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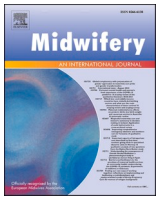

Multilevel modelling of the determinants of low birth weight in frontier, outermost and underdeveloped regions: Evidence from the Indonesian National Socioeconomic Survey (2019–2021)

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ABSTRACT

Background: The prevalence of low-birthweight infants is increasing in Indonesia. A low birth weight can have a negative effect on a child's development. Understanding the factors influencing low birth weight may enable preventative actions.

Aim: To analyse the determinant factors of low-birthweight infants in frontier, outermost and underdeveloped regions in Indonesia.

Methods: A cross-sectional study was conducted using a secondary dataset from the Indonesian National Socioeconomic Survey, 2019–2021. The sample included 27,678 inhabitants aged 16–64 years. The Indonesian regions of Nusa Tenggara Timur, Nusa Tenggara Barat, Sulawesi Tengah, Sulawesi Tenggara, Gorontalo, Maluku, Maluku Utara, Papua and Papua Barat were included. A multilevel logistic regression was conducted to determine the relationship between variables. $p < 0.05$ was considered to indicate significance in the fixed-effects model findings.

Findings: Women who lived in a rural area [OR 1.176, 95 % confidence interval (CI) 0.088–0.235] and had never used contraception (OR 1.227, 95 % CI 0.096–0.313) were more likely to have low-birthweight infants. In contrast, water resources, social assistance/welfare, maternal age and gross domestic product per capita had no significant effect on the prevalence of low-birthweight infants.

Discussion and conclusion: Living in a rural area and lifetime non-use of contraception were found to be significant risk factors for low birth weight in frontier, outermost and underdeveloped regions in Indonesia. Increasing health facilities in rural areas and establishing programmes on the use of contraception may be positive strategies to reduce the prevalence of low-birthweight infants.

Introduction

Low birth weight (LBW) is a serious health concern worldwide, with estimated LBW rates rising globally. LBW is defined as <2500 g regardless of gestational age (World Health Organization, 2023). It is estimated that 15–20 % (>20 million) of babies worldwide are born with LBW (United Nations Children's Fund, World Health Organization, 2019; World Health Organization, 2023). To address this concern, the World Health Organization set the target for the number of LBW babies to decrease to 10.5 % by 2025 (United Nations Children's Fund, 2023). In South–east Asia, the estimated prevalence of LBW was 12.3 % (United Nations Children's Fund, 2023). In Indonesia, the prevalence of LBW infants increased from 11.32 %

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in 2019 to 11.37 % in 2020 to 12.27 % in 2021 (Badan Pusat Statistik, 2020, 2021; UNICEF East Asia and the Pacific Regional Office, 2021). In 2019, the most common cause of neonatal death in Indonesia was LBW (7150 cases, representing 35.5 % of total neonatal deaths) (Kementerian Kesehatan Republik Indonesia, 2021). Due to the increase in cases, the Indonesian Government set a target for a 30 % reduction in the number of infants born with LBW by 2024 [Kemeterian Perencanaan Pembangunan Nasional (Badan Perencanaan Pembangunan Nasional), 2019].

A newborn with LBW is more likely to die from illness, experience disease, and develop several adult ailments. Neonatal concerns include jaundice, respiratory distress, sepsis and apnoea, while hypoxia and hyaline membrane disease are the most common causes of death in LBW infants (Pabbati et al., 2019). Neonates with LBW have a higher chance of experiencing neonatal asphyxia, fetal distress and death (Njim et al., 2015). Throughout life, an individual born with LBW is more likely to suffer from stunted growth; have a low IQ; and have increased risk of mortality, heart disease, diabetes and other non-communicable diseases (United Nations Children's Fund, World Health Organization, 2019).

LBW is caused by several factors, which can be categorised as: (1) maternal malnutrition (haemoglobin concentration/anaemia, difficulties during pregnancy, underweight, overweight before and during pregnancy); (2) maternal health problems (high blood pressure, diabetes, infection); (3) maternal characteristics (low or high maternal age, multiparity, poor birth spacing); and (4) other factors [smoking, alcohol, medically unnecessary caesarean birth, low number of antenatal care (ANC) visits, low education, poverty and preterm birth] (Khan et al., 2018; United Nations Children's Fund, World Health Organization, 2019; Lestari et al., 2021). Furthermore, low socioeconomic status is related to LBW; for example, mothers who are unemployed and have a low family income face barriers in accessing healthcare facilities, resulting in their child being born with LBW (Mahumud et al., 2017; Paramitasari et al., 2018). Consuming contaminated water during pregnancy has been shown to increase the risk of LBW by 6.5 % (Currie et al., 2013). Antenatal support from the government in the form of social assistance is correlated with better birth outcomes, such as a reduction in LBW (Curtis et al., 2019).

The Indonesian Government has implemented policies and interventions to address the prevalence of LBW. However, implementing various policies and regional health initiatives tends to be direct and less adaptable to local conditions and concerns. Geographical and sociodemographic factors in Indonesia vary greatly from one region to the next. As a result, policies and interventions need to be adapted to local characteristics, such as geographical location, cultural variations and socioeconomic community conditions.

To the authors' knowledge, few studies have looked into risk factors for LBW in underdeveloped regions in Indonesia (Cholifa et al., 2018; Elistia and Syahzuni, 2018; Safitri et al., 2022; Wahyuni, 2022; Wahyuningsih et al., 2022). Underdeveloped regions are described in Presidential Regulation No. 131 of 2015 as 'regions with underdeveloped lands and populations in comparison to others on a national scale' (JDIH BPK, 2020). A region is called an underdeveloped region if it meets specific requirements, which include people's economies, human resources, facilities and infrastructures, regional financial capacity, and accessibility. Given the high prevlence of LBW in Indonesia, there is a need for research to determine factors related to the current situation. These findings will help enhance maternal and child health care and policy making to reduce the number of cases of LBW in rural Indonesia. Staff in public health centres have a responsibility to identify women at risk for LBW, and to provide quality care to reduce maternal and child morbidity and mortality (United Nations Children's Fund, 2016).

Methods

Study design

This cross-sectional study used secondary data from the Indonesian National Socioeconomic Survey (SUSENAS) 2019–2021. SUSENAS, carried out biannually by the Central Bureau of Statistics (BPS), Indonesia in March and September, is a multipurpose household survey that encompasses 300,000 households from all districts and covers all regions of Indonesia. The sample size consisted of a minimum of 360 households in 95 % of districts, making it a nationally representative socioeconomic household survey (https://www.rand.org/labor/bps/susenas.html).

SUSENAS uses probability samples to estimate the coverage of LBW at both district and provincial levels, making it a suitable data source for monitoring the prevalence of LBW. The sampling process was conducted in three stages. Firstly, a probability proportional method was used to select 25 % of the total census blocks. Secondly, systematic sampling was employed to select a specific number of census blocks in each urban or rural stratum within each district, with the selection process weighted accordingly. Lastly, systematic sampling was used again, this time with implicit stratification based on the highest degree of education of the head of the household, to select 10 families. Data collection was conducted by proficient enumerators through in-person interviews at the respondent's residence following the acquisition of signed informed consent forms. To gain further insights into the survey, sampling techniques and the allocation of census blocks, the reader is referred to http://microdata.bps.go.id/mikrodata/index.php/catalog/653/related_materials. SUSENAS datasets can be accessed upon request through the website Silastik.bps.go.id. The data sets used in this study were: birth weight (code 1504C/child's birth weight in g); district categories (code 105/urban or rural); usage of contraception (code 1601/three options: has used, currently using, never used); water has taste (code 1813C/percentage of family using water with taste); water has foam (code 1813D/percentage of family using water with foam); water has odour (code 1813E/percentage of family using water with odour); receive social assistance (code 2208/percentage of family receiving social assistance from the government); maternal age (code 1501/mother's age at first pregnancy); and public health centre (code 1105/percentage visiting primary health care).

The SUSENAS data set has an ethical licence from the National Health Research and Development Agency, Ministry of Health of the Republic of Indonesia. In addition, permission to use this data has been approved by BPS (No. 60/LADU/0000/04/2022).

Population and sampling

The original data set was estimated to include 500,000 households. First, the original data set was cleaned depending on the availability of baseline data consisting of living area, usage of contraception, water resources, social assistance/welfare, maternal age, public health availability, and gross domestic product (GDP) per capita. Cases that lacked baseline data were removed. The dataset was then limited to frontier, outermost and underdeveloped regions in Indonesia, namely: Nusa Tenggara Timur, Nusa Tenggara Barat, Sulawesi Tengah, Sulawesi Tenggara, Gorontalo, Maluku, Maluku Utara, Papua and Papua Barat. This resulted in a sample of 27,678 inhabitants aged between 16 and 64 years.

Variables

The independent variables were: living area (urban, rural), usage of contraception (has used contraception, currently using contraception, never used contraception), water resources, received social assistance/welfare, maternal age (<15 years, 15–24 years, >25 years), public health centre availability, and GDP per capita. The dependent variable was the status of LBW. Infants with LBW were considered to have a positive status

Table 1
Sociodemographic information.

Variables	Count/mean	Percentage/SD
Area, *n* (%)		
Urban	7042	25.44 %
Rural	20,636	74.56 %
Usage of contraception		
Has used contraception	2982	10.77 %
Currently using contraception	15,342	55.43 %
Never used contraception	9354	33.80 %
Water resource		
Water has taste		
Yes	599	2.16 %
No	27,079	97.84 %
Water has foam		
Yes	114	0.41 %
No	27,564	99.59 %
Water has odour		
Yes	238	0.86 %
No	27,440	99.14 %
Receive social assistance/welfare		
Yes	3766	13.61 %
No	23,912	86.39 %
Maternal age (years)		
<15	297	1.07 %
15–24	21,046	76.04 %
>25	6335	22.89 %
Public health centres	273	113
GDP per capita	42,314	20,062

SD, standard deviation; GDP, gross domestic product.

Data analysis

Multilevel dichotomous logistic regression was used for data analysis. The multilevel model was able to capture the heterogeneity among the provinces. This method can also determine the impact of independent variables at the provincial level on the occurrence of LBW infants. The unit analysis for multilevel modelling in this research comprises two levels. The first level is provinces, and the second level is respondents. The initial level employed was each province, as this allows for a comprehensive examination of the distinct characteristics. Modelling at this level offers a more comprehensive depiction than basic analysis, and enables the quantification of diversity at each level (Finch et al., 2019). In addition, logistic regression was used because the dependent variable was a categorical variable with two classes. As a result, multilevel dichotomous logistic regression was used to analyse the factors that impact LBW.

Three models were used in this study: an individual model, a null model, and a full model. The individual model consists of independent variables from the individual data, including living area, usage of contraception, water resources, and maternal age. Individual data were nested at the provincial level; therefore, the characteristics of the provincial level were considered through the number of public health centres and GDP per capita for each province. The null model was computed without using any independent variables. Finally, in the full model, the independent variables from the provincial level were considered, including the number of public health centres and GDP per capita. In addition, the likelihood ratio test was used to evaluate whether the full model was able to describe the characteristics of the data better than the individual model. All variables were assessed using odds ratios (OR), and $p < 0.05$ was taken to indicate statistical significance. All data were analysed using R Statistics (R Core Team, New Zealand). All data were analysed using R Project for Statistical Computing with the support of lme4 (Finch et al., 2019).

Table 2
Comparison test of three models.

Model	AIC	BIC	Loglik	Deviance	χ^2	df	*p*-value
Null	26,154	26,170	−13,075	26,150			
Individual	26,110	26,200	−13,044	26,088	62.42	9	<0.001
Individual	26,110	26,200	−13,044	26,088			
Full	26,101	26,208	−13,037	26,075	12,589	2	0.002

Results

The sociodemographic data revealed that the majority of LBW infants were born to mothers living in rural areas (74.56 %) (see Table 1). Contraception was used by 55.43 % of mothers. Based on the water source, nearly all households consumed clean water as defined by three criteria: no taste (97.84 %), no foam (99.59 %), and no odour (99.14 %). Regarding social welfare, 86.39 % of families did not receive any social welfare from the government. The majority of mothers were aged 15–24 years (21,046 mothers; 76.04 %), with maternal age <15 years for only 297 mothers (1.07 %). In total, there were 273 public health centres in the areas that provide health care to the sample group. GDP was IDR 42,314 per capita.

The multilevel model was used to explain the variable characteristics of each province. The comparison likelihood test was used to determine whether the model's appropriateness might be improved considerably by including the GDP and primary health care variables. Two comparison tests were concluded. The first test compared the null model (a model without predictor variables) with the individual model. The second test compared the individual model with the full model. Based on the comparison likelihood test, adding individual predictor variables increased the suitability of the former model compared with the null model significantly ($p < 0.001$). Addition of the provincial characteristic variables also increased the suitability of the full model compared with the individual model ($p = 0.002$) (Table 2). The model used in this study is the full model because it can explain all of the variables, including GDP and public health, and is the final step in comparing the three models. The assessment level starts from the null model and continues with the individual model.

Multivariate analysis showed that mothers who did not use contraception had a significantly higher risk of having LBW infants than those who used contraception ($p = 0.000$). Mothers who lived in a rural area were more likely to have LBW children ($p = 0.000$) compared with mothers who lived in an urban area. Meanwhile, the likelihood of giving birth to a LBW infant was unaffected by the quality of the water source ($p > 0.05$). No significant association was found between receiving social assistance/welfare and LBW ($p = 0.903$), or between maternal age and LBW (15–24 years, $p = 0.324$; >25 years, $p = 0.186$). In this dataset, the incidence of LBW was not associated with the availability of public health care services in the region ($p = 0.394$) or GDP per capita ($p = 0.073$) (see Table 3).

Discussion

Mothers who did not use contraception were more likely to have a LBW infant than mothers who used contraception. This outcome supports a previous study which concluded that the use of modern contraception reduced the risk of having a LBW infant (World Health Organization, 2019). Contraception is used to prevent unintended pregnancies, thereby reducing maternal and child morbidity and mortality (Garro, 2015). Contraception is also used as a birth spacing method to reduce the risk of birth problems, such as LBW and preterm birth (Zemestani et al., 2022). Contraception allows mothers to control their fertility, enhance their economic development, improve their education, and empower them to maximize their health. It has been shown, however, that 214 million women of reproductive age from developing countries want to avoid using modern contraception (Garro, 2015). In India, mothers with limited access to contraception contribute to the prevalence of short-interval pregnancies. These 6-month intervals during pregnancy result in a 17.7 % increase in the number of LBW babies (Kannaujiya et al., 2020).

Table 3
Factors related to low birth weight in frontier, outermost and underdeveloped regions in Indonesia.

Variable		Individual level		Full model	
		Estimate (95 % CI)	OR (*p*-value)	Estimate (95 % CI)	OR (*p*-value)
Intercept		−1.724 (−2.33 to −1.118)	0.178 (0)	−4.273 (−7.835 to −0.712)	0.014 (0.019)
Area, *n* (%)	Urban	ref		ref	
	Rural	0.161 (0.088 to 0.234)	1.175 (0)	0.162 (0.088 to 0.235)	1176 (<0.001)
Usage of contraception	Has used contraception	ref		ref	
	Currently using contraception	−0.001 (−0.106 to 0.104)	0.999 (0.985)	−0.003 (−0.107 to 0.102)	0.997 (0.962)
	Never used contraception	0.208 (0.1 to 0.317)	1.232 (0)	0.205 (0.096 to 0.313)	1227 (<0.001)
Water has taste	Yes	ref		ref	
	Not	0.053 (−0.18 to 0.287)	1.055 (0.655)	0.049 (−0.185 to 0.283)	1.05 (0.68)
Water has foam	Yes	ref		ref	
	Not	0.005 (−0.555 to 0.564)	1.005 (0.987)	0.013 (−0.55 to 0.576)	1.013 (0.963)
Water has odour	Yes	ref		ref	
	Not	0.133 (−0.265 to 0.53)	1.142 (0.512)	0.129 (−0.27 to 0.529)	1.138 (0.526)
Receive social assistance/welfare	Yes	ref		ref	
	Not	0.009 (−0.083 to 0.101)	1.009 (0.85)	0.006 (−0.086 to 0.098)	1.006 (0.903)
Maternal age (years)	<15	ref		ref	
	15–24	−0.149 (−0.432 to 0.134)	0.861 (0.302)	−0.142 (−0.425 to 0.14)	0.867 (0.324)
	>25	−0.203 (−0.491 to 0.086)	0.816 (0.168)	−0.194 (−0.482 to 0.094)	0.823 (0.186)
Public health centres				−0.075 (−0.247 to 0.097)	0.928 (0.394)
GDP per capita				0.278 (−0.026 to 0.583)	1.321 (0.073)

OR, odds ratio; CI, confidence interval; GDP, gross domestic product.

Managing pregnancy intervals using contraception can enhance child survival. For example, in developing countries, the risk of LBW is twice as high if conception occurs within 6 months of the previous birth (Cleland et al., 2012). The risk of death of a child aged <1 year has been shown to decrease by 10 %, and for a child aged 1–4 years by 21 % if there is a pregnancy interval of at least 2 years (Cleland et al., 2012; Barclay and Smith, 2022). A similar result was found in Ethiopia, where an interpregnancy interval of 18 months was shown to have a poorer perinatal outcome than a 24–60-month interval, and LBW was closely associated with an interval of ≤18 months (Jena et al., 2022). In another study, the lowest chance of LBW was found in women who had interpregnancy intervals between 36 and 41 months, with a rate of only 15.8 % (Kannaujiya et al., 2020). The absence of effective contraception and short birth intervals means that a woman's parity becomes higher, increasing her risk of morbidity and mortality (Lestari et al., 2021). Women with shorter birth intervals and high parity have a higher risk of having a LBW infant than women with longer birth intervals and low parity (Merklinger-Gruchala et al., 2015). Close birth spacing may result in inadequate growth conditions, causing LBW. Short birth intervals may have an adverse effect on perinatal outcomes (Barclay and Smith, 2022). For example, short birth intervals are known to increase LBW, but are also associated with low APGAR score, increased incidence of neonatal respiratory distress, early neonatal death, and anaemia in the newborn (Cholifah et al., 2018; Korsa et al., 2021). Short birth intervals are also more likely to result in premature rupture of membranes, prolonged labour, pre-eclampsia, and risk of malposition or mal-presentation compared with birth intervals ≥33 months (optimum birth interval) (Korsa et al., 2021). Promoting optimal pregnancy spacing through effective family planning is therefore very important, especially for women in developing countries (Wahyuningsih et al., 2022).

Based on this study, the area of residency was also a factor that correlated with the incidence of LBW infants. This finding was consistent with previous evidence showing that babies born in rural or isolated areas have a higher chance of being LBW (14.4 %) than babies born in urban areas (8.7 %) (Donal et al., 2018). In India, the prevalence of LBW was lower in urban areas than in rural areas, and it was considerably greater among babies with interpregnancy intervals of <6 months compared with those with interpregnancy intervals of 18–23 months (Kannaujiya et al., 2020). Women living in rural areas have higher rates of anaemia, which is known to increase the risk of LBW (Ahankari et al., 2017). Nutrition was found to be associated with LBW in rural areas in Malaysia (Kaur et al., 2019). A woman living in a rural area may have lower nutritional status, and should be encouraged to improve her nutrition and monitor her middle-upper arm circumference regularly during pregnancy (Kaur et al., 2019). The middle-upper arm circumference indicates maternal fat, lean tissue stores, protein and energy reserves in the body (Papathakis et al., 2016).

The present findings agree with previous research which found that maternal age was not associated with risk of LBW babies (Johnson et al., 2017). In contrast, a study in the Americas found that maternal age <20 years or >35 years was significantly associated with risk of having a LBW baby (González-Jiménez and Rocha-Buelvas, 2018). Although maternal age was not found to be associated with LBW babies in this study, Indonesia still faces the issue of early child marriage, which has negative consequences. This is because young women aged <20 years have immature reproductive organs, and this can affect their pregnancy and fetus, resulting in LBW (Tarigan et al., 2023).

Healthcare facilities in rural areas have been identified as a factor associated with the prevalence of LBW in Bangladesh (Khan et al., 2018). Poor healthcare access has been linked to a lower number of ANC visits (Khan et al., 2018). A minimum of four ANC visits has been shown to reduce the prevalence of LBW babies. A mother with inadequate ANC visits has a 16.87 times higher chance of having a baby with LBW compared with a women with adequate ANC access (Donal et al., 2018). The availability of primary health care in this study did not correlate with the incidence of LBW. This concurs with previous work which showed that adequate healthcare coverage and facilities did not reduce the number of LBW babies directly (Erasun et al., 2021). For example, at the primary healthcare level, the referral system for LBW was still insufficient (Erasun et al., 2021; Jebessa et al., 2021).

This study found no significant correlation between water resources and LBW babies. However, a previous study in the Americas found correlation between water pollution and LBW babies (González-Jiménez and Rocha-Buelvas, 2018). Water contamination may differ from one place to another. Several examples of contaminants found in water include heavy metals, nitrates, pesticides, herbicides, agricultural and residential discharges, and microbial and other chemical substances (Currie et al., 2013). Changes in odour and colour may indicate water contamination. When contamination is suspected, it is essential to find the source of contamination to limit its effect on the human body (Palansooriya et al., 2020).

This study found that GDP per capita was not associated with LBW. This result was similar to a previous study in which GDP was not associated with the prevalence of LBW babies. Higher GDP did not mean a lower percentage of LBW babies (Erasun et al., 2021), despite the fact

that GDP is related to economic growth which can indicate a country's welfare (Elistia and Syahzuni, 2018; Erasun et al., 2021). In addition, social assistance is a government programme to support a person or family. This study found no correlation between social assistance and the incidence of LBW. This is similar to a previous study which found that families with government support have children of good height and weight (Ahankari et al., 2017) . Governments can create various social programmes that are suitable for their country. In the USA, a few programmes, such as nutritional education, not only increase child weight and reduce LBW, but have a limited or very weak positive effect on LBW (Swanson and Chavez, 2020). Choosing and maintaining a beneficial programme to reduce LBW was a long-term goal to reduce the prevalence of LBW in the USA (Swanson and Chavez, 2020).

Strengths and limitations

This study used a large sample of routinely collected national data. As such, the researchers were unable to control the variables which may affect the research outcomes. Therefore, research designs must be adopted to match the existing data. There may be other factors that affect the prevalence of LBW infants that were not identified in this study.

Conclusions

This study found that the factors that play an important role in the prevalence of LBW infants in the frontier, outermost and underdeveloped regions of Indonesia are: mother lives in a rural area; and mother has never used contraception. Maternal age, access to public health centres, social assistance, water quality and household GDP were not found to affect the likelihood of having a LBW infant in the frontier, outermost and underdeveloped regions of Indonesia. The frequency of LBW infants is an important indication of public health that can be used to forecast future health. Furthermore, maternal health services from primary care to referral need to be strengthened in order to provide optimal health services for pregnant women and meet the national long-term goal.

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Data availability statement and ethics

The SUSENAS data set has an ethical licence from the National Health Research and Development Agency, Ministry of Health of the Republic of Indonesia. In addition, permission to use this data was approved by the Statistical Dissemination Directorate of Statistics Indonesia (BPS) (No. 60/LADU/0000/04/2022). This dataset obtained from the BPS is anonymised. The SUSENAS data set is available upon request from BPS (https://silastik.bps.go.id/v3/index.php/). BPS has imposed legal restrictions that prevent the public sharing of data.

CRediT authorship contribution statement

Nuzul Qur'aniati: Writing – review & editing, Writing – original draft, Validation, Resources, Methodology, Formal analysis, Data curation, Conceptualization. **Ulfia Fitriani Nafista:** Writing – review & editing, Writing – original draft, Validation, Resources, Methodology, Formal analysis, Data curation, Conceptualization. **Prilyandari Dina Saputri:** Writing – review & editing, Writing – original draft, Validation, Resources, Methodology, Formal analysis, Data curation, Conceptualization. **Fildzah Cindra Yunita:** Writing – review & editing, Validation, Resources, Methodology, Formal analysis, Data curation, Conceptualization. **Mundakir:** Writing – review & editing, Writing – original draft, Validation, Resources, Methodology, Formal analysis, Data curation, Conceptualization. **Alison Hutton:** Writing – review & editing, Visualization, Methodology, Conceptualization. **Linda Sweet:** Writing – review & editing, Visualization, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no conflict of interest.

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