

RESEARCH ARTICLE

Investigating Adolescent Vulnerability in Indonesia: A Socio-Remote Sensing Big Data Analytics Study Using Night Light Data

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ABSTRACT The rising prevalence of behavioral and mental health challenges among Indonesian adolescents, affecting nearly one in three, is a pressing concern intensified by constant internet exposure and heightened social comparisons. This study, using data from Indonesia's National Socioeconomic Survey, examines the likelihood of mental health issues in adolescents, incorporating variables like mobile phone usage, emotional and behavioral disorder classifications, travel experiences, insurance ownership, maternal residence, house surface area, and night light remote sensing data. Our findings reveal that urban adolescents face a higher susceptibility to behavioral disorders compared to rural peers, with males being 1.18 times more likely to experience behavioral and emotional disturbances than females. This research validates the suitability of these variables for assessing vulnerability among adolescents. Leveraging big data analytics, it highlights the multifaceted determinants of adolescent vulnerability in Indonesia, stressing the need for targeted interventions and policies to enhance their well-being.

INDEX TERMS Adolescent, vulnerability, big data analytics, mental health, behavioral.

I. INTRODUCTION

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Adolescent vulnerability is an important issue to discuss in sustainable development programs. The impacts of

COVID-19 and its consequent to large-scale restrictions have led to stunting, malnutrition, and vulnerability because many people with low and middle economic statuses have lost their jobs. The problem of Sustainable Development Goals (SDGs) point 2 is further exacerbated by a report from UNICEF explaining that the prevalence of stunting among children under the age of 5 was 31.8% in 2020. In addition, millions of people are suffering due to mental or emotional health problems, and the prevalence rates of these issues are increasing. Nonetheless, severe mental health problems and mental illness are not synonymous [1]. Someone can suffer from severe mental problems and not be diagnosed with mental illness [2], [3], [4]. On the other hand, an individual who has been diagnosed with a mental illness might also be physically ill. There are high socioeconomic costs associated with the escalating strain of mental illness, such as the promotion treatment, and prevention of mental health issues [5], [6], [7], [8], [9], [10], [11]. Mental health is associated with a person's behavior and is viewed as fundamental to their physical health and, thus, quality of life. Understanding and promoting mental health is highly important, as it is a global concern [2], [12], [13], [14], [15], [16].

Promoting mental health awareness is necessary because it helps to counter the current approaches and concerns in our communities. When all people are aware of mental health concerns, they are able to identify problems, discover new solutions, and dispel stigmas and fears related to mental health. Increased awareness also encourages other people to ask for help when they need it. Together, we can lay the groundwork for a vibrant culture that respects and acknowledges the importance of mental health [17], [18], [19], [20]. Having a focus on mental health awareness has the additional benefit of making it simpler to identify the specific signs and conditions of an illness. An early interference pathway can lead to a more favorable response to treatment procedures. The probability that a given person can manage their illness and subsequently enhance their mental health increases with the speed at which they receive treatment [21], [22], [23], [24].

The rights of children and adolescents need to be recognized at every SDG point to ensure good health, high-quality education, high-quality food and good nutrition. Today, there are still many children and adolescents who do not receive a high-quality education, especially in the remote areas of Indonesia. Thus, future generations will be threatened if we do not have the ability and access to good education to achieve Society 5.0. The Penta-Helix collaboration [25], [26], [27], [28], [29], [30], [31] focuses on equality and inclusion to ensure that children and adolescents have good skills.

To achieve its goal of educating the nation, the government needs to pay attention to the education of its citizens. Education is one of the crucial sectors in building a nation. The level of education in a country can affect national development in terms of both welfare and the success of a nation. Education is also an activity carried out by educators consciously to build

the ability of students so that they can become people who excel and can compete [32], [33], [34], [35]. Education can be considered a process due to the existence of a set of activities that are systematic and directed at the goal of change, both in terms of behavior, ways of behaving, solving problems and knowledge used in competing in social life. This is also in line with Law No. 20 of the 2003 Republic of Indonesia, which concerns the national education system and states that the function possessed in national education today is to instill morals and knowledge and form personalities and excellent national civilizations, thus realizing the achievement of state goals through the potential of the nation's children by considering aspects of divinity and spiritualism, culture and society to become democratic and responsible citizens. In this regard, it is fitting that education should receive special attention for every party [36], [37], [38]. The attention of both the community and the government, who work collaboratively to bring better changes to the quality of the education system in Indonesia, means that the government needs to meet the educational needs of each of its citizens through rules or policies related to education [39], [40].

To provide a more comprehensive understanding, this paper is organized into distinct sections. Section I offers an introduction, laying the groundwork for the study. Moving on, Section II explores previous work, offering a comparative analysis with vulnerability indices crafted by other researchers. The subsequent Section III delves into the intricacies of the methods and data employed in our study. The comprehensive presentation of results unfolds in Section IV, elucidating key findings. Finally, Section V encapsulates the study's conclusions, summarizing the insights derived from the research endeavor.

II. PREVIOUS WORK

Table 1 describes recent vulnerability index studies related to children and adolescents. The commonly used methods are still very basic and conventional. The current study used big data analytics, which is useful for reasoning and perspective analytics. Data science now plays an essential role in processing data. Currently, the world has entered the digital age where people can easily access the information they would need. Therefore, to analyze the problem, we also use information regarding night light as remote sensing data [41], [42], [43], [44], [45], [46] that can be used to enrich socioeconomic information.

From the policy perspective, using data in the decision-making process is becoming more beneficial because it is directed toward adequate, effective, and efficient public policy. Hence, policy-makers can choose alternative solutions and provide arguments based on data usually obtained from empirical analysis. Beyond policy-making, data can also be used in assessments. This makes the role of data in policy essential. However, of course, data do not stand alone. They need to be processed and analyzed to become practical knowledge [30], [31].

The current state of regulations in Indonesia concerning the management of emotional and behavioral disorders lacks clear definition. While there have been efforts through regulations and initiatives to address mental health concerns, including emotional disorders, challenges persist in their effective implementation and the availability of resources.

Over the past few years, there has been a growing awareness of the critical importance of mental health in Indonesia. Collaborative efforts involving the government and various stakeholders have been made to enhance mental health services. Despite these endeavors, significant hurdles remain. Resource constraints pose a considerable challenge, limiting the ability to provide comprehensive mental health services. Additionally, accessibility to mental health services is unevenly distributed, particularly in remote areas, exacerbating the existing disparities in healthcare access.

One prominent issue that continues to impede progress is the societal stigma attached to mental health problems. This stigma can hinder individuals from seeking help, perpetuating a culture of silence around mental health issues. Combating this stigma is essential for creating an environment that encourages open discussions and promotes seeking assistance for emotional and behavioral disorders.

In moving forward, a concerted effort is needed to refine and strengthen existing regulations, ensuring a more precise framework for addressing emotional and behavioral disorders. Simultaneously, increased investment in mental health resources, especially in underserved areas, is crucial. Fostering a culture of understanding and acceptance will contribute significantly to dismantling the barriers that hinder effective management and support for mental health in Indonesia.

In summary, we highlight the current condition of vulnerability among adolescents and the prevalence of behavioral and/or emotional disorders at the household level in Indonesia. We used the dataset from the last wave of the National Socioeconomic Survey (SUSENAS) 2021, Republic of Indonesia. No other study has fully highlighted this pertinent information regarding child and adolescent vulnerability. Using the SUSENAS dataset, the category of adolescent behavioral and/or emotional disorders has an unbalanced class. We aim to determine the percentage of the population that has ever taken a recreational trip (R901) and the percentage of the population that has health insurance in March 2021 (R1101) (see Fig. 1A). Following the explanation of night light intensity, 2021 aggregates NASA Black Marble (Night Light/NLT) with the Proportion of Important Variables Percentage of the population that has ever used the internet between January and March 2021 (R808) (see Fig. 1B).

Variable codes correspond to question blocks in SUSENAS. Thus, we performed the cluster vulnerabilities using k-means. This cluster information is important for labeling vulnerable areas of Indonesia. Hence, we selected 4 clusters with the justification of the best eigenvalue in the scree plot (see Fig. 2). We further elaborated the cluster information using logistic regression in consideration of the class

of regions that have the unbalanced status of adolescents' behavioral and/or emotional disorders in Indonesia. Logistics regression is the appropriate method for cognitive analytics, and we also obtained the odds ratio to capture the phenomenon of the odds value of each variable we applied. Our results show adolescents' behavioral and/or emotional disorders by considering multiple important variables collected from the SUSENAS, including adolescents' status of living in urban and/or rural areas, living with a mother, floor area (square meters), insurance status, proxy night light, travel experience, internet usage, and working status (see Appendix A). Moreover, we provide recommendations regarding challenges in protecting child and adolescent development in Indonesia (see Fig. 3). The novelty of this study is that we use nightlight (NLT) remote sensing data to capture light intensity information (see Fig. 4).

Night Light Data is often utilized to assess economic activity, urbanization, and development levels, among other indicators. Night Light Data can be particularly insightful when examining income levels. Areas with brighter nighttime lights may indicate higher economic activity and prosperity, while dimly lit regions might suggest lower income levels. This information can be valuable for policymakers and researchers seeking to understand and address economic disparities. In terms of education quality, Night Light Data may indirectly reflect educational infrastructure and access to resources. Well-lit regions could indicate areas with better educational facilities and resources, while darker areas may suggest potential challenges in education provision. Analyzing changes in nighttime lights over time can provide insights into the dynamics of educational development. Access to healthcare can also be inferred from Night Light Data.

Well-lit urban areas may have better healthcare infrastructure and services, while darker or less illuminated regions might face challenges in healthcare accessibility. Monitoring changes in nighttime lights can offer valuable information about improvements or deteriorations in healthcare infrastructure. However, it's essential to note that while Night Light Data provides valuable insights, it has limitations. Brightness alone may not capture the complexity of socio-economic factors, and other data sources are necessary for a comprehensive analysis. Additionally, caution should be exercised to avoid oversimplification and misinterpretation of the data, as various factors, such as cultural practices or energy usage patterns, can influence night-time light levels. Our Night Light Data stands out as an innovative tool for evaluating socio-economic factors such as income levels, education quality, and healthcare access. Its application contributes to a more nuanced understanding of regional development. However, for a thorough and accurate analysis, it is essential to complement Night Light Data with other pertinent data sources. This comprehensive approach offers a distinct advantage in socioeconomics, offering an up-to-date indication of regional economic conditions compared to traditional measures like GDP or other economic proxies.

TABLE 1. Recent research on child and adolescent vulnerability.

Sources	Variables	Main Purposes	Index	Methods
[47]	Exposure and metabolism	Children's environmental health risks	-	Descriptive analysis
[48]	Socioeconomic status, household composition and disability, minority status and language, housing and transportation	Performing retrospective cohort study to investigate the effect of high social vulnerability index (SVI) levels	Social vulnerability index (SVI)	Multivariable logistic regression analysis
[49]	Socioeconomic status, household composition and disability, minority status and language, housing and transportation	Emergency management in resilience community	Social vulnerability index (SVI)	Risk calculation using expectation of loss
[50]	Poverty, gender, race and ethnicity, age, and disabilities	Measuring the social vulnerability toward extreme weather events	Social vulnerability index (SVI)	Pareto ranking and principal component analysis
[51]	Socioeconomic and livelihood, biophysical (agriculture), institution and infrastructure (general), institution and infrastructure (health)	Analyzing the association between climate change vulnerability and women and children's health (WCH)	Climate vulnerability index	Fractional regression and spatial analysis
[52]	Population density, health factors, demographic and socioeconomic factors, natural and built environment factors	Extreme heat waves elevate the population's risk for heat-related morbidity and mortality	Heat vulnerability index	Unweighted z-score
[53]	COVID-19 vaccine administration data	Measuring vulnerability related to the first dose of the COVID-19 vaccination	Social vulnerability index (SVI)	Basic statistics and spatial analysis
[54]	Medicaid claims and enrollment data	Sociodemographic characteristics between children with and without pre- and posttest BMI	Social vulnerability index (SVI)	Linear regression
[55]	Investigate the effects of climate change on livelihood vulnerability in riverbank erosion bait community flood-prone area of Punjab, Pakistan	Investigate the effects of climate change on livelihood vulnerability in riverbank erosion bait community flood-prone area of Punjab, Pakistan	Livelihood vulnerability index	LVI composite approach
[56]	Experience in videogame application based on a classical paradigm in experimental psychology	Determining index scores for behavioral classification	Pinky-piggy index score.	Descriptive analysis
[57]	Childhood anxiety sensitivity index (CASI), state-trait anxiety inventory for children (STAIC), intolerance of uncertainty scale for children (IUSC), children's response styles scale (CRSS), children's revised impact of event scale (CRIES), children's depression inventory (CDI)	Performing longitudinal research to examine psychological distress in children during the COVID-19 pandemic	Socioemotional vulnerability	Descriptive analysis and linear models
[58]	Nine study cycles in the NHANES database: 2001–2002, 2003–2004, 2005–2006, 2007–2008, 2009–2010, 2011–2012, 2013–2014, 2015–2016, 2017–2018). Children and adolescents aged 12–19 years who had complete information on the components of METS and 24-h dietary recall data for computing dii were eligible to be included.	Determining factors associated with the Dietary inflammatory index (DII)	Metabolic syndrome (METS); Dietary Inflammatory Index (DII).	Univariate and multivariate logistic regression
[59]	Twelve healthy family indicators with stunting incidence	Determining the relationship between the index of healthy families and the incidence of stunting among toddlers	Healthy family index	Cross-sectional approach and chi-square tests
[60]	Psychological, physical, educational	Justifying the physical, psychological, and educational vulnerabilities, as well as factors that influence the involvement of children in flood disaster-related activities	School children vulnerability	Univariate, bivariate, and multivariate analysis
[61]	Total Population, Per Capita Income, Below Poverty, African American Characteristic, Hispanic, Elderly, Female-Headed Households, Disabled.	Producing the metrics with a greater degree of precision, transparency, and credibility	Hierarchical social vulnerability index	Monte-Carlo-based uncertainty analysis
[62]	Twenty-two statistical variables	Proposing a SEVI model adjusted for sensitivity that can be used to improve expert-opinion accuracy.	Social vulnerability index	Spatial multicriteria analysis
[63]	Evacuation curves mobility, inundation mobility, and census data.	Proposing a methodology to incorporate social vulnerability into current methodologies to estimate the percentage of people who evacuate an inundation hazard zone.	Response Time by Social Vulnerability Index (ReTSVI).	Monte-Carlo simulation, PCA, ANOVA, Kruskal–Wallis,

TABLE 2. Susneas block questions.

BLOCK	QUESTIONS	REF CODE SUSENAS
BLOCK X. DESCRIPTION OF FUNCTIONAL DISTURBANCES (FOR CHILDREN AGED 2 AND ABOVE)	DOES (name) EXPERIENCE BEHAVIORAL AND/OR EMOTIONAL DISTURBANCES? 5. Yes, consistently experiencing disturbances 6. Yes, frequently experiencing disturbances 7. Yes, experiencing disturbances to a small extent 8. Not experiencing disturbances	1007
BLOCK IV. DEMOGRAPHIC INFORMATION	DOES (name) IDENTIFY AS MALE OR FEMALE? 1. Male 2. FEMALE	405
	WHAT IS THE AGE OF (name)?	407
BLOCK XI. DESCRIPTION OF HEALTH COMPLAINTS AND OUTPATIENT CARE	WHAT HEALTH INSURANCE DOES (name) HAVE? A. BPJS Health for Premium Assistance Recipients (PBI) B. BPJS Health Non- PBI/Independent C. Regional Health Insurance (Jamkesda) D. Private Insurance E. Company/Office X. NONE	1101
BLOCK VIII. INFORMATION AND COMMUNICATION TECHNOLOGY DESCRIPTION	IN THE LAST 3 MONTHS, HAS (name) EVER USED THE INTERNET (INCLUDING FACEBOOK, TWITTER, YOUTUBE, INSTAGRAM, WHATSAPP, ETC.)? 1. Yes 5. No	808
BLOCK IX. TRAVEL AND VICTIM OF CRIME INFORMATION	SINCE JANUARY 1 - DECEMBER 31, 2019, HAS (name) EVER TRAVELED (TO COMMERCIAL TOURIST DESTINATIONS? STAYED IN COMMERCIAL ACCOMMODATIONS? OR TRAVELED A DISTANCE ≥ 100 KM ROUND TRIP)? THAT WAS NOT FOR SCHOOL OR WORK ON A REGULAR BASIS? 1. Yes 5. NO → 904	901 A AND B
BLOCK VII. INFORMATION ON SAVINGS AND EMPLOYMENT	DURING THE PAST WEEK, DID (name) HAVE ANY EMPLOYMENT/WORK, BUT TEMPORARY?	

III. METHODS

This study integrates cross-sectional data from surveys with satellite imagery. The independent variable in this research is

dichotomous, indicating the presence or absence of an emotional disorder event. Hence, logistic regression is deemed the most appropriate statistical method for the analysis. Table 2 elucidates the SUSENAS blocks utilized along with their respective reference codes. As explained in the previous section, there is currently no robust regulation in Indonesia specifically addressing adolescent vulnerability. Therefore, the novelty of this research can be seen as an initial initiative to complement the framework for the government and related ministries. Additionally, it aims to raise public awareness regarding the mental health and behavior of children and adolescents.

With the absence of specific regulations concerning adolescent vulnerability in Indonesia, this study provides a valuable contribution as an initial step to fill this gap. The research findings can serve as a strong foundation for the development of more concrete regulations and policies related to the protection and well-being of children and adolescents. By providing a deeper understanding of adolescent vulnerability, this research is expected to guide the government and relevant ministries in designing more effective preventive and intervention measures. With a solid foundation, the implemented regulations are hoped to be more accurate and relevant in addressing the mental health and behavioral challenges among children and adolescents.

Moreover, our research also has a significant impact on increasing public awareness of mental health and behavioral issues among children and adolescents. With the growing understanding and awareness of the public, it is expected to create a more responsive and supportive environment, both in terms of prevention and the management of mental health issues. Thus, this research not only makes a scientific contribution but also has the potential to bring positive changes in the development of policies and public awareness regarding the mental health and behavior of children and adolescents in Indonesia.

A. CALCULATING ADOLESCENT EMOTIONAL DISORDERS IN INDONESIA USING BIG DATA ANALYTICS

The data in this study are collected from the March 2021 National Socio-Economic Survey (SUSENAS) by BPS Statistics Indonesia. This survey sampled 345.000 households nationwide with a stratified two-stage sampling method. Although the observation units were households, this survey collected both household and individual data. The National Socio-Economic Survey (SUSENAS) covered various indicators related to population, education, health, fertility and family planning, housing, information and communication technology, social protection, food insecurity, and expenditure.

Samples were taken from 198.642 individuals aged 10 to 19. The data preprocessing stage only included coding, and no further adjustments were made. The binary logistic regression model is used to analyze the relationship between one response variable and several independent variables, where 1 indicates the presence of a characteristic and 0 indicates

the absence of a characteristic [64], [65]. In the logistics regression, we are able to estimate the value of x , which also lies in a very wide range probability (0to1), known as the odds ratio, thus containing information to obtain the probability value of the occurrence of the dependent variable that can be predicted [65]. Logistic regression is useful for data with unbalanced classes in data science or big data analytics. The biclustering algorithm with possibilistic membership concept is a modification of the possibilistic clustering method (PCM). This algorithm works by reducing the $X_{M \times N}$ matrix to produce one bicluster with low residuals. The objective function that is minimized in PBC is shown in Equation 1.

$$J_B = \sum_m \sum_n \left(\frac{a_m + b_n}{2} \right) d_{mn}^2 + \lambda \sum_m (a_m \ln(a_m) - a_m) + \mu \sum_n (b_n \ln(b_n) - b_n) \quad (1)$$

Equation 1 explains that the constant λ, μ has a row membership vector a_m , column membership vectors b_n and squared residual matrix of bicluster $[d_{mn}^2]_{m \times n}$. The following are the main steps of bicluster with the possibilistic biclustering algorithm:

Step 1: Determine the parameters λ and μ and then determine the convergence condition ε for the row and column membership values.

Step 2: Initiate the values of a_m and b_n with random numbers between 0 and 1.

Step 3: Calculate the membership value of each object in matrix X against the bicluster with u_{mn} , as the membership value of the object in Row i and Column j .

$$u_{mn} = \frac{a_m + b_n}{2}$$

Step 4: Calculate the bicluster cardinality with

$$p = \sum_m \sum_n u_{mn}$$

Step 5: Calculate the squared residual matrix with

$$d_{mn}^2 = \frac{(x_{mn} + x_{MN} - x_{mN} - x_{Mn})^2}{p}$$

$$x_{MN} = \frac{\sum_m \sum_n u_{mn} x_{mn}}{\sum_m \sum_n u_{mn}}$$

$$x_{mN} = \frac{\sum_n u_{mn} x_{mn}}{\sum_n u_{mn}}$$

$$x_{Mn} = \frac{\sum_m u_{mn} x_{mn}}{\sum_m u_{mn}}$$

Step 6: Calculate the vector a'_m with equation

$$a'_m = \exp\left(-\frac{\sum_n d_{mn}^2}{2\lambda}\right)$$

Step 7: Calculate the vector b'_n with equation

$$b'_n = \exp\left(-\frac{\sum_m d_{mn}^2}{2\mu}\right)$$

Step 8: Calculate the Euclidean distance between a'_m and a_m

Step 9: Calculate the Euclidean distance between b'_n and b_n

B. EXPLORING NIGHT LIGHT DATA AS AUXILIARY VARIABLES IN INDONESIA

Expanding on the statement, when dealing with logistic regression models that incorporate a substantial number of independent variables and are trained on limited datasets, there is a heightened risk of overfitting, particularly when utilizing maximum likelihood estimation. Overfitting occurs when a model captures not only the underlying patterns in the data but also the noise or random fluctuations, leading to poor generalization performance on new, unseen data.

In the context of logistic regression, where the goal is often to predict the probability of an event occurring, overfitting can result in a model that fits the training data too closely. This means the model may perform exceptionally well on the data it was trained on but fails to generalize accurately to new, unseen data. To estimate the parameters in this paper, we use the maximum likelihood method, which requires the first and the second derivatives of the likelihood function. Other estimators, such as hierarchical likelihood [66], [67], [68], [69], [70] can be implemented.

Initially, we undertake the task of formulating the log-likelihood function and determining the values of θ that maximize this function. Given the binary nature of the labels we are predicting and the fact that the logistic regression function provides the probability of the label being one, it is crucial to interpret each label as a Bernoulli random variable.

$$Y \sim \text{Ber}(p)$$

$$p = \sigma(\theta^T x)$$

In this context, we can express the likelihood of the entire dataset as follows:

$$L(\theta) = \prod_{i=1}^n P(Y = y^{(i)} | X = x^{(i)})$$

$$= \prod_{i=1}^n \sigma(\theta^T x^{(i)})^{y^{(i)}} \cdot [1 - \sigma(\theta^T x^{(i)})]^{(1-y^{(i)})}$$

To elaborate, for each data point in our dataset, the likelihood represents the probability of observing the actual outcome based on the model's predictions. In logistic regression, where we are dealing with binary outcomes, the likelihood is typically expressed using the Bernoulli distribution, as it precisely models the probability of success or failure.

$$LL(\theta) = \sum_{i=1}^n y^{(i)} \log \sigma(\theta^T x^{(i)}) \log [1 - \sigma(\theta^T x^{(i)})]$$

The novelty of this research is that we employ a remote sensing variable known as night-light (NTL). Night light (NTL) is a longstanding and well-established proxy for measuring economic activities in a region, particularly for gross

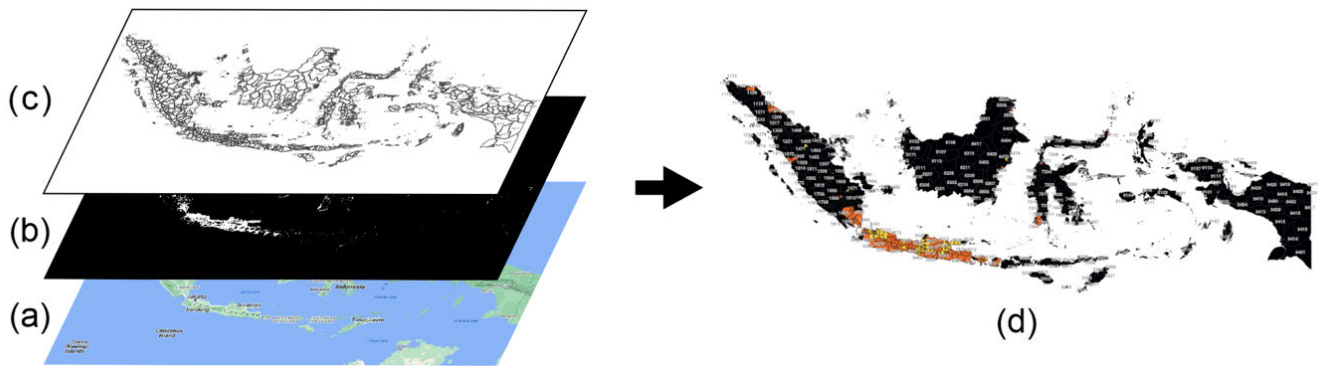


FIGURE 1. Zonal-statistics calculation conducted in QGIS. (a) Real-world terrain; (b) Value layer: Black Marble imagery; (c) Zone layer: Polygons outlining district boundaries; (d) Output: Nightlight intensity per district.

domestic product (GDP) [71], [72], [73]. Nighttime light has been found to be positively correlated with the Gross Domestic Product (GDP) or Gross Regional Product (GRP) at different spatial scales. Night-light (NTL) satellite data can help meet this need. Unlike utility records, satellite-based measurements are collected onboard space-based platforms that can provide global and consistent coverage [74].

The benefits of incorporating night light data into economic analyses are as follows: (1) estimating GDP at finer levels of spatial resolution than are available through official statistics, (2) estimating GDP change (as opposed to levels) at high temporal frequencies, and (3) estimating GDP in areas with poor or no reporting [75]. We find the link between NTL and economic activities, especially estimated by wages, to be slightly overestimated in large urban areas and underestimated in rural areas [73]. NTL reflects the level of regional economic activity development as measured by household wealth, education and health condition. The relatively bright and relatively intense NTL is indicative of a relatively wealthy, well-educated and healthy local population [76]. Black Marble is a product suite (VNP46) produced by NASA and openly shared via Black Marble. VNP46 is the refined version of the Visible Infrared Imaging Radiometer Suite (VIIRS) Day/Night Band (DNB) data, which has been calibrated, corrected, and validated to be used effectively for scientific observations [77], [78], [79]. The calibration and improvement included removing cloud-contaminated pixels and correcting for atmospheric, terrain, vegetation, snow, lunar, and stray light effects. There are several Black Marble products available, with various temporal resolutions: daily (VNP46A1 and VNP46A2), monthly (VNP46A3), and yearly (VNP46A4). In the context of consistency, monthly and annual composites perform better than other composites [79]. Both composites are treated with seasonal adjustment, outlier removal, and artificial light detection. Considering the quality of the data and the coverage of the study period, we used the annual composite (VNP46A4) in this study. All the composites in the VNP46 product suite are published in grided layer format with a size of $10^0 \times 10^0$ for each tile (see Fig. 1).

IV. RESULTS

A. ASSESSING EMOTIONAL AND BEHAVIORAL VULNERABILITY OF ADOLESCENTS WITH INTERNET LITERACY, TRAVEL EXPERIENCE, HAVING HEALTH INSURANCE, AND NIGHT-LIGHT INTENSITY AS AUXILIARY VARIABLES

To improve the education system, the government, in accordance with the Sustainable Development Goals (SDGs) plan prepared by the National Development Planning Agency BAPPENAS in 2017, has included the education sector as a concern in the plan. The education sector aims to ensure inclusive and equitable quality education and expand learning opportunities for all. Indicators in the education sector include all students at the primary and secondary education levels, as stated in the Universal; free secondary education; quality education facilities; gender equality with respect to early childhood care, development and preschool education; all people have the same opportunity to obtain affordable and high-quality technical, vocational, and university education, thus significantly increasing the number of youth and adults with relevant skills for their work; all students have the same opportunity to receive good education, which ensures equal access to education and equal opportunity for all genders in education; all adolescents have equal literacy and numeracy skills; all adolescents have the knowledge and skills to support sustainable development; education facilities that are accessible to individuals with disability, individuals of all genders, and children; nonviolent environments; an increased number of scholarships for developing and remote countries; and an increased supply of qualified educators, especially in remote areas.

The variables were described as proportions. Regarding night light in Indonesia, a bright area indicates that Java has a better socioeconomic condition than Kalimantan, Sumatra, Sulawesi and Papua (see Fig. 1 category NTL). Java is the most populated island in the world. More than 149 million people are living in the province, which is more than 56% of the total population in Indonesia. Hence, it is not surprising that regional groups in Java spatially dominate the structure of Indonesia's economy, contributing to the GDP of 58.7%.

Sumatra Island ranks second at 21.54%, followed by Kalimantan Island at 8.05%, Sulawesi Island at 6.52%, Bali and Nusa Tenggara Island at 2.75%, and Maluku and Papua Island at 2.44%.

This pattern observed in rural areas, where homes are distantly situated and surrounded by an abundance of dense vegetation, contributes to a reduction in the intensity of night light. The phenomenon is notably accentuated in regions like Papua, where the architectural structures of homes tend to be lower in elevation compared to the towering trees in the vicinity. This interplay between the spatial distribution of homes and the lush tree canopy may be regarded as a vulnerability or limitation in the context of Night Light Data captured through remote sensing techniques. Understanding these nuances is crucial for a comprehensive interpretation of the data and for acknowledging the unique challenges that may arise in capturing accurate night light information in diverse geographical settings.

The most exciting information gathered from using this variable in the National Socio-Economic Survey (SUSENAS) is the distribution of insurance holdings in each province in Indonesia (see **Fig. 1 R1101**). Child Insurance Ownership in Indonesia is lacking with justification from the R101 question block, which indicates that many regions still have a score below 22%, specifically in the Bangkalan area, the Sula Islands Regency of Nusa Tenggara and other areas in central and eastern Indonesia (See **Fig. 1 R1101**). Those areas with low participation rates in child insurance ownership are also labeled Priority Areas for Poverty Reduction 2020-2024 and categorized as extremely low income. In addition, the night light variable in Java (see **Fig. 1 NTL**) has the highest intensity compared to other regions, i.e., Sumatra, Kalimantan, Maluku, and Papua, which have low intensities (see **Fig. 1 NTL**). The variable night light (NTL) can also be used as a proxy for a region's economic level; the brighter the light is, the better the economic status. The NTL variable captured through the Defense Meteorological Satellite Program (DMSP) - Operational Linescan System (OLS) sensor of the visible and near-infrared (VNIR) band can help scientists observe and detect light pollution sources. Therefore, NTL is highly variable in space and time scales and can be used to identify several social and economic aspects, including economic development conditions; therefore, NTL intensity is used as a significant predictor of the spatialization of a region's GDP and economic level.

When a region is identified as bright with respect to NTL, it can be concluded that the region has a good state of ICT for digitalization. Consequently, people in the region are exposed to the internet more frequently than people in regions with low NTL intensity. The same goes for connecting with the population who had recreational travel in 2020 (**Fig. 1 R901**). The higher the NTL intensity is, the more often the people are traveling in accordance with economic conditions and supporting infrastructure; this is consistent with the research showing that culinary tourism is the most frequent tourist activity for families in urban areas.

Similarly, among the population of individuals with health insurance in March 2021 (**Fig. 1 R1101**), it stands to reason that the area with the highest intensity is DKI Jakarta, which is the capital city in Indonesia. However, the findings are different in several other areas. The low-intensity areas also contain many people with extremely poor economic status. These areas have a purchasing power parity (PPP) of below US\$1.9 per day. According to the 10th SDG goal, the government's role is to reduce inequality. The current inequality in Indonesia is also involved in the problem of inequality in insurance coverage. However, the Indonesian government has social assistance programs for its population, including the Smart Indonesia Program (PIP), the National Health Insurance Program (JKN-KIS), the Family Hope Program (PKH), and the Rastra Social Assistance/Non-Cash Food Assistance. The Indonesia Pintar Program is a program of assistance in the form of funds from the government to elementary, junior high school, and high school/vocational school students and the same level, both formal and formal, for poor households.

The growth of early childhood development and care in Indonesia is increasing yearly. As of the 2020/2021 school year, there are an estimated 187,211 early childhood education schools: kindergartens, playgroups, day-care centers, and early childhood education units. However, most children with access to early childhood education were supported by high-economic-status parents. This is different from low-income parents. Low-income parents tend to send their children directly to primary education. Whereas the importance of early childhood education needs to be a concern for parents, this is based on the faster development of children at an early age and prevents children from falling behind in education when entering primary school. The Sustainable Development Goals Indicator Study report states that children with higher levels of education and care are usually those who were breastfed.

The second indicator is that every learner has equal technical, vocational, and university education opportunities. These three levels of education are secondary education, which is currently challenging to access in Indonesia, although special quotas have been provided for remote areas. This issue concerns the current government's readiness to overcome the demographic bonus from 2020-2035. If not balanced with employment growth, the demographic bonus will undoubtedly lead to high unemployment in Indonesia, where education should solve unemployment. Based on the university statistics issued by the Ministry of Education and Culture, in 2019, only 34.58% of the Indonesian population received higher education; this number is still lower than other ASEAN countries. Of course, this prevalence rate may decrease this year due to the pandemic and its impact on the community's economy. Among the two paths that students can take after graduating from high school, 65% of students decide to go into work; thus, the level of university education still needs to be higher. Although there is an increase in the number of schools, the number of students tends to decrease every year, so there is a contradictory trend

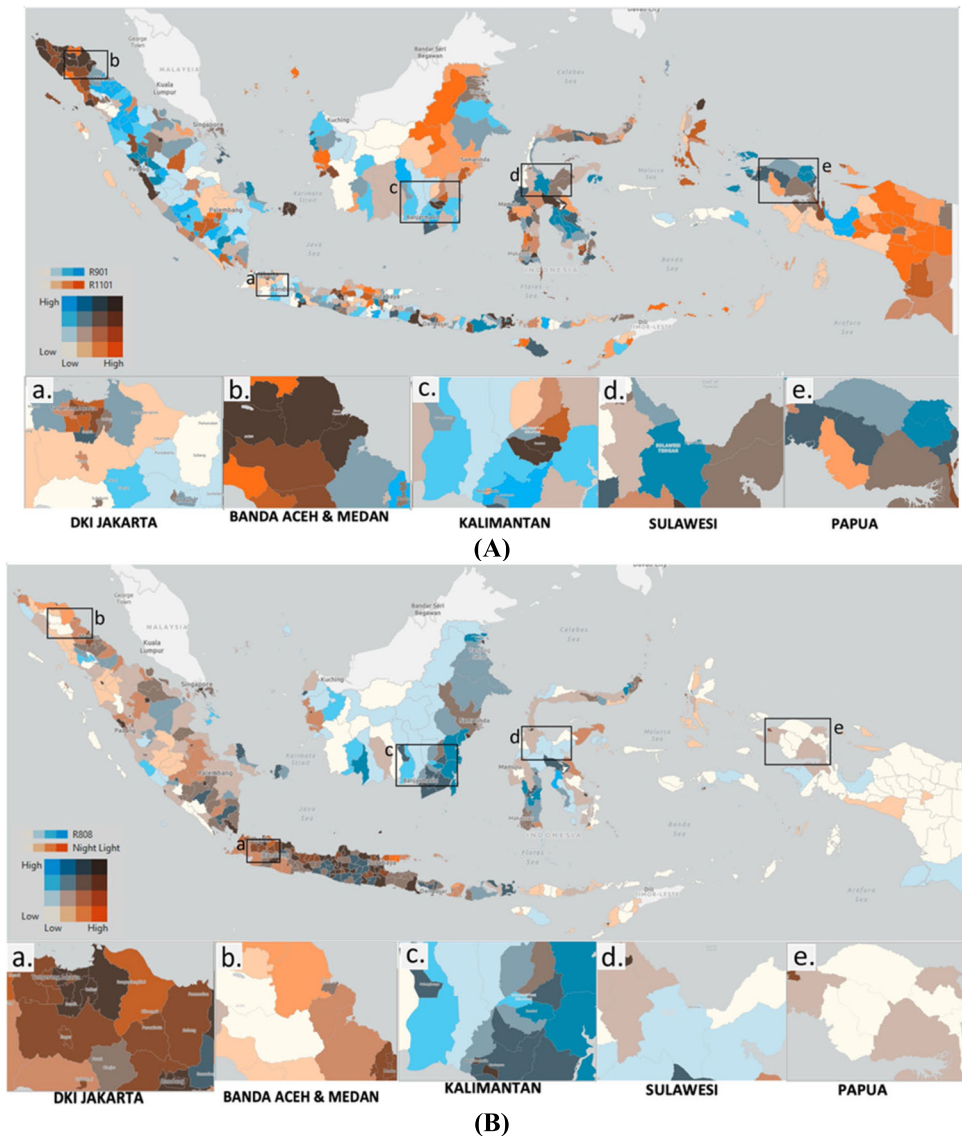


FIGURE 2. Bivariate clustering analysis of R901 and R1101 is represented in (A), while (B) depicts the relationship between R808 and Night Light.

between the number of schools and the number of students. This shows that there is room for improvement regarding the government's policy to provide education for every citizen 9 to 12 years old, as stated in the Minister of Education and Culture Regulation Number 80 of 2013 concerning Universal Secondary Education.

In addition, almost all students at the school level experienced a decline in the 2019/2020 academic year. This is partly due to the pandemic. Facts on the ground also show that there is still a gap between expectations and the implementation of education-related policies. There are two existing problems: problems related to existing activities in education and the resulting output, and problems related to the additional needs of the operation of Indonesia's inadequate education system. The current problems in the learning process that occur in schools are due to the learning system carried out by teachers

that is still one-way or top-down. Schools – or, in this case, teachers – are still fixated on one aspect of learning, namely, the cognitive aspect, without focusing at other aspects. Therefore, it is challenging for students to develop their potential and think innovatively.

B. CHILDREN AND ADOLESCENTS' RIGHT TO RECREATION AND LEISURE

It is worth acknowledging that children and adolescents are also prone to stress. Consequently, children and adolescents deserve the right to engage in recreation and refresh their minds. Stress-free conditions are important to ensure the optimal development of children and adolescents. In this study, only three cities reported that the prevalence rates of vacation and travel for children and adolescents were greater than 40%, while the rates in Belitung Regency were 75.7% for

children and 88.3% for adolescents. The region with the lowest level of travel among children and adolescents is Sorong Papua (Fig. 2A and B). Most districts and cities in Papua also have the lowest participation indices among all areas in Indonesia. Thus, this is an issue of high concern. It was interesting to find that the prevalence of travel among children and adolescents is relatively low in large cities such as Jakarta, Surabaya, and Makassar compared to the provinces of West Java and Central Java, although the national average prevalence rates for children and adolescents are 13.51% and 18.11%, respectively.

Some of this can be linked to the duration of school hours in Indonesia. In Indonesia, school hours usually start at 06:30 and end at 14:00. In fact, some students even stay until late in the afternoon as they have to participate in tutoring or other activities. In contrast, school last for 4-5 hours per day in Finland and 5 hours and 40 minutes in Ireland. In South Korea, the teaching and learning hours are very long; students in South Korea arrive at school at 7:40 am, learning begins at 8:20 am, and school ends at 7:30 pm. In short, South Korean students spend approximately 11 hours at their school. In fact, many alternative activities can be used so that children and adolescents can obtain formal education with a more attractive and exciting program, such as nature school. Nature school is an alternative education inspired by the environment and uses nature as a source of learning. In essence, nature schools also base their curriculum on the general curriculum in formal and private schools. Globally, the curriculum includes the creation of good morals, the acquisition of science and technology, and the creation of a proper understanding of their leadership.

Nature-based learning refers to the perspective that learning activities can help children develop various abilities that are used to interact creatively with the natural environment. Learning activities use the natural environment with variations to meet the developmental needs of early childhood. Nature-based learning will help foster children's auto-stimulation and self-activity, thus enabling the active learning process. The natural environment will provide many real learning experiences and/or fundamental instruction. Nature-based learning will provide an environment for children to develop awareness, concern, or sensitivity to various natural and environmental conditions. Nature-based learning will help children obtain meaningful learning processes and results as well as practical and functional instruction. Through nature-based learning, children can explore, comprehend and directly apply the learning process in various aspects of real life. Thus, children can understand that learning about various matters will have meaning in life both now and in the future.

Nature schools continue to use the existing national curriculum and modify it with a new outlook due to the development of the age. Schools are now not only located in a luxurious and magnificent school building; instead, education professionals are proposing alternative educational models. Nature is the best tutor in educating by experience. Learning

will be more meaningful if children and young people experience what they learn rather than knowing it. All schools have reasonable goals. The curriculum dramatically affects the learning of children and adolescents; even though these schools use the same curriculum, the locations are different, and thus, the outcomes are also different. The curriculum will always experience progress and adjust based on the surrounding geographical location. In addition, various environmental crises and symptoms are the basis for establishing natural schools since humans live in nature that must utilize and preserve nature, and its contents are God's creations. Therefore, the curriculum used includes a typical Nature School curriculum while also incorporating thematic content. Through an adventure in nature, children and adolescents are able to apply the learning process as a whole and stimulate the development of talent, physical, social and intrapersonal.

Nature school has become a long-held reality for those who want a new approach to the educational world. The existence of alternative natural schools is not just a change in systems, methods, and learning targets but an educational paradigm that will improve the quality and results of education itself. Furthermore, the strategic target is that students can be an essential human resource investment that respects and welcomes nature in the future. In Indonesia, nature schools are generally integrated from early childhood to high school. Nature schools prepare their students to have a good education and attitude toward life, both scientific and moral, a passion for the surrounding environment, and even entrepreneurship from an early age. People also respond positively to the existence of nature schools, which aim to increase the number of schools in Indonesia with the concept of nature.

We also explore the floor area at the household level, considering that the more spacious the house is, the more space children and adolescents have for activities and exercise. The data show that the area of the house that categorizes children and adolescents as having emotional disorders is 9-250 m², with a median value of 54 m². This means that having a small house area impacts adolescence behavioral and/or emotional disorders. The area of the house can also be used as an indicator of the level of household welfare and has a high economic capacity. In this model, we use logistic regression. We provide a dataset that can be used by interested readers along with the R code (see Appendix A). The research sample is adolescents aged 10 to 19 years, and the sample size is 198.642 people.

adolescent = subset(SSN_under26, age<20) & (age >9))

The variable list used was as follows:

- emotional_disturbance_existing (1= experienced, 0=not experienced)
- area_urban (1=urban, 0=rural) - male (1=male, 0=female)
- working (1=working, 0=not working)
- using_mobile (1=using, 0=not using)
- class (kmeans-clustering result)

The prevalence of adolescents with emotional disturbances is relatively low, at approximately 0.44%. However, it is

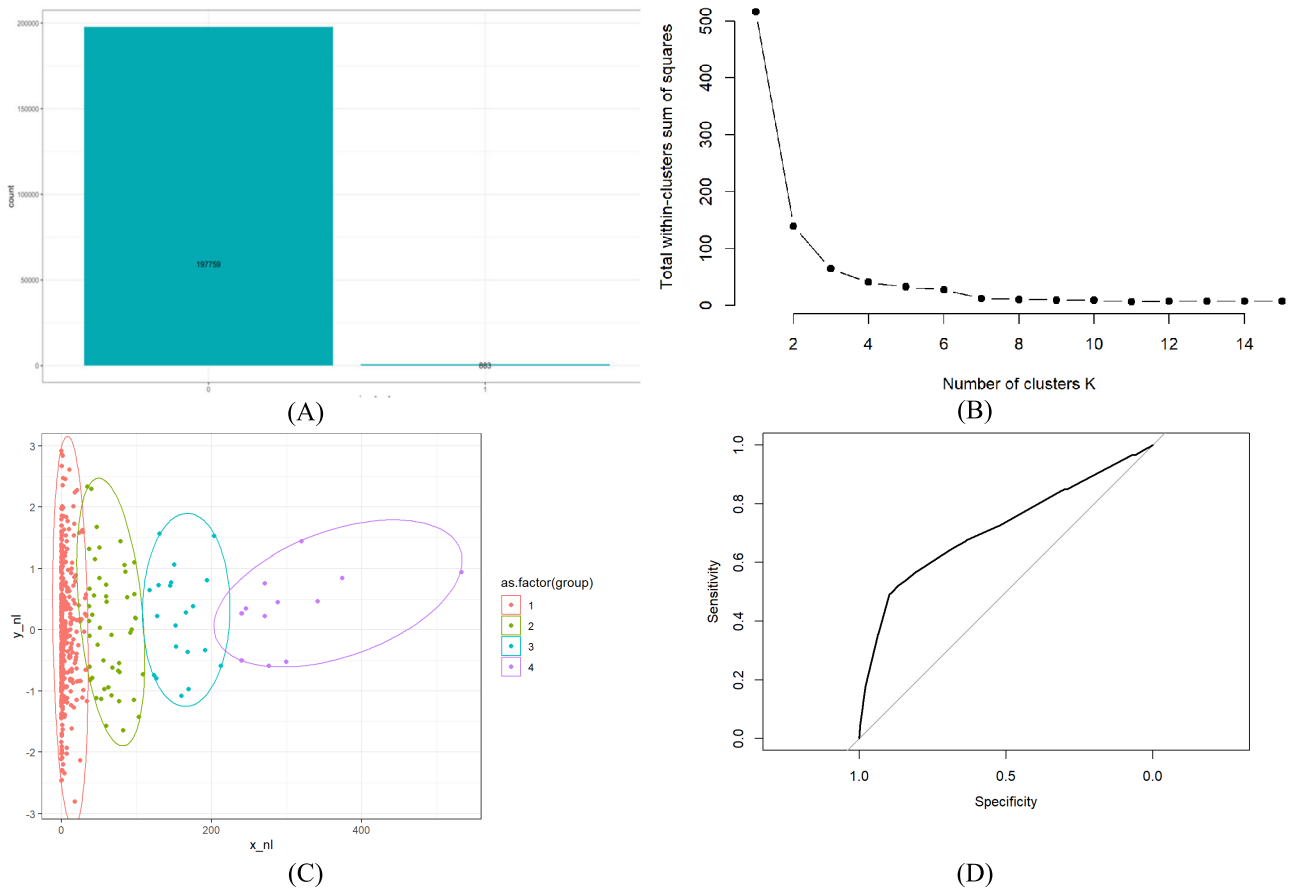


FIGURE 3. The depiction of Adolescents Emotional Proportion is presented in (A), followed by the Scree-plot for determining the optimal cluster in (B), and the Group Factor Cluster illustration in (C). Additionally, the Model ROC is visualized in (D).

possible that cases/conditions of behavioral and emotional disorders are not detected, as this question is based on perception (undercoverage; see Fig. 3A). The data are not balanced, so logistic regression is an appropriate statistical method; in particular, it provides important information about cognitive factors, such as odds ratios [80].

The entire model deployment process was carried out in R using the ‘stat’ library [81], [82]. The clustering of NTL data was achieved through the application of k-means clustering, utilizing the Hartigan and Wong method. The parameters employed in constructing the model were carefully selected, with number of clusters set to 4, maximum iteration limited to 10, and random start configured at 1. The logistic model, based on Cox [64], [65], was constructed using the glm function, where the family parameter was set to binomial. No prior weights or offsets were assigned in this process.

To create clusters, we used k-means, and the best cluster was four (Fig. 3B, C). In line with this, to construct the clusters, we used four factors based on the scree plot. The scree-plot shows the total variance explained (Fig. 3B). The eigenvalues continue to decrease, and the first factor up to the fourth factor has the best eigenvalue. From the four clusters generated from the nightlight variable as a proxy for

the level of urbanization and welfare of a region, it can be noticed that most districts are included in cluster 1; cluster 1 describes “normal” urbanization conditions in Indonesia. The nightlight intensity increased for clusters 2 and 3 and was highest in cluster 4 (Fig. 2C). All members of cluster 4 are cities (area code begins with digit 7, more detail in Appendix A), which includes four cities in DKI Jakarta and other most considerable cities in Indonesia.

The percentage of adolescents (15-24 years old) not attending school, working, or training, which can be said to be Youth not in employment, education, or training (NEET), is most spaced out in North Sulawesi Province, amounting to 29.94 percent. The value is relatively high since almost one-third of adolescents in North Sulawesi Province do not perform any self-development activities. At a young age, it is a productive age for self-development. In addition, Indonesia is currently experiencing a demographic boom. In line with this, all stakeholders need to be engaged to seize this moment. The statistical outcomes shed light on how well our model is performing. The Null Deviance, at 11327 on 198641 degrees of freedom, gives us a sense of how much of the data’s variability is explained without considering any predictors. On the other hand, the Residual Deviance, hitting

TABLE 3. Logistic regression and odds ratio.

Variables	Estimate	Z value	p value	Odds Ratio
Intercept	-4,053	-	2.e-16***	0,017
Region (1)	0,313	61,761	0,00014***	1,368
Gender (1)	0,168	2,458	0,0139*	1,183
Employed (1)	-0,478	-3,062	0,0022**	0,620
Cellular (1)	-2,182	-	2.e-16***	0,113
Clustering (2)	0,114	30,769	0,372	1,120
Clustering (3)	0,161	0,900	0,368	1,174
Clustering (4)	0,579	3,375	0,00074***	1,785

Note: *** $p < 0,001$; ** $p < 0,01$; * $p < 0,05$

10448 on 198634 degrees of freedom, tells us how much variability remains unaccounted for after factoring in our predictor variables. The lower the Residual Deviance, the better the model fits the data. The Akaike Information Criterion (AIC) at 10464 serves as a handy summary, considering both the model's fit and complexity. A lower AIC, in this case, suggests a good balance. The model fine-tuned itself through 9 iterations of the Fisher Scoring algorithm, emphasizing a meticulous adjustment of parameters. Overall, these findings give us confidence that our model not only fits the data well but does so efficiently by considering the intricacies of the dataset.

The odds ratios presented in **Table 3** provide valuable insights into the association between residential location and the likelihood of experiencing behavioral or emotional disorders among adolescents. The finding suggests that adolescents living in urban areas face a 1.7 times higher probability of encountering such disorders compared to their counterparts in rural areas. This observation prompts further considerations regarding the potential factors contributing to this urban-rural discrepancy.

Urban environments often bring unique challenges, including increased stressors, peer pressures, and access to various stimuli, which may influence the prevalence of behavioral and emotional issues among adolescents. Additionally, factors such as the availability of mental health services, educational resources, and community support systems may differ between urban and rural settings, contributing to variations in disorder prevalence. Our research is consistent with previous research, which indicates that the prevalence rates of anxiety and depression among young people in urban areas are increasing, along with green open spaces in these urban areas [83]. In addition, living in an urban slum also causes adolescents to experience depression and emotional suffering, even to the point of dying by suicide. [84], [85].

Another interesting finding in this study is that adolescents in urban areas in Indonesia are more likely to experience behavioral and/or emotional disorders (see **Appendix A**).

Subsequently, the analysis revealed that male adolescents exhibited a 1.18 times higher likelihood of experiencing behavioral and/or emotional disturbances compared to their female counterparts. This observation suggests a gender-related aspect in the prevalence of such disturbances among adolescents. Understanding these gender-based differences is crucial for tailoring targeted interventions and support systems to address the specific needs and challenges faced by male adolescents in the context of behavioral and emotional well-being. Further research may explore the underlying factors contributing to this gender disparity, enabling the development of more nuanced and effective strategies for promoting mental health in adolescent populations. This is similar to previous research, which explains that boys with sufficient knowledge of coping with emotional disturbances have a lower likelihood of dying by suicide [86]. Despite these findings, other studies have shown that adolescent boys have better coping strategies with respect to identifying mental health and did not experience significant depression when facing social restrictions during the COVID-19 pandemic [87]. Our study also found that unemployed adolescents were 1.61 times more likely to experience behavioral and/or emotional disturbances than employed adolescents. This is expected, as the family's economic condition is related to the burden adolescents bear to provide for their financial needs. However, in Indonesia, adolescents who do not work tend to be more stressed because they are considered a family liability. On the other hand, our results are in contrast to a previous study that stated that twenty percent of adolescents in Turkey who worked had a higher prevalence of abnormal emotional and behavioral problems than those who did not work [88].

The first cluster result describes the distribution for individuals aged from 10-18 years old, and we discovered that clusters A and B describe the cluster with majority classes. Biclusters C, E, and I are included in the area with low health care subscriptions. Bicluster D describes low internet literacy but high health care subscription. Cluster F represents remote areas with high health care subscription information. Bicluster G defines significant cities with high night light intensity but lower health care subscriptions. Bicluster H corresponds to high mobility and low health care subscription, which is most prevalent in mining areas in Papua. Biclusters J and K describe areas with high internet literacy and health care subscription. Interestingly, bicluster J includes northern and central Jakarta, Indonesia's central business area.

We highlight that adolescents who are working are those who have poor socioeconomic conditions, and it is also commonly believed that being employed is one of the contributing factors to mental health disorders [89]. Again, this phenomenon can be further examined by comparing it with the case of the adult population. Additional findings have indicated that working adolescents are either expected to behave as "adults" or are deliberately considered "adults" by others.

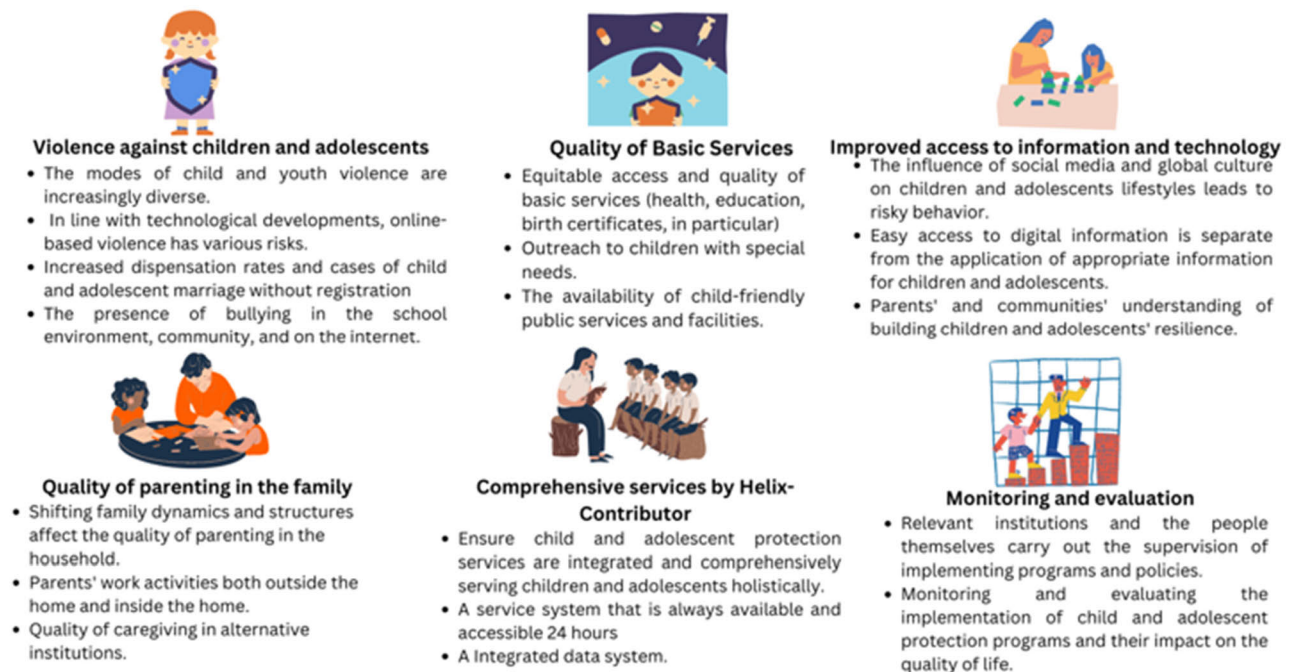


FIGURE 4. Challenges for the development of child and adolescent protection in the future.

Our results on vulnerability clustering for the 19- to 25-year-old category show clear evidence. Biclusters *A* and *B* define the majority of biclusters spread over 249 homogeneous districts/cities throughout Indonesia. Bicluster *C* indicates areas with low health care subscriptions, 14 districts/cities. This means that some districts/cities that fall into this area may also have low financial inclusion and insufficient knowledge of the importance of insurance. Bicluster *D* represents low mobility but a high health care subscription majority in Papua. Our findings are in line with previous research that classified mostly districts/cities in Papua due to the lack of out-migration as well as the very limited access to outside labor [90], [91].

It was also interesting to find that bicluster *E* was able to explain the current condition in Jakarta Greater Area, Medan, and Bandung, major cities with very high nightlight intensity. We also found that the NTL intensity in Indonesia is heterogeneous, and there is a tendency for outliers at the upper and lower boundaries, especially when looking at the distribution of NTL in western, central, and eastern Indonesia. Biclusters *F* and *H* explain the 5 districts/municipalities with high health care subscriptions that are homogeneous in DKI Jakarta. Another finding is that bicluster *G* is an area with a low internet literacy category, and this is specific only to Papua; this is also in line with previous research that Papua is very vulnerable to several other vulnerability indices [71], [92], [93], [94], [95], [96], [97] and needs special attention and quick action for equalization of all of the SDG points.

Adolescents who did not use mobile phones were 9.09 times more likely to experience conduct disorders and/or

emotional disturbances than those who used mobile phones. Nevertheless, it cannot simply be said that cell phones can prevent the potential for distress [98], [99]. Most likely, adolescents with behavioral and/or emotional disturbances are intentionally denied access to cell phones [100], [101]. Based on the outcome of the clustering, phone use was utilized as an independent variable in the modeling as a proxy for welfare and a region's urbanization level.

The modeling results suggest that adolescents living in cities included in cluster 4 are 1.78 times more likely to experience behavioral and/or emotional disorders than those living in other areas. Our first findings support that many adolescents experience behavioral and emotional disturbances in urban areas. People in urban areas are more heterogeneous than those in rural areas. Some people in urban areas feel more stressed because of feeling compared and living up to certain social standards, religious standards, and standards of living to be perceived by their environment.

C. ADOLESCENTS AND THE PERCEPTION OF MARRYING YOUNG

The focus of this study is areas that are labeled vulnerable clusters (See: Appendix A), which include individuals aged 5-19 years old, and aged from 19-25 years old, particularly in areas of extreme poverty, where adolescents are perceived to be marrying young. This impetus is in line with previous research showing that socioeconomics influences adolescents to marry early [102]. There is a tendency for adolescents who have low motivation for education to have the intention to get married younger.

A recent new item published in Indonesia on January 14, 2023, stated that the Ponorogo Religious Court (PA) received a report of 191 requests for children to marry in 2022. Most of the reasons include an adolescent becoming pregnant and giving birth. As reported by detikJatim [103], of the 191 incoming marriage dispensation applications, the most common age range for submitting applications was 15 to 19 years, with as many as 184 cases. The 7 remaining applicants were under the age of 15. Concerning the level of education, children with a junior high school education were the most likely to apply for a marriage license (106 applicants). Additionally, 54 applicants reported that elementary school was their highest level of education, 25 applicants reported that high school was their highest level of education, and 6 applicants reported not attending school. In this research, we also discovered that the Ponorogo region, East Java, is part of a vulnerable cluster.

Some traditions and norms apply in rural areas in Indonesia, where many parents marry off their children to avoid *Zinā'*, especially when someone has proposed to the child/adolescent [104]. However, *Zinā'* or *zinā* is an Islamic legal term referring to unauthorized sexual intercourse. Depending on traditional jurisprudence, *Zina* can include adultery, fornication, prostitution, rape, sodomy, incest, and bestiality [104]. The negative impacts of marrying young include a greater risk of infant mortality, a greater risk of premature birth and malnourishment, and a higher risk of growth retardation or stunting [104], [105], [106]. Additionally, early marriage will also impact the community, including poverty levels and the psychology of underprepared parents.

V. CONCLUSION

The cultural shift to become data-driven has been induced by uncertainty. There are so many phenomena that can hardly be foreseen. Therefore, every business actor must be more resilient, flexible, and open to all opportunities that exist. A data-driven ecosystem will make it easier for businesses to implement customer-centered product development, including in the education sector. The support and learning system is still often generalized and decontextualized, even though students need a more personalized learning experience. Furthermore, data science will add to the teacher's pedagogical expertise in recognizing meaningful insights, identifying student subgroups, and designing and applying appropriate techniques within the facilities of a customizable technology platform. However, the application of data science could be broader. Several studies have focused the data-driven society in an entirely new direction, which is autonomous learning, i.e., a state of teacher-free classrooms. Not only does this encourage more personalization, but it also encourages creativity and innovation among students by giving them independence and flexibility in regard to learning approaches. In addition, autonomous education can include virtual teaching assistants that can track and organize learning patterns and schedules for students.

The complexity of problems and changes in the global world requires the education system to be able to answer all the challenges of today's world. The government has made many efforts to improve the quality of education in Indonesia. Such efforts can include improving the curriculum and the learning approaches among teachers and students in schools, because the method of learning activities in schools has a strong influence on learning outcomes. Child and adolescent protection are necessary for creating an environment where every child and adolescent can enjoy proper physical, mental, and social development. The protection of children and adolescents is a manifestation of justice in a society. Thus, child and adolescent protection is sought in various state and social life fields.

Child and adolescent protection activities have legal consequences in both written and unwritten legal matters. The law is a guarantee for child and adolescent protection activities. With the concept of the protection of children and adolescents as a holistic, all-inclusive, and comprehensive vision, the law places the obligation to protect children and adolescents on the principles of nondiscrimination, principles of the best interests of children and adolescents, principles of the right to life, continuity, and progression, and principles of appreciation for the views of children and adolescents. Children and adolescents are considered goals in carrying out sustainable development. Development in education is based on the state philosophy of Pancasila. It is directed at shaping the development of people who are Pancasila and to develop Indonesian individuals who are physically and spiritually healthy, possess knowledge and skills, can develop creativity and responsibility, can nourish democratic and tolerant attitudes, may develop high intelligence, show noble character, and love their country and love their fellow human beings in accordance with the provisions contained in the 1945 Constitution.

To achieve the development of education and science, more facilities are to be provided with the right priorities and in accordance with the ability to finance them, both from the state and from the community itself, and to have the chance to utilize their time productively and prepare themselves for greater responsibilities in the future, as well as to increase their contribution to the national development process (See Fig.4). To this end, improving facilities for skills training, leadership training, recreation, sports, and community service opportunities are being pursued.

In Indonesia, there is still no proper regulation regarding a blueprint to enhance awareness of emotional and behavioral disorders among children and adolescents. There are still many aspects that need to be redeveloped to create a comprehensive and effective framework for addressing these issues. A holistic approach is needed, encompassing education, community support, counseling, and perhaps the integration of mental health-focused curricula within the educational environment. Therefore, clear and comprehensive regulations or guidelines can serve as a foundation to guide these efforts.

The significance of well-crafted regulations lies in their ability to provide clear guidance to involved parties, including the government, educational institutions, and families. Furthermore, community support and involvement of other stakeholders are crucial for these efforts to effectively raise awareness of emotional and behavioral disorders among children and adolescents. In developing new regulations or guidelines, involving mental health experts, educators, and community advocates would provide valuable perspectives. Engaging various stakeholders is expected to create a comprehensive framework capable of addressing the challenges faced in increasing awareness of the mental health of children and adolescents in Indonesia.

COMPETING INTERESTS

The authors declare no competing interests.

DATA AVAILABILITY

The source code and the material and findings data of this study are openly available in full access by the corresponding author

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

AUTHOR CONTRIBUTION

Rezzy Eko Caraka: conceived the research and constructed the experimental design; Rezzy Eko Caraka, Toni Toharudin, Yunho Kim, Rung-Ching Chen, Anjar Dimara Sakti, and Bens Pardamean: managed the project; Rezzy Eko Caraka and Puspita Anggraini Kaban: analyzed the data; Rezzy Eko Caraka: participated in the verification and interpretation of data; Rezzy Eko Caraka, Puspita Anggraini Kaban, Khairunnisa Supardi, and Robert Kurniawan: drew the study design, carried out data management, and constructed a database; Rezzy Eko Caraka: finalized the instrument; Rezzy Eko Caraka, Yunho Kim, Puspita Anggraini Kaban, Khairunnisa Supardi, Robert Kurniawan, and Syihabuddin Ahmad Mufti: wrote the final manuscript; and Toni Toharudin, Rezzy Eko Caraka, Yunho Kim, Puspita Anggraini Kaban, Khairunnisa Supardi, Robert Kurniawan, Rung-Ching Chen, Syihabuddin Ahmad Mufti, Anjar Dimara Sakti, Prana Ugiana Gio, Maengseok Noh, and Bens Pardamean: read and approved the final manuscript.

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