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Compliance with Innovative Safety Measures in the Nigerian Sawmilling Industry: A Case Study of Kwara State

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Abstract

The sawmilling industry in Nigeria faces significant occupational health and safety challenges due to outdated technology, inadequate safety practices, and poor working conditions. This study evaluates compliance with innovative safety measures in the Nigerian sawmilling industry, specifically focusing on the use of safety equipment and Personal Protective Equipment (PPE). The study was conducted in Kwara State, Nigeria, using a two-stage sampling technique to select 125 sawmill workers, with 121 valid responses collected. Data were analysed using descriptive statistics, Likert-type scale analysis, and multinomial logistic regression to identify determinants of safety compliance. The findings revealed that while basic safety equipment such as first aid kits and silencers are generally available, their usage is inconsistent, with notable underutilization of critical PPE like industrial helmets and safety glasses. The multinomial logistic regression revealed that experience, income, awareness of laws was positively significant with compliance to use of safety equipment at $p < 0.05$. The study highlights a gap between awareness and the use of safety equipment, emphasizing the need for targeted interventions, including training programs, stricter enforcement of safety regulations, and the adoption of modern safety technologies. These findings underscore the necessity of improving safety compliance in the sawmilling industry to enhance worker safety and reduce occupational hazards. Therefore, the study recommends sawmill authority(s) should oversee and do proper implementation as regards the use of safety equipment and provide further innovative strategies as a measure to curb environmental disturbances and reduce health hazards among the sawmillers.

Keywords: Sawmillers, Safety Equipment, Safety Compliance, Personal Protective Equipment (PPE), Occupational Health and Safety, Nigeria

INTRODUCTION

The sawmilling industry plays a pivotal role in the forest product sector, converting logs into valuable products such as planks and boards through mechanized processes. While sawmilling has a long history, recent decades have witnessed significant advancements in technology, including the introduction of electrically powered mills, improved saw designs, and mechanized sorting systems. However, these technological advancements have not been adequately adopted, particularly in developing countries such as Nigeria, where manual operations still predominate due to limited access to innovation and modern equipment and prevalent of health and environmental hazards associated with poor working condition and improper waste disposal within the sawmilling industries (Adewole *et al.*, 2023; Fuwape and Onyekwelu, 2021; Ofonime & Queen, 2018).

The Nigerian sawmilling industry faces significant occupational health and safety challenges, which are exacerbated by the reliance on outdated technology, poor working conditions, and inadequate safety practices. As presented by Olajide *et al.* (2022), the prevalence of obsolete machinery and insufficient worker training increases the risk of workplace accidents and exposure to hazardous conditions. Additionally, the environmental impact of sawmilling activities, particularly the generation of waste and emission of pollutants, is a growing concern, underscoring the need for technological innovation and improved safety measures (Ogunbayo *et al.*, 2023).

This industry particularly the informal sawmills, experience ranges of hazards; one of which is wood dust (Maharani, Yutaka, Yajima & Minoru, 2010). It is estimated that about two million people are routinely exposed occupationally to wood dust worldwide (IARC, 1995). Wood processing procedures such as sanding, cutting, or milling generate dust which result in several health problems; notably cough, breathlessness, eye irritation, sneezing (Labreche *et al.*, 2013; Aguwa, Okeke & Asuzu, 2011). For instance, a study in Calabar, Nigeria reported respiratory symptoms such as cough, sneezing, and catarrh in 94 percent of the respondents, likewise a study in south-west part of Nigeria reported the prevalence of cough and sneezing among respondents (Osuchukwu *et al.*, 2015; Adeoye *et al.*, 2014). Other related hazards reported among sawmill workers include unguarded moving parts of machinery, noise, and heat (Agu, 2016). These possibly result in several health conditions such as injuries, ear injuries, and fatigue (Bamidele, Adebimpe & Dairo, 2011).

Modern innovations in machinery and safety equipment are critical for mitigating these risks. However, financial constraints often limit the adoption of such innovations in the Nigerian sawmilling sector (Odewale & Adetunji, 2019; Sterbova *et al.*, 2016). Effective safety measures, including the use of personal protective equipment (PPE) and adherence to safety protocols, are essential for protecting workers and reducing accidents. Amponsah-Tawiah and Dartey-Baah (2016), noted that the implementation of these safety innovations requires both employer commitment and worker compliance, supported by adequate training and education.

The concept of innovation in safety practices is not just about introducing new technologies but also ensuring that these innovations are perceived as beneficial and are effectively integrated into daily operations. The Technology Acceptance Model (TAM) highlights that the perceived usefulness and ease of use of new technologies significantly influence their adoption. This framework is relevant in understanding the adoption of safety measures in sawmills, where the decision to implement new technologies or practices is often influenced by factors such as cost, perceived benefit, and ease of integration into existing workflows (Akanbi *et al.*, 2023).

The Technology Acceptance Model (TAM) was established to predict individual behaviour toward the adoption of innovation. The key variables in TAM are Perceived Usefulness and Perceived Ease of Use. Reviews have shown that these two variables typically explain 40 percent of an individual's intention to use a technology in a variety of contexts including impact of safety measures in sawmill industry (Holden and Karsh, 2010), and that intention to use may or may not predict actual use of the technology. Like every other industry, new technology and innovations are constantly introduced to improve the production efficiency and likewise safety of the workers and

the immediate environment. Therefore, the sawmill industry like every other is faced with decision making to decide between technologies to adopt and which one not adopt.

Therefore, the study investigates various hazards prevalent at sawmills, identify adopted innovations to mitigate against harmful occurrences at sawmills, and likewise their level of compliance to the use of Environmental and Personal Protective Equipment (PPE). Forest workers and timber sawyers must be trained to adopt and wear suitable Personal Protective Equipment (PPE). PPE may include the use of protective clothing, protective footwear, suitable hand gloves, and protective headgear, which may integrate personal hearing safety and feet protectors. (ISO, 1991).

The implied hazard effect of sawmill activity on their workers stems on the need to ascertain the level of compliance to adopt various protective measures to ensure safety at work and after their daily routine. Though, the investment cost on the purchase of these equipments might increase production cost in the short run but invariably will reduce inefficiency and militate against harmful occurrences at sawmills and its immediate environment.

Hence, this current study seeks to evaluate the compliance with innovative safety measures in the Nigerian sawmilling industry. The objectives are to:

- identify the types of safety equipment used in sawmills,
- assess the level of compliance with the use of innovative safety equipment,
- examine the determinants influencing compliance among sawmill workers.

Specifically, the following are the research questions that emanates from this study:

- What are the types of safety equipment used in sawmills
- What is the level of compliance with the use of innovative safety equipment
- What are the determinants influencing compliance among sawmill workers

MATERIALS AND METHOD

Study Area

This study was conducted in Kwara State, Nigeria, located between latitudes 7°45'N and 9°30'N and longitudes 2°30'E and 6°25'E. Kwara State spans an area of approximately 32,500 square kilometres and shares borders with Niger State to the north, Kogi State to the east, and Ondo and Osun States to the west. The geographical positioning of Kwara State makes it a critical link between northern and southern Nigeria, facilitating the flow of goods and resources. According to Ogunwusi (2020) and Coker *et al.* (2019), the state's proximity to the rainforest zone contributes to the availability of timber, which supports local lumber processing and the activities of sawmill across the region.

Data Collection

Data for this study were collected from both primary and secondary sources. Primary data were obtained through structured questionnaires designed to gather responses from sawmill workers. These primary data sources were supplemented with secondary information from relevant, up-to-date literature, including published articles, government reports, and industry documents Adedokun *et al.* (2022).

Sampling Technique and Sample Size

The study utilized a two-stage sampling technique to select participants. In the first stage, sawmills were purposively selected from a list of operational sawmills in Kwara State, as employed by Nwosu *et al.* (2021). The second stage involved the random selection of 125 respondents from the selected sawmills. This selection of the respondents was captured from the list of registered sawmills in the study area which justify the sample selection and stems on availability of sawmill workers due to the nature of their activities. The samples included sawmill owners, supervisors, machine operators, and saw doctors. Of the 125 questionnaires distributed, 121 were completed and returned, resulting in a 96.8% response rate, which is considered adequate for statistical analysis.

Methods of Data Analysis

To achieve the study's objectives, a combination of descriptive statistics, Likert-type scale analysis, and multinomial logistic regression was employed.

The data for this study were analysed using Stata 14 and IBM SPSS Statistics 25 statistical packages. Descriptive statistics were used to analyse the socio-economic characteristics of the sawmill workers and to assess the availability and use of safety equipment in the sawmill. It provided a comprehensive overview of the demographic profile and working conditions of the respondents as opined by Okojie and Okojie (2023). Essentially, the Likert-type scale, a widely used psychometric tool, was employed to measure the level of compliance with safety measures and the usage of personal protective equipment (PPE) among sawmill workers. A four-point scale was used: "Frequently Used" (4), "Occasionally Used" (3), "Rarely Used" (2), and "Never Used" (1). The scores were aggregated, and the mean score of 2.50 was calculated as the threshold for evaluating compliance levels. According to Aluko and Amusa (2023) and Hassan *et al.* (2018), this method is effective for gauging attitudes and behaviours in occupational health studies. A reliability test was carried out to check for the internal consistency using the report of the Cronbach's alpha value (0.73) was found to be within the threshold ($\alpha \geq 0.70$).

Additionally, Multinomial Logistic Regression Analysis (MLRA) was used to identify the determinants of safety compliance among sawmill workers. The model estimated the probability of workers adopting different levels of the safety equipment (Incinerator; Environmental health aids equipment (First aid box); Silencer; Protective safety wares) usage, categorized into low, medium, and high adoption levels. The choice of multiple linear regression was intended to predict the probability of belonging to a specific category relative to a reference category, with each equation comparing one outcome category to the selected reference group using maximum likelihood estimation, which is considered more appropriate than ordinary regression for this purpose. Also, the listwise deletion method was used to cater for missing data in the data set.

Multicollinearity test was carried out with the data set and was assessed using the variance inflation factor (VIF). All VIF values were between the accepted range of 0.26 and 2.37 which is within the threshold of 5. Indicating that multicollinearity was not a concern for this model.

The regression model was specified as;

$$P_{ij} = \frac{e^{\beta jXi}}{1+\sum^{3} e^{\beta kXi}} \quad \text{…for j= 1, 2, 3}$$

The parameter estimates measure the impact of a unit increase in the relevant explanatory variable on the log odds ratio of the particular state in relation to the base line category.

The Multinomial Logit Model is implicitly expressed as

$$Y_i = \beta_0 + \beta_1X_1 + \beta_2X_2 \_\_\_\_\_ \beta_9X_9 + \varepsilon_i$$

β_0 = common constant
Y_i = level of adoption of safety equipment (dependent variable)
ε_i= error term
X_i = independent variables, includes the following:
X_1 = age (Years)
X_2 = household size (Number)
X_3 = educational level (Years)
X_4 = business experience (Years)
X_5 = Sawmilling as main source of income (No=0; Yes=1)
X_6 = Other income source (Naira value)
X_7 = frequency of waste disposal (Weeks)
X_8 = awareness of law and regulation (No=0; Yes=1)
X_9 = member of cooperative society (No=0; Yes=1)

RESULTS AND DISCUSSION

Respondent demographics and socioeconomic characteristics

Table 1 provides insight into the operational characteristics of sawmills in Ilorin. A significant majority (71.9%) of the workforce comprises hired labour, while 28.1% of the labour is provided by family members. All respondents owned licenses for their operations, and the vast majority (92.6%) renewed their licenses annually, indicating compliance with regulatory requirements (Ogunbiyi & Adedayo, 2023). License payment varied, with 82.64% paying less than ₦14,000 annually, reflecting a relatively low cost for maintaining legal operations. This accessibility in licensing fees might contribute to the high rate of compliance observed (Chinedu & Ifeoma, 2023).

Table 1: distribution of respondents by both demographic and socioeconomic characteristics

Characteristics	Category	Frequency (Total=121)	Percentage (100%)
Age (Years)	≤ 40	34	28.10
	41-50	60	49.59
	51-60	26	21.49
	>60	1	0.83
	Mean	*46*	
Gender	Male	113	93.40
	Female	8	6.60
Marital Status	Single	1	0.80
	Married	120	99.20
Household Size	≤ 3	8	6.61
	4-5	63	52.07
	6-7	36	29.75
	>7	14	11.57
	Mean	*5.4*	
Level of Education	No formal education (0)	4	3.3
	Primary (1-6)	25	20.7
	Secondary (7-12)	68	56.2
	Tertiary (>12)	24	19.8
Experience	≤ 10	36	29.70
	11-20	65	53.72
	21-30	19	15.7
	>30	1	0.83
	Mean	*15.3*	
Labor Type	Hired	87	71.90
	Family	34	28.10
Own License	Yes	121	100
	No	0	0
License Payment	≤ 14000	100	82.64
	15000-25000	12	9.92
	26000-36000	6	4.96
	>36000	3	2.48
Renewal Status of License	Yearly	113	92.60
	Never	7	5.7

Most respondents were male (93.4%), with females representing just 6.6%. According to Bamidele and Odukoya (2024), this gender disparity is likely due to the labour-intensive nature of sawmill work, the significant capital investment required, and traditional societal roles that discourage female participation in such industries. The average age of respondents was 46 years, with the majority (49.6%) falling within the 41-50 age range, indicating that this sector is predominantly managed by middle-aged individuals.

Nearly all respondents were married (99.2%), which could reflect cultural expectations for stability and responsibility in business ownership (Ajani & Igbokwe, 2023). The average household size was 5.4, typical for the region, suggesting that sawmill workers support moderately sized families (Egbo & Eze, 2023).

Regarding business experience, 53.7% of respondents had between 11 to 20 years of experience, with an average experience level of 15.3 years. This long tenure in the business suggests a stable and profitable industry, where individuals have little incentive to leave. The data also suggest that the business provides consistent opportunities, encouraging long-term involvement and potentially reducing poverty within the community (Egbo & Eze, 2023).

Safety Equipment Availability and Usage

The availability and usage of safety equipment are crucial for minimizing occupational hazards in sawmills. Table 2 indicates that while essential safety equipment such as first aid boxes (83.5%) and silencers (69.4%) are generally available, incinerators are notably less common (17.4%).

Table 2: Distribution of Respondents According to Availability and Non-Availability of Safety Equipment at Sawmills

Equipment	Frequency (Percentage)		Total
	Available	Not Available	
Incinerator	21 (17.4)	100 (82.6)	121 (100)
First Aid Box	101 (83.5)	20 (16.5)	121 (100)
Silencer	84 (69.4)	37 (30.6)	121 (100)

As opined by Ahmad and Anwar (2023), this disparity could be attributed to the perceived necessity of these items or the high cost associated with acquiring them.

Table 3 highlights the usage of available safety equipment. Silencers, which reduce noise pollution, are the most frequently used (57.85%), reflecting their availability and importance in reducing hearing damage among workers. However, the use of first aid boxes is disproportionately low relative to their availability, with only 4.96% using them frequently. This suggests potential issues with maintaining stock or awareness of their importance. The incinerator, despite its low availability, also sees limited use, reinforcing the idea that cost and perceived necessity may hinder its adoption (Ajani & Igbokwe, 2023).

Table 3: Distribution of Respondents According to Use of Sawmill Safety Equipment

Equipment	Frequency (Percentage)				Mean	Rank
	Frequently use	Occasionally use	Rarely use	Never use		
a. Silencer	70(57.85)	9(7.44)	5(4.13)	37(30.58)	2.92	1st
b. First Aid Box	3(4.96)	45(37.19)	50(41.32)	20(16.53)	2.11	2nd
c. Incinerator	8(6.61)	11(9.09)	2(1.65)	100(82.6)	1.37	3rd

Personal protective equipment (PPE) usage

The use of personal protective equipment (PPE) is essential for safeguarding workers from occupational hazards. Table 4 shows that industrial gloves and overalls are the most commonly used PPE, with usage rates of 38.84% and 42.15%, respectively. These items are critical according to Chinedu and Ifeoma (2023), for preventing injuries from sharp tools and heavy materials commonly handled in sawmills. However, there is a marked underutilization of other protective gear such as earmuffs (only 4.96% always use them) and safety glasses (5.79%). The low usage of earmuffs could be due to a lack of awareness about the long-term effects of noise exposure, such as hearing loss. Similarly, the underutilization of safety glasses suggests that eye protection is undervalued, potentially leading to preventable injuries. The industrial helmets (6.72%) was rarely used, highlighting a significant gap in safety practices, potentially leaving workers vulnerable to head injuries (Ogunbiyi & Adedayo, 2023).

Table 4: distribution of respondents according to use of PPE

PPE	Frequency (Percentage)				Mean	Rank
	Always	Occasionally	Rarely	Never		
a. Industrial gloves	47(38.84)	61(50.41)	12(9.92)	1(0.83)	3.27	1st
b. Overall	51(42.15)	56(46.28)	7(5.79)	7(5.79)	3.25	2nd
c. Face mask	16(13.22)	53(43.80)	45(37.19)	7(5.79)	2.64	3rd
d. Earmuff	6(4.96)	13(10.74)	62(51.24)	40(33.06)	1.88	4th
e. Safety glass	7(5.79)	15(12.40)	31(25.62)	68(56.20)	1.68	5th
f. Industrial Helmet	0(0.00)	3(2.52)	8(6.72)	110(90.91)	1.25	6th

Compliance with Safety Standards

Table 5 presents the level of compliance with safety equipment usage and waste disposal measures. Compliance was categorized into high, medium, and low levels based on respondents' mean scores. The findings reveal that compliance with using silencers is relatively high (59.5%), while compliance with other equipment, such as incinerators (84.3%) and first aid boxes (64.5), is notably low. The lowest compliance was observed with industrial helmets, where 96.7% of respondents exhibited low compliance, indicating a critical area for intervention (Bamidele & Odukoya, 2024).

These findings suggest that while there is awareness and some level of adoption of safety equipment, there are significant gaps that need to be addressed to ensure worker safety. The low compliance rates, particularly with critical PPE; incinerator, earmuff, industrial helmet, highlight the need for increased training and enforcement of safety standards within the industry (Ahmad & Anwar, 2023).

Table 5: Sawmillers' Level of Compliance to Use of Innovative Safety Equipment

Safety Equipment	Level of Compliance (Percentage)			Total (%)
	High	Medium	Low	
Incinerator	7.4	8.3	84.3	100
First Aid Box	2.5	33.1	64.5	100
Silencer	59.5	7.4	33.1	100
Face mask	13.2	43.8	43.0	100
Industrial gloves	38.8	51.2	9.9	100
Ear muffler	5.0	12.4	82.6	100
Safety glass	5.8	12.4	81.8	100
Overall	42.1	46.3	11.6	100
Industrial Helmet	0	3.3	96.7	100
Disposal Measures				
Open burning	19.8	35.5	44.6	100
Packing by household	15.7	40.5	43.8	100
Landfills	11.6	43.8	44.6	100
Packing by poultry owners	23.1	63.6	13.2	100

Determinants of sawmillers' level of compliance to use innovative safety equipment

This section discussed various factors that determine sawmiller's level of compliance to use innovative safety measures at sawmills. The mean score was used to group the respondents into three different categories, based on their level of compliance to use safety measure: ≤1.57 (Low); 1.64-1.86 (Medium) and >1.86 (High). The levels of compliance are therefore in three categories, where: 1 represents sawmillers with low compliance level; 2 represent sawmillers with medium compliance level; 3 represent sawmillers with high compliance level.

Table 6, aggregates and summarizes the level of compliance to the use of safety measures among the sawmillers using their mean scores to group each respondent's usage into high, medium and low compliance levels.

Table 6: Mean Score on Level of Compliance to Use Safety Measures at Sawmills

Category Levels	Frequency	Percentage (%)
High compliance	29	24.0
Medium compliance	50	41.3
Low compliance	42	34.7
Total	121	100

The result of the multinomial regression and its marginal effect was run to determine the factors that influence respondent compliance level to adopt innovative safety measure equipment at sawmills. The low compliance category was chosen as the reference group. Table 7a; Category 2, awareness of laws was positively significant ($p < 0.05$)

Table 7a: Determinants of Compliance to Safety Measures at Sawmills (Category 2)

Variables	Medium Compliance Level (Category 2)			Low Compliance (Category 1) Base Outcome
	Coefficient ($p < 0.05$)	Z Value	Marginal Effect	Coefficient (Marginal Effect)
Constant	-8.560	-2.46	50	42
Age	0.086	1.45	-0.003	-0.233(0.015)
Household size	-0.400	-1.78	-0.022	0.867(-0.058)
Education	1.304	3.07	0.070	-2.830 (-0.188)
Experience	0.089	1.26	-0.008	-0.272(-0.017)
Main income source	-2.498	-1.55	0.069	-5.743(0.181)
Income	3.91E-06	1.44	-2.04E-07	-10.95E-06(-6.94E-07)
Disposal duration	0.565**	1.05	0.199	-0.220(-0.028)
Awareness of laws	3.338**	2.94	0.401	-7.018(-0.693)
Member of cooperative	-0.277	-0.36	0.014	0.752(0.045)

Table 7b: Determinants of Compliance to Safety Measures at Sawmills (Category 3)

Variables	High Compliance Level (Category 3)			Low Compliance (Category 1) Base Outcome
	Coefficient ($p < 0.05$)	Z Value	Marginal Effect	Coefficient (Marginal Effect)
Constant	-12.32729	-3.08	50	42
Age	0.147	2.20	0.018	-0.233(0.015)
Household size	-0.467	-1.85	-0.036	0.867(-0.058)
Education	1.526	3.24	0.118	-2.830(-0.188)
Experience	0.183**	2.36	0.025	-0.272(-0.017)
Main income source	-3.245	-1.94	-0.250	-5.743(0.181)
Income	7.04E-06**	2.39	8.98E-07	-10.95E-06(-6.94E-07)
Disposal duration	-0.345**	-0.60	-0.171	-0.220(-0.028)
Awareness of laws	3.680**	2.56	0.292	-7.018(-0.693)
Member of cooperative	-0.475	-0.55	-0.059	0.752(0.045)

significantly increases the odds of medium compliance by 40.10%. The increase in awareness of laws among the respondent the more likely sawmiller will comply with the adoption of safety equipment at mills at 40.10% based on the result of its marginal effect. Duration of waste disposal at sawmill was positively significant which relates to the study of Odibo (2018). Its marginal effect explained a significant increase in compliance by 19.9% increase relative to the low compliance level.

From Table 7b, Category 3, years of experience was positively significant ($p < 0.05$) significantly increases the odds of compliance by 2.5% which corresponds to the findings of Ogunyebi, Afolabi, & Abraham (2025), that highlighted a positive relationship between working experience and awareness of safety and impact of their activities on the environment. That is, the more years they spend in the business tends to favour the adoption of innovative safety measure at sawmills relative to the base outcome. This is in relation to the research carried by Radwa *et al.* (2020) identified age, marital status and related trainings as significant factor to use of safety equipment.

Additionally, respondents' income was positively significant, increasing the odd of high compliance level. As income of miller's increase the more likely for them to use the safety equipment compared to the reference group. Duration of waste disposal at mills was negatively significant.

CONCLUSION

The findings of this study indicate that there is generally low compliance with the use of

innovative safety equipment. A significant imbalance exists between the level of awareness and the actual compliance with specific safety measures among sawmill workers. Also, awareness of law, frequency of waste disposal, experience and income significantly determine influenced adoption.

RECOMMENDATIONS

- Implementation and Monitoring: Sawmill management should take an active role in not only implementing but also continuously monitoring the use of safety equipment. Regular inspections should be conducted to ensure that safety protocols are adhered to, thereby reducing environmental disturbances and minimizing health risks.
- Enforcement of Safety Regulations: The introduction of strict sanctions for non-compliance with safety measures should be considered essential. These sanctions should be clearly defined and communicated to all workers to reinforce the importance of adhering to safety protocols.
- Awareness and Training Programs: Government agencies, such as the National Orientation Agency (NOA) should expand their efforts in conducting regular safety training and awareness programs, in areas of safety measures and proper waste management practices.
- Collaboration with Health and Safety Experts: Sawmills should collaborate with occupational health and safety experts to conduct risk assessments and develop tailored safety plans.

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Ethical Statement
The study involved human participants, and ethical approval was obtained from the University affiliation ethical review board (UIL/PGS/42). All the involved participants (respondents) were provided informed consent prior their involvement in the study.

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Conflict of Interest
The authors declared no conflicts of interest concerning the research, and authorship

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