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Assessment of indoor air pollution in causing respiratory illness among women residing in rural areas of Mysuru

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ABSTRACT

Introduction: The use of inefficient and harmful fuels and technology within and outside the home is the primary cause of indoor air pollution. Approximately 2.4 billion people on the planet still cook over open flames and inefficient stoves using solid fuels and kerosene. The availability of cleaner cooking options varies more in rural than in metropolitan settings. Therefore, there is a need to determine the prevalence of indoor air pollution among rural women, its association with respiratory disorders, and the frequency of respiratory illnesses among rural women residing in houses with or without indoor air pollution.
Materials and methods: This analytical cross-sectional study was done for a period of six months from June to November 2020. The study conducted in 210 households living in the rural field practice areas of JSS Medical College, Mysuru. For the selection of villages, a multistage random sampling technique was used. Three villages are selected from the rural setting: Suttur, Hadinaru, and Kadakola. The households were included by probability proportionate to the size sampling technique. Pre-tested, semi-structured, phase and content validated questionnaires were used to obtain the details on socio-demographic characteristics, meter values of indoor air pollutants like Particulate Matters (PM_1, $PM_{2.5}$, PM_{10}) and Volatile Organic Compounds (VOCs), respectively with the factors affecting respiratory illness and the episodes of the illness. Data was entered in Microsoft Excel and analyzed using descriptive and inferential statistics using SPSS V.26.
Results: The prevalence of indoor air pollution in the present study was 13.3%. In the homes of rural women, there was a statistically significant variation in the concentration of the three particulate matter sources that cause indoor air pollution. Additionally, among the women living in rural families, there was a statistically significant difference in the concentration of PM_{10} that caused respiratory disease.
Conclusion: The current study demonstrated the higher concentrations of pollutants such as PM_{10}, $PM_{2.5}$, and $PM_{1.0}$, as well as their significant relation with indoor air pollution in rural families. To prevent indoor air pollution and its health risks, clean energy must be used for household needs.

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Introduction

The World Health Organization (WHO) defines air pollution as any environmental contamination caused by a chemical, physical, or biological agent that modifies the intrinsic properties of the atmosphere. Interior and outdoor pollution are the two types of air pollution, which refers to the presence of toxins in the air both inside and outside the home [1]. Burning and cooking by using solid fuels like wood, coal etc. remains as the traditional source of indoor air pollution [2].

Approximately 2.4 billion people on the planet still cook with kerosene and solid fuels (wood, charcoal, coal, and crop waste) over open flames and inefficient stoves. The majority of these folks are from low- and middle-income nations and are impoverished. The availability of cleaner cooking options varies more in rural than in metropolitan settings. In 2020, 14% of people living in cities relied on polluting technology and fuels, whilst 52% of people worldwide lived in rural areas [3]. The indoor environment is polluted by numerous gases and particles during fire cooking. Pollutants like carbon monoxide, carbon dioxide, sulphur dioxide hydrocarbons, and volatile organic compounds are produced during cooking using biomass fuels [4].

In India, about 0.2 billion population utilize fuel for preparing food. Out of this, 49% use wood, 28.6% use liquefied petroleum gas, 8.9% use cow dung, 2.9% use kerosene, 1.5% use charcoal, 0.4% use biogas, and 0.1% use electricity. Improper burning of biomass fuel products such as particulate matter, polyaromatic hydrocarbons, carbon monoxide, etc. leads to serious health issues. Burning of coal leads to the release of sulphur oxides, fluorine, and arsenic. Pollutants like oxides of sulphur and nitrogen cause Chronic Obstructive Pulmonary Disease (COPD), and bronchial asthma and destroy functions of the lung. Carbon monoxide exposure causes low birth weight and increases perinatal deaths. Polycyclic aromatic hydrocarbons lead to cancers of the nasopharynx, larynx, and lung, and leukemia. Women and younger children are the most affected demographics, as they spend the most time at home [5].

Nearly 3.2 million deaths are recorded annually as a result of illnesses linked to indoor air pollution, according to the World Health Organization. Particulate matter and other pollutants weaken the immune system, irritate the lungs and airways, and reduce the blood's ability to carry oxygen. These factors contribute to indoor air pollution. Among these 3.2 million fatalities, lower respiratory infections such as pneumonia account for 21% of deaths, COPD accounts for 19%, and lung cancer accounts for 6%. Adults in middle-class and lower-class countries account for 23% of COPD deaths, which are caused by indoor air pollution exposure. About 11% of lung cancer deaths are linked to exposure to carcinogens from indoor air pollution, which is brought on by the use of solid fuels such as coal, wood, and charcoal. In 2019, indoor air pollution claimed 86 million health life years, with household women in middle- and low-income countries bearing a disproportionate share of this cost. [3]

Due to indoor air pollution, many significant health issues are reported, ranging from a decline in lung function to Chronic Obstructive Pulmonary Diseases. Personal exposure to indoor air pollutants can be caused by a variety of circumstances, such as cooking methods, solid biomass fuel burning, and home conditions. Reducing avoidable air pollution exposures can significantly lower the rates of illness and mortality [6].

The present investigation was carried out against this backdrop in order to ascertain the prevalence of indoor air pollution in rural Mysore, the frequency of respiratory ailments among women living in rural homes with or without indoor air pollution, and the correlation between indoor air pollution and respiratory ailments in rural Mysore.

Materials and methods

Study design and population source

Women living in rural field practice at JSS Medical College, Mysuru's Department of Community

Medicine participated in the community-based analytical cross-sectional study. The survey was conducted for a period of six months from June to November 2020. Women in the age group 18 years and above who are permanently residing in the rural areas (Residing in the same village for last year according to the definition in the census 2011) were included in the study. The study did not include any women who were unwilling to participate.

Sampling technique

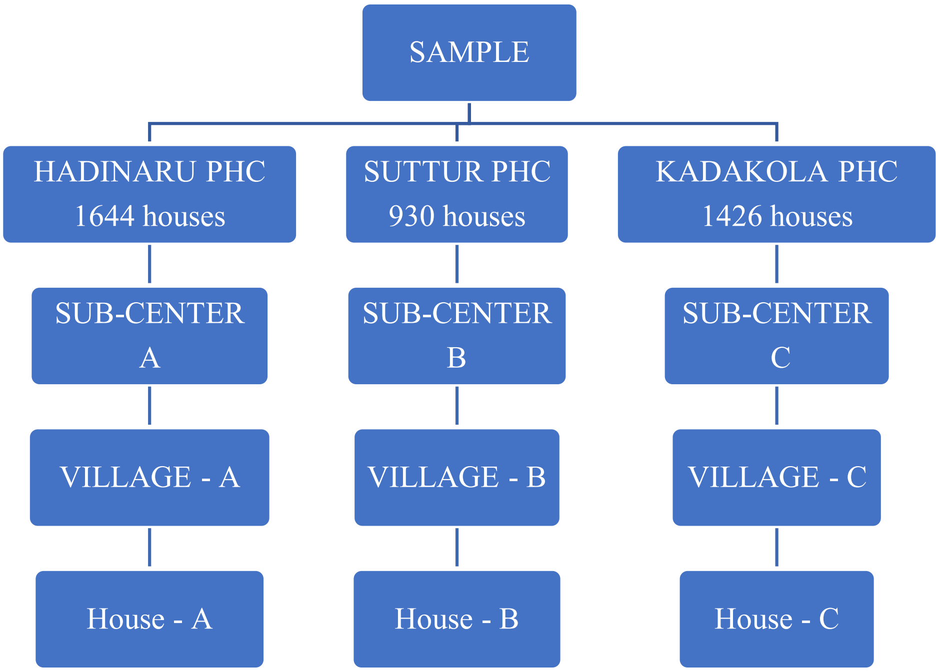

Fig. 1. Sampling technique

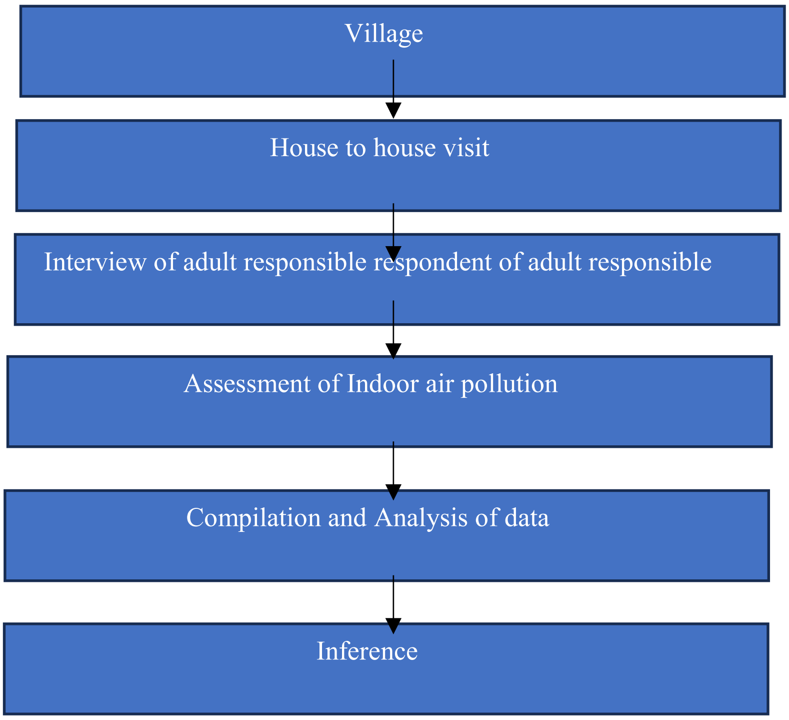

Fig. 2. Study conduct

Study conduct

The data collected in the rural field practice areas of JSS medical college, Mysuru i.e. Suttur, Hadinaru, and Kadakola. For finding out the number of houses to be included from each village, the probability proportionate to size technique was used. For the selection of houses from villages, systematic random sampling was used after collecting the list of houses from the local panchayat/Anganwadi Centre (Fig. 1).

Study tool

Pre-tested, semi-structured, phase and content validated by 6 experts, the questionnaire was set up based on the expert opinion. The questionnaire was piloted to 15 families and were used for data collection. Three sections made up the questionnaire.

Socio-demographic characteristics

Age, Gender, literacy level, occupation, monthly income, marital status, type of family, history of illness, either inhaling or being around second-hand smoke. the kind of heating system, as well as the method of food preparation and cooking.

Indoor air pollution

By using laser scattering detection to measure temperature, humidity, $PM_{2.5}$, PM_{10}, HCHO, and TVOC levels in the air around us, the Prana Air CAIR+ Air Quality Monitor helps to detect these airborne contaminants. The portable air quality pollution meter detector was used in each residence to test the levels of volatile organic compounds (VOCs) and indoor particle matter (PM_{10}, $PM_{2.5}$, and PM_1). Based on the cut off values of each pollutant, if at least any two of the pollutant (particularly $PM_{2.5}$ and PM_{10}) having values above the cut off inside the house, then it considered as the presence of indoor air pollution inside the house. [7]

Respiratory illness

Operational definitions for respiratory illnesses are used to elicit information on respiratory illnesses in the last year. Each episode of respiratory illness was enquired concerning symptoms, severity, duration, and treatment. Details on no. of episodes and duration of each episode were collected. In the case of the availability of medical records, the data was verified.

Operational definition of respiratory illness: Any episode of cough with or without expectoration for more than 24 h, with or without associated with fever, body ache, headache, chest pain, or breathlessness.

Study procedure

From June to November 2020, the study was carried out in the Department of Community Medicine's rural field practice at JSS Medical College. In order to choose the participants, systematic random sampling was used. After obtaining permission from the Institutional Ethics Committee, JSS medical college, Mysore, the women of the rural households were explained in their local language about the objective of the study and method of data collection. Upon obtaining the informed and written consent to partake in the research, through direct interview method, the inquiries from the pretested, semi-structured, phase and content validated questionnaire were read aloud to the women and the responses were noted (Fig. 2).

Data analysis

The computation of the sample size was done using the reported concentration average 24 h exposure rates to particulate matters leading to indoor air pollution to be 231 ± 109 mg/m^3 among the households using biomass fuel, the sample size was determined to be 206, rounded to 210, with a 15% relative allowed error and a 5% alfa level. [5]. Data was entered into Microsoft Excel 2019 followed by analysis using SPSS.26. 0. (Statistical package for the social science, Licensed to JSSAHER) Windows, Version 26.0. (IBM Corp. Released 2019. IBM SPSS Statistics for Armonk, NY, USA). The demographic characteristics such as age, sex, etc. were represented using arithmetic mean, standard deviation, and percentages. Unpaired t test/ Mann- Whitney U test applied to assess the difference of the quantitative variables. Association indoor air pollution and respiratory illnesses as well as sociocultural factors influencing indoor air pollution were tested through the chi-square test/fisher's exact test. At p-value of <0.05 was considered statistically significant.

Table 1. Distribution of study subjects based on socio-demographic characteristics of the study participants

Characteristics	Variables	Frequency	Percentage
Age (years)	≤20	9	4.3
	21- 40	67	32.0
	41 - 60	105	50.0
	61 and above	31	14.7
Education	Illiterate	89	42.4
	Primary school certificate	6	2.9
	Middle school certificate	14	6.7
	High school certificate	61	29.0
	Intermediate/Diploma	20	9.5
	Graduate	20	9.5
Occupation	Unemployed	113	53.8
	Labourer, plant and machine operating, crafts, and related trade	63	30
	Skilled agriculture and fishery worker	14	6.7
	Workers with skills, salespeople in shops and markets	14	6.7
	Clerks	2	0.9
	Technicians as well as related experts	4	1.9
Type of family	Nuclear family	188	89.5
	Joint family	22	10.5
Marital status	Unmarried	24	11.4
	Married	149	71.0
	Widow	37	17.6
Socio-economic status (BG Prasad classification)	Upper lower	10	4.8
	Lower middle	139	66.2
	Upper middle	57	27.1
	Upper class	4	1.9

Results and discussion

A total of 210 women residing in rural areas were included in the study. From the study done, it is observed that among 210 study subjects, women belong to the age group of 41 to 60 years i.e.,50.0% (105), followed by 32% (67) which belongs to the 21 to 40 years of age group,14.7% (31) belongs to the 61 and above age group and only 4.3% (9) belongs to <20 age group. The sociodemographic details of the study participants are summarized in Table 1. From Table 1, we find the majority of the women [42.4% (89)] are Illiterate, followed by High school level of education by 29.0% (61), Intermediate or Diploma by 9.5% (20), Graduate by 9.5% (20) and the least Primary school education by 2.9% (6). From the above table, the majority of the women [53.8% (113)] are Unemployed, followed by Labourer, plant and machine operating, crafts and related trade 30% (63), Skilled Agricultural & Fishery Workers by 6.7% (14), Skilled Workers, Shop & Market Sales Workers by 6.7% (14), Technicians and Associate Professionals by 1.9% (4) and Clerks by 0.9% (2). In the study, none of the women were working as Professionals. Among the study subjects, the majority 89.5% (118) are nuclear families, 10.5% (22) are Joint families and there are no Three-generation families. From the above data, we computed and found that the majority of the people belong to the lower middle class 66.2% (139), followed by 27.1% (57) belongs to the upper middle class, 4.8% (10) belongs to the upper lower class and 1.9% (4) belongs to the upper class according to BG Prasad classification.

Table 2. Distribution of study subjects based on House and fuel characteristics

Characteristics	Variables	Frequency	Percentage
Type of House	Semi pucca	177	84.3
	Pucca	33	15.7
Ventilation inside the House	Adequate	196	93.3
	Inadequate	14	6.7
Cross ventilation	Present	181	86
	Absent	29	14
LPG Connection	Yes	208	99.0
	No	02	1.0
Prefer wood during festivals	Yes	10	4.8
	No	200	95.2
Prefer wood during social gatherings	Yes	05	2.4
	No	205	97.6

Table 2 gives data about the household environment in causing Indoor air pollution and Respiratory illness. From the study, we found that the majority of the study subjects had semi-pucca Houses 84.3% (177) followed by 15.7% (33) were Pucca Houses, and no Kaccha house was found. Inside the house, the majority have adequate ventilation 93.3% (196), and 6.7% (14) don't have adequate ventilation. Most of the study participants have cross ventilation inside the house 86.2% (181) and 13.8% (29) don't have cross ventilation inside the house. Nearly 99% (208) of the study subjects have having LPG connection and only 1.0% (02) do not have an LPG connection. Among the study subjects 95.2% (200) and 97.6% (205), do not prefer the use of wood during festivals and social gatherings.

Based on the values of interior air pollutants assessed using the Prana Air CAIR + Air Quality Monitor inside the house, Table 3 demonstrates that 86.7% (182) of the study subjects do not have indoor air pollution, whereas only 13.3% (28) subjects do. Consequently, the current study's prevalence of indoor air pollution was 13.3%. From Table 3, it can be observed that among (n=210) the majority of the study subjects do not have any respiratory illness i.e., 95.7% (201) and only 4.3% (09) subjects have respiratory illness.

Table 3. Distribution of study subjects based on presence of Indoor air pollution and respiratory illness

Characteristics	Variables	Frequency	Percentage
Presence of IAP	Yes	28	13.3
	No	182	86.7
History of RI	Yes	09	4.3
	No	201	95.7

Table 4. Pollutants of indoor air pollution (n=210)

Pollutants	Mean	Std. Deviation
PM_{10} (μg/m$^{3)}$	61.190	41.2084
$PM_{2.5}$ (μg/m$^{3)}$	46.976	23.5684
$PM_{1.0}$ (μg/m$^{3)}$	31.524	38.1558
TVOC (mg/m$^{3)}$	.1633	1.54679

The present investigation yielded mean values of 61.190, 46.976, 31.524, and 0.1633 for PM_{10}, $PM_{2.5}$, $PM_{1.0}$, and TVOC (mg/m^3), respectively (Table 4). The 24-h standard average of PM_{10} and $PM_{2.5}$, as per the National Ambient Air Quality Standards 2020 (NAAQS), is 150 $\mu g/m^3$ and 35 $\mu g/m^3$, respectively. This indicates that the concentration of $PM_{2.5}$ is somewhat higher than the normal average.[8] The mean and standard deviation of PM_{10}, $PM_{2.5}$, and $PM_{1.0}$ pollutant concentrations within the house were 63.5±27.4, 39.4±18.1, and 4.3±7.7, respectively, in another study conducted by Azam Nadali et al.[9] In contrast, the mean and median concentrations of $PM_{2.5}$ and carbon monoxide (CO) were found in a research by K. Rumchev et al. to be 3.80 mg/m^3, 1.18 mg/m^3, and 4.63 mg/m^3, 2.47 mg/m^3, respectively [10].

Table 5 shows that the mean concentrations of PM_{10}, $PM_{2.5}$, and $PM_{1.0}$ were found to be greater in the homes of women who were living with indoor air pollution than in the homes of their counterparts. These differences were found to be statistically significant (p=0.0025, p=0.001, and p= 0.001).

Table 5. Comparison of pollutants among houses with and without indoor air pollution

Pollutants	Indoor air pollution		P-value
	Present (n=28)	Absent (n=182)	
PM $_{10}$ ($\mu g/m^{3)}$)	69.50(40.5, 81.5)	56.0(41.5, 78.0)	0.0025
PM $_{2.5}$ ($\mu g/m^{3)}$)	57.0(36.0, 68.5)	44.0(32.0, 54.2)	0.001
PM $_{1.0}$ ($\mu g/m^{3)}$)	37.5(24.5, 41.5)	28.0(21.0, 34.0)	0.001
TVOC ($mg/m^{3)}$)	.07(.06, .08)	.00(.00, .00)	0.824

Table 6. Comparison of pollutants among houses with and without Respiratory Illness

Pollutants	Respiratory Illness		P-value
	Present (n=9)	Absent (n=201)	
PM $_{10}$ ($ugm^{3)}$)	71.6 ± 32.7	60.7 ± 41.5	0.0358
PM $_{2.5}$ ($ugm^{3)}$)	53.0 ± 30.0	46.7 ± 23.2	0.551
PM $_{1.0}$ ($ugm^{3)}$)	33.5 ± 15.4	31.4 ± 38.8	0.721
TVOC ($mgm^{3)}$)	0.043 ± .078	0.168 ± 1.5	0.275

Table 7. Relationship between Indoor air pollution and RI

Indoor air pollution	Respiratory illness			Chi-square	P-value
	Present	Absent	Total		
Present	2 (22.2)	26 (13.0)	28 (13.3)		
Absent	7 (78.8)	175 (77.0)	182 (86.7)	0.642	0.422

Table 6 also revealed that, in comparison to their contemporaries, the women with respiratory illnesses had significantly higher PM_{10} concentrations (p=0.0358). This implies that there was a statistically significant difference in PM_{10} concentration causing Respiratory illness among the women of rural households.

According to the study, done by Raj Kumar et al, 76% of rural women used biomass fuel. Particulate matter and VOC concentrations were found to be higher in the group of women, who did not have a separate kitchen. When compared to the other individuals using separate kitchens with sufficient ventilation, those groups of women were shown to have a higher prevalence of respiratory problems over the course of a year. The average 24-h $PM_{2.5}$ concentration was higher in households (11.1 mg/m^3) not having a separate kitchen than the rest who had (3 mg/m^3), and it is significantly associated with respiratory symptoms [11].

The relationship between indoor air pollution and respiratory illness in women living in rural households is shown in Table 7. Table 7 indicates that among women living in rural families, there was no statistically significant relation between indoor air pollution and respiratory illness.

On the other hand, a study conducted in rural Orissa by Esther Duflo et al. discovered a strong association between using a stove that uses cleaner fuels and having improved respiratory health, indicating that the usage of traditional stoves may be the reason why respiratory disorders occur [12]. The study conducted by Professor Stephen B. Gordon, MD, et al. found that the most vulnerable groups to indoor air pollution are children and women living in extreme poverty. It has been discovered that indoor air pollution is more closely linked to cancer and respiratory tract illnesses in low- and middle-income nations. Burning of biomass fuels like coal has a stronger association with respiratory tract cancers and chronic obstructive pulmonary diseases [13]. In a similar vein, research by Seppo T. Rinne et al. indicates that although there was no statistically significant difference between the indoor air pollution caused by biomass use and pulmonary function in rural women, the study's findings show that indoor air pollution from biomass gas has a negative impact on children's lung function [14].

According to our research, indoor air pollution was substantially correlated with PM_{10}, $PM_{2.5}$, and $PM_{1.0}$ concentrations, and respiratory illnesses among women residing in rural homes were significantly correlated with PM_{10} concentrations. Furthermore, among rural women, there is no significant link between indoor air pollution and respiratory ailments. 43.2% of rural Indian homes and 69.3% of rural Karnataka households utilize clean fuel for cooking, according to the National Family Health Survey (NFHS)-5 (2019–2021) [15]. According to our survey, 99% of rural women utilize clean LPG fuel in their homes, indicating a decline in the needless burning of solid biomass fuels for cooking in the rural field practice region. This study also has a few limitations. First, the sample size is limited. To investigate the relationship between indoor air pollution and respiratory illnesses, a larger sample size is necessary. Secondly, the non-probability sampling was carried out. Furthermore, the temporal associations are also been limited due to its cross-sectional study design. Based on self-reported data, the prevalence of respiratory illnesses is determined and may be subject to recall bias.

Conclusion

The current study demonstrated that pollutants such as PM_{10}, $PM_{2.5}$, and $PM_{1.0}$ are found in greater quantities and are strongly linked to indoor air pollution in rural homes. Among the above pollutants, PM_{10} had a significant relation in causing respiratory illness among women in rural households. The existence of indoor air pollution and the presence of respiratory illnesses are not significantly related. There is a need to use clean energy for domestic purposes to avoid indoor air pollution and health hazards associated with it. Improvement in housing standards to improve ventilation and cross ventilation can help in the prevention of health hazards due to indoor air pollution. Enhancing rural people' knowledge of the health risks associated with indoor air pollution and discouraging the use of solid fuels for domestic purposes are imperative. Local panchayats and women's self-help groups should be effectively utilized to spread the knowledge of the health risks posed by indoor air pollution.

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Competing interests

The authors declare they have no conflicts of interest or competing interests.

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Ethical considerations

"The writers have adhered strictly to all ethical guidelines, including those pertaining to multiple publishing and/or submission, redundancy, misconduct, informed consent, data fabrication and/or falsification, and plagiarism."

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