key" holds very true here and is extremely important for good health. Thus, a balance in daily diet is very important.

The high carbohydrate intake of Indians (currently at 66–75%) must be reduced to 50–55%. Increasing the energy from proteins by 20–25% which comes primarily from vegetarian sources, energy from fats (20–30%) especially coming from MUFA along with an adequate amount of fiber in the diet is essential to prevent and manage NCDs.<sup>[6]</sup>

In recent times, there has been a drastic change in the eating pattern with the influx of ready-to-eat unhealthy foods, ultra-processed foods, high fat, high carbohydrate, and high sugar foods. A decline in the intake of fruits, vegetables, and fiber has been observed.

Along with dietary changes, a decline in physical activity and increase in stress levels has also led to rise in obesity and other NCDs like diabetes mellitus.<sup>[7]</sup>

In the present study, an attempt was made to understand the impact of nutrient diversity on the blood sugar levels of the urban Indian diabetic population. As diabetes mellitus has become a global burden particularly in developing countries, a closer look at the quality-and not only of the quantity of foods eaten-is important.

Some of the limitations of the study are as follows: The study was conducted in COVID-19 pandemic; hence, the data collection was restricted and body fat analysis and weight circumference could not be taken. HbA1c levels could not be measured as the doctor under whom the study was conducted did not believe in asking the patients to measure HbA1c and thus it could not be a part of the study.

## CONCLUSION

From the above study, we trust that including foods diverse in various nutrients will help improve the biochemical parameters and the quality of life of patients with diabetes mellitus and help in controlling the development of NCDs in people already at risk of it.

**Table 5:** Pearson's correlation of food groups and lipid profile of subjects

Food groups	TC	TG	HDL	LDL	VLDL
Cereals and millets	0.109	-0.132	0.069	0.136	-0.014
Grain legumes	0.256*	0.135	-0.051	0.173	0.154
Green leafy vegetables	0.265	0.079	0.090	0.338	-0.038
Other vegetables	-0.147	0.050	-0.085	-0.163	0.171
Fruits	-0.040	-0.016	0.301*	-0.096	-0.113
Roots and tubers	-0.298	-0.174	-0.212	-0.249	-0.155
Nuts and oilseeds	-0.077	-0.065	-0.131	-0.010	-0.081
Sugar	-0.072	-0.066	0.218	-0.065	0.112
Milk and milk products	0.034	0.018	-0.028	-0.018	0.041
Egg and egg products	0.008	-0.042	-0.006	0.021	-0.066
Poultry	0.070	-0.236	0.277	0.044	-0.173
Freshwater fish and shellfish	0.460*	-0.249	0.261	0.417*	-0.184
Edible oils and fats	0.207	0.097	0.024	0.170	0.102
Breads and rolls	0.143	-0.155	0.065	0.170	-0.182
Biscuits	-0.174	-0.247	-0.040	-0.078	-0.247

TC: Total cholesterol, TG: Triglycerides, LDL-C: Low-density lipoprotein-cholesterol, HDL-C: High-density lipoprotein-cholesterol, VLDL-C: Very low-density lipoprotein-cholesterol, \*Correlation is significant at the 0.05 level (2-tailed). \*\*Correlation is significant at the 0.01 level (2-tailed).

**Table 6:** Pearson's correlation of food groups and diabetic profile of subjects

Food groups	FBS	PPBS	HbA1c
Cereals and millets	0.012	0.015	0.229
Grain legumes	0.141*	0.132	-0.226
Green leafy vegetables	0.004	-0.016	0.827*
Other vegetables	0.149*	0.118	0.019
Fruits	-0.062	-0.085	-0.367
Roots and tubers	-0.163	-0.184*	0.347
Nuts and oilseeds	-0.004	-0.019	-0.132
Sugars	0.040	0.055	0.396
Milk and milk products	-0.050	-0.017	0.167
Egg and egg products	-0.073	-0.119	0.227
Poultry	-0.088	-0.114	0.524
Freshwater fish and shellfish	0.124	0.106	0.827*
Edible oils and fats	0.181*	0.178*	0.120
Breads and rolls	-0.004	-0.061	-0.025
Biscuits	-0.115	-0.066	0.056

FBS: Fasting blood sugar, PPBS: Post-prandial blood sugar, \*Correlation is significant at the 0.05 level (2-tailed).

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