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GENERALIZED GAMMA REGRESSION FOR ANALYZING ALCOHOL CONSUMPTION SURVIVABILITY

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ABSTRACT

Alcohol consumption remains a public health problem, affecting various organ systems. Its impact can be detrimental to adolescents, leading to disturbed social and economic development. Gender differences exist, with male adolescents being more affected. This research aims to understand alcohol consumption among male adolescents in Indonesia. This study used pseudo longitudinal data from the 2017 Indonesian Demographic Health Survey (IDHS) and employed a survival analysis method using the generalized gamma approach. A total of 12,373 (weighted) adolescents were analyzed, with 4,573 of them classified as events. A time ratio (TR) was reported. Smoking was identified as the most substantial variable, shortening the survivability of alcohol consumption by 19%. Additionally, living in rural areas, having tried drugs, and having had sex were identified as risk factors, while education level and mobile phone ownership were protective factors. Risk behaviors shorten alcohol consumption survival among adolescents. Cross-sectoral interventions and comprehensive counseling are essential for effective prevention.

Kata Kunci:
Analisis kesintasan,
Konsumsi alkohol,
Regresi Generalized Gamma,
Remaja,
Survei Demografi Kesehatan Indonesia

ABSTRAK

Konsumsi alcohol masih menjadi masalah dalam kesehatan masyarakat karena mempengaruhi keberlangsungan sistem organ tubuh. Permasalahan tersebut memiliki dampak yang besar bagi remaja dan dapat berakibat pada gangguan pertumbuhan ekonomi dan sosial. Ada perbedaan pola konsumsi alkohol antara jenis kelamin dan remaja laki-laki lebih terdampak akibat konsumsi tersebut. Penelitian ini mencoba memahami konsumsi alkohol pada remaja laki-laki di Indonesia. Penelitian ini merupakan penelitian sekunder dari data Survei Demografi dan Kesehatan Indonesia (SDKI) 2017 menggunakan analisis kesintasan dengan pendekatan generalized gamma. Sejumlah 12.373 remaja (angka tertimbang) dianalisis dan 4.573 diantaranya merupakan kejadian yang diamati, yaitu konsumsi alkohol. Penelitian ini menggunakan Time Rasio (TR). Merokok teridentifikasi sebagai variabel yang paling substansial dan memperpendek kesintasan sebesar 19%. Selain itu, tinggal di daerah rural, pernah mencoba narkoba, dan pernah melakukan hubungan seksual teridentifikasi sebagai faktor risiko, sementara tingkat pendidikan dan kepemilikan ponsel merupakan faktor protektif. Perilaku berisiko tersebut memperpendek kesintasan remaja. Perlu adanya intervensi lintas sektor dan konseling yang komprehensif sebagai langkah pencegahan.

INTRODUCTION

Alcohol consumption continues to be a concerning public health problem. The prevalence of alcohol consumption was estimated to be 1.34 billion (95% CI: 1.06–1.62 billion) in 2020, an increase from 983 million (95% CI: 718–1190) in 1990 (1). This alarming increase could create negative health consequences. Its impact on health includes various impacts on different organ systems, ranging from destructive impacts on brain cells, increasing risk of secondary cardiomyopathy, liver cirrhosis, to heightened risk of atrial fibrillation (2). The excessive use of alcohol is also identified as a mental health problem, named Alcohol Use Disorders (AUD) and tends to be concurrent with other mental illnesses such as bipolar (3). Furthermore, alcohol problems also cause an economic turmoil where

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alcohol consumption leads to economic loss. A study reported that due to alcohol dependency, a significant percentage of America populations reported a severe savings loss (4).

On the other hand, the impact could also be detrimental to adolescents' subpopulation. This is due to the deteriorating effect of alcohol on adolescents' development (5). Additionally, adolescents who consume alcohol are more likely to develop AUD later once they are practicing binge drinking (6). The consequences would be more severe in adolescents with low socioeconomic status (7), leading to poor social and economic developments. However, despite the negative consequences, the prevalence of alcohol consumption among adolescents remains notably high. A study reported that among school-goers adolescents, the prevalence of alcohol consumption was 25.2% (8). Male adolescents showed higher prevalence than female adolescents. This also showed a possible gender difference in alcohol consumption. Previous study also added that being male adolescents was a risk factor of alcohol consumption, including hazardous drinking (9). Similarly in Indonesia, the prevalence of alcohol consumption among male adolescents was higher than female adolescents (10). Previous study highlighted the role of educational level and occupation as factors that may be associated with alcohol consumption. Previous study also highlighted other risky behavior such as smoking that can predict future alcohol consumption (11).

However, previous studies missed some important information regarding the initiation of alcohol consumption. This was attributed to the limitations of the cross-sectional study design employed in previous studies. Therefore, to understand more about the initiation of alcohol consumption, we aim to understand the associated factors of alcohol consumption using a pseudo longitudinal data to address the research gap using Indonesia Demographic Health Survey 2017 (IDHS) as the latest representative data to capture adolescents' health behavior. Pseudo longitudinal method was chosen as it is less exhaustive than longitudinal study, but able to provide temporality estimation that is comparable to the longitudinal method. The estimation is considered important in risk behavior study, including alcohol consumption (12).

METHODS

Population and Sample

This survival study utilized a secondary dataset (IDHS 2017), focused on male adolescents aged 15–24 years old. Two criteria were used for exclusion: 1) adolescents who could not recall their age at first alcohol consumption, and 2) adolescents with missing data for any variable. A total of 12,373 was included in the analysis.

Dataset and Patients Involvements

This study employed a secondary dataset, namely Indonesian Demographic Health Survey 2017 (IDHS 2017). No patients were involved in this study. As a secondary dataset research, an ethical clearance was waived. However, the IDHS 2017 received an ethical approval from the IRB-7 (Institutional Reviewer Board-7) during its data collection process.

Dependent Variables

The dependent variable for this study was the event of alcohol consumption, marked by the age when the adolescents started to consume alcohol. This was inferred from a question asking, "How old were you when you had your first drink of alcohol?" Adolescents who ever consumed alcohol were categorized as an event.

Independent Variables

Independent variables were extracted from various studies that took place in countries with similar socioeconomic backgrounds in Indonesia and also similar datasets analyzed in each study (10,13,14). Such variables included other behavior, external influences, and also socio-demographic factors, as well as accessibility of alcohol, measured by a proxy of money earnings. Table 1 fully describes the independent variables in this study.

Data Analysis

This study employed a survival analysis using pseudo longitudinal data from IDHS 2017 where we observed and analyzed cohort individuals until a well-defined event occurred. In this study, the event was alcohol consumption. The transition of never consumed

alcohol to consume alcohol is defined in a period of t where t was inferred from the age of alcohol consumption started, successfully transforming cross-sectional IDHS 2017 dataset into pseudo longitudinal data and, therefore, enabling us to analyze time-to-event dataset.

Table 1. Independent variables

Variables	Question	Answer	Recode
Place of Residence	*Self-explanatory*	1. Rural 2. Urban	
Education	What is the highest level of school you attended?	1. Primary school 2. Junior high school 3. Senior high school 4. Academy/DI/DII/DIII 5. Diploma/University	1. Below high school (answers 1–2) 2. High school (answers 3) 3. Above high school (answers 4–5)
Earnings	Are you paid in cash or kind for the work or are you not paid at all?	1. Cash only 2. Cash and kind 3. In kind only 4. Not paid	1. Cash (answers 1–2) 2. In kind (answers 3) 3. Unpaid/no jobs (answers 4/no responses)
Ever tried smoking	Have you tried to smoke cigarettes?	1. Yes 2. No	-
Ever tried drugs	Have you yourself ever tried to use drugs (or similar names in local terms)?	1. Yes 2. No	
Ever had sex	Have you ever had sexual intercourse?	1. Yes 2. No 3. Don't know	1. Yes 2. No (adolescents who responded with don't know were excluded)
Own a mobile phone	Do you own a mobile telephone?	1. Yes 2. No	-

There are various approaches to analyze a time-to-event dataset, from semi-parametric model to parametric model. The semi-parametric model is one of the most notable methods in survival analysis, namely Cox Proportional Hazard where its baseline takes no distribution. However, previous study showed that Cox Proportional Hazard models showed poor performance compared parametric models in analyzing time-to-event, given that its AIC (Akaike Information Criterion) and BIC (Bayesian Information Criterion) were the highest among all models (15). Therefore, we utilized AFT (Accelerated Failure Time) parametric models. There are several parametric models available, all of which assume different distributions of random errors. The expression of survival analysis in AFT can be expressed by the following equation [1].

$$log\ t_j = x_j\beta\ + z_j \qquad [1]$$

The notation of x_j defined covariates, t is the survival time, and z_j is the error distributed by the density of $f(.)$. Setting the density is considerably important. There are various parametric models when the density of $f(.)$ is modified. Illustrating this matter, for instance, setting $f(.)$ to be normal, then the model would be a lognormal regression model. If $f(.)$ is set to be logistic density, then the model of log logistic regression model would be available. Therefore, addressing which

parametrics model is important. Previous studies have noted that a parametric model named generalized gamma is an extremely flexible, rich, and robust model (16). The model is often used to evaluate survival models and gives a wide perspective of explanatory study. Therefore, researchers employed the generalized gamma model to discuss the survival analysis of alcohol consumption in this study.

Univariate analysis is discussed first to address the prevalence of alcohol consumption over independent variables. Bivariate analysis is conducted to address variable selection. Insignificant variables are not modeled into adjusted models. The significance level was set at 0.05. A time ratio (TR) was reported instead of hazard ratio (HR) as this study employed the generalized gamma parametric model in this study. Additionally, we also utilized weights, stratum, and cluster according to the IDHS 2017 dataset to accommodate complex sample design in the survey. Data analysis was performed using Stata 17.0 version.

RESULTS

Survival Graph

The total of alcohol consumption was 4,573 (event, weighted numbers) and 7,800 adolescents (weighted numbers) who never tried alcohol were censored in this study. The first exit point (the point where the event occurred) was five years, meaning that there were adolescents who consumed alcohol as early as five years old. At that point of time, the survival function was at 99%. The survival graph of survival functions in a period of t can be seen in Figure 1.

Overall, the plot initially appeared to be flat and then gradually declined over time. The decline began somewhere between 5 and 10 years, becoming more noticeable after 10 years, reflecting the median exit point (17 years old). The survival function was around 69.67% in the median exit point. The graph then continued to decline until the final exit point, which was 24 years old. In the final point, six adolescents consumed alcohol and the survival function declined to 46.94%.

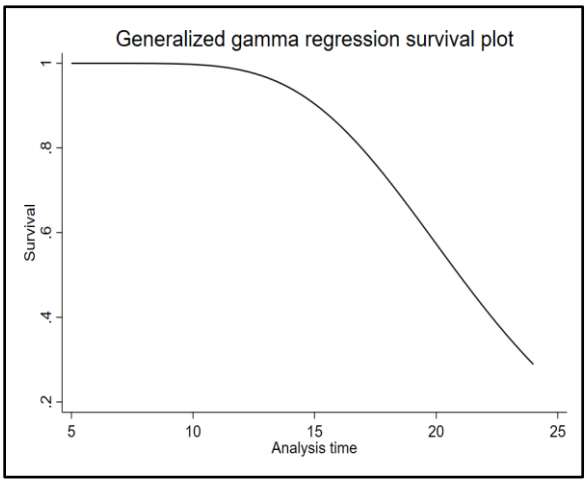

Figure 1. Survival plot

Distribution of Alcohol Consumption

The average age of first alcohol consumption was 16.14 (95% CI: 16.05–16.24). The prevalence of alcohol consumption was described using row percent in all variables. Notable prevalence of alcohol consumption was seen among various variables. Nearly 93% of adolescents who had tried drugs also consumed alcohol. In addition, 89% of adolescents who ever had sex also consumed alcohol. Table 2 describes the prevalence of alcohol consumption in a detailed manner.

Table 2. Prevalence of Alcohol Consumption

Variables	Alcohol Prevalence (%)	95% Confidence Interval
Place of Residence		
Rural	38.55%	[36.46–40.69]
Urban	35.63%	[33.93–37.36]
Education		
Below High School	41.04%	[38.55–43.58]
High School	34.81%	[33.24–36.42]
Above High School	38.07%	[35.11–41.04]
Earnings		
Paid by money	48.28	[46.45–50.12]
Paid by *in-kind*	50.96	[29.74–71.84]
Unpaid/No jobs	25.89	[24.34–27.49]

Variables	Alcohol Prevalence (%)	95% Confidence Interval
Ever tried smoking		
Yes	44.82	[43.29–46.35]
No	9.87	[8.56–11.6]
Ever tried drugs		
Yes	92.95	[90.07–95.04]
No	34.12	[32.81–35.45]
Ever had sex		
Yes	89.04	[86.75–90.97]
No	32.63	[31.31–33.97]
Own a mobile phone		
Yes	37.30	[35.92–38.70]
No	35.12	[31.80–38.58]

Table 3. Adjusted and Unadjusted Time Ratio

Variables	Unadjusted Time Ratio	Adjusted Time Ratio
Place of Residence		
Urban	Ref	Ref
Rural	0.97 [0.95–0.98]***	0.98 [0.96–1.00]*
Education		
Below High School	Ref	Ref
High School	1.04 [1.02–1.05]***	1.00 [0.98–1.02]
Above High School	1.11 [1.08–1.15]***	1.07 [1.04–1.10]***
Earnings		
Paid by *in-kind*	Ref	-
Unpaid/No jobs	1.11 [0.96–1.29]	-
Paid by money	1.07 [0.93–1.25]	-
Ever tried smoking		
No	Ref	Ref
Yes	0.78 [0.76–0.80]***	0.81 [0.79–0.83]***
Ever tried drugs		
No	Ref	Ref
Yes	0.75 [0.74–0.77]***	0.82 [0.80–0.84]***
Ever had sex		
No	Ref	Ref
Yes	0.79 [0.77–0.80]***	0.84 [0.82–0.85]***
Own a mobile phone		
No	Ref	Ref
Yes	1.05 [1.03–1.08]***	1.04 [1.02–1.07]***

*significant for $p < 0.05$; ** significant for $p < 0.01$; *** significant for $p < 0.001$

Unadjusted and Adjusted Association of Alcohol Consumption

Looking at the unadjusted model, we found that all variables were statistically significant, except for the variable earnings (*p-value*: 0.165 for unpaid/no jobs and *p-value*: 0.344 for paid by cash category). Therefore, the adjusted model excluded the variable earning.

The time ratio varied for each variable in the adjusted model; however, we successfully identified several risk factors and protective factors. Adolescents who lived in rural areas, ever tried smoking, ever tried drugs, and ever had sex were at risk to consume alcohol earlier. The survival time of rural adolescents to consume alcohol is 2% lower than the survival times of adolescents in urban areas for an increase of one year. This suggested that adolescents in rural area were expected to consume alcohol by 2% sooner than urban adolescents.

Similarly, adolescents who had tried smoking and drugs were expected to consume alcohol by 19% sooner and 18% sooner,

respectively, than adolescents who never tried those behaviors. In addition, adolescents who ever had sex were expected to consume alcohol 16% earlier than adolescents who never had sex before. Ever tried smoking was identified as the most substantial variable in the adjusted model, given that it modified the survival time with the largest percentage, compared to other variables.

Regarding protective factors, both education and mobile phone ownership prolonged the time to consume alcohol. Adolescents whose education levels were above high school had 7% longer survival times than the survival times of adolescents in below high school. The effect of '*high school*' education category was significant independently, but became insignificant when adjusted by other variables in the adjusted model. Additionally, adolescents who owned a mobile phone had 4% longer survival times to consume alcohol than adolescents who did not.

Smoking as the Most Substantial Variable

This study identified that "ever tried smoking" was the most substantial variable. The generalized gamma survival plot then was employed according to the category of "ever tried smoking."

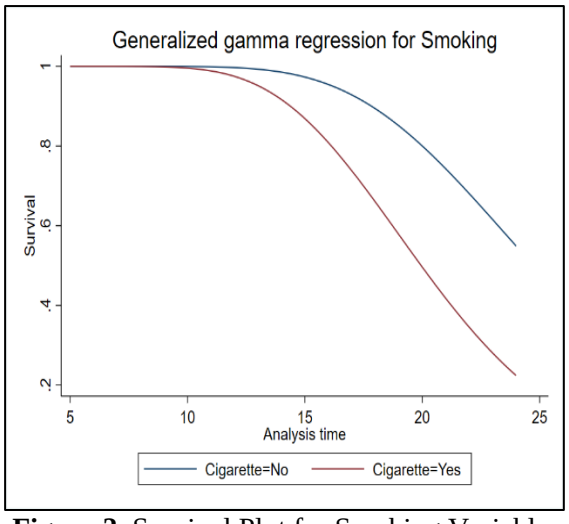

Figure 2. Survival Plot for Smoking Variable

Initially at birth (where age equals to 0), the survival functions for both categories were 100%. Both survival functions had declined insignificantly to 99.99% at the age of 5. Significant changes in survival functions were observed at age 14, where the survival rates for adolescents who never tried smoking and those who had tried smoking differed significantly, at 97.06% and 90%, respectively.

The survival function for adolescents who had tried smoking then had declined to 64.36%, compared to 91.01% for adolescents who had never tried smoking at the age of 17 (the median age of the exit point). Later, the survival function for adolescents who had tried smoking was 39.58%, compared to 82.29% for adolescents who had never tried smoking at the final exit point (age 24).

DISCUSSION

This study successfully identified several risk factors, protective factors, as well as the most substantial variables. The strength of our study included its dataset where we used a nationally representative survey across the Indonesian archipelago, making the generalizability to be high. Additionally, we also employed a new survival approach called a generalized gamma survival model. To our knowledge, this research is among the first to do so, offering a new perspective of survival model interpretations in public health schemes in Indonesia.

This study found that risk behaviors such as ever tried smoking, ever tried drugs, and ever tried sex shorten survivability of adolescents to consume alcohol. Moreover, it is proven that adolescents who had tried smoking, drugs, and sex were expected to consume alcohol 19%, 18%, and 16% sooner, respectively. This finding was similar to previous studies (17). Multiple studies reported that concurrent risk behaviors in adolescents were commonly found across various countries. One study noted that the occurrence of one risky behavior would potentially lead to another risky behavior, marking one as a stepping stone (18). A study stated that risk perceptions of risky behavior was low among adolescents with high impulsivity (19). On the other hand, cognitive function is associated closely with impulsivity (19), that is, impulsive people possess poor cognitive understanding and tend to do risky behavior (20). However in adolescents, it is known that the prefrontal cortex has not yet fully "matured" and "developed" (21). Thus, this led adolescents to perform risk behavior earlier, based on impulsivity rather than rational judgment. Additionally, another study noted that substance use affected cognitive functions, including alcohol. Alcohol was found to disrupt cognitive flexibility (22). Since the brain is not

yet fully developed in adolescents, initial substance use also tends to disrupt brain development (23), causing adolescents to be more prone to more premature behaviors or impulsive behaviors.

Moreover, place of residence was also associated with alcohol consumption, that adolescents in rural areas were likely to consume alcohol 2% sooner than adolescents in urban areas. Results for rural-urban disparity of alcohol consumption have been inconsistent.

One study stated that living in urban areas increased the likelihood to consume alcohol (24). However, another study stated that living in rural areas was a risk factor (25). Similarly, this study found that living in rural areas was a risk factor due to the nature of rural areas, that is low economic activities and poor economic development with more poverty (26). This risk is also heightened by current social development in rural areas in Indonesia with lower participation rate in school and bootleg alcohol (unrecorded alcohol) were easier to access and cheaper in rural areas (27). Lower school participation reduces the protective influence of education, which typically provides structure, awareness, and healthier decision-making skills (28). At the same time, the presence of bootleg increases exposure opportunities. Together, these conditions contribute to early alcohol initiation among rural adolescents.

On the other hand, we found that mobile phone ownership prolonged the survivability to consume alcohol by 4%. The findings of mobile phone ownership were inconsistent. One finding from a study stated that mobile phones increased the odds of consuming alcohol (29). However, the finding in our study was similar to previous study that stated that mobile phone could be utilized to interact on social media and decrease real-life interactions, thus leading to less alcohol intake (30). However, the study noted that this phone use needed to be validated further as it depended on the nature of social interaction through the phone. If adolescents use their phone to avoid real-life interactions for playing games or watching video, they can avoid real-life interactions that may incite alcohol use. However, if adolescents use their phone to make appointment for social drinking with friends, then mobile phone ownership can be a risk factor (30,31).

Education level was also associated with prolonged survivability of alcohol consumption, although only for above high school level. This finding was similar to the previous study. The association between education level and alcohol consumption could be due to a better perception of alcohol effects as high education levels shaped better cognitive skills that affected health-related decisions (14). Early initiation of alcohol resulted in poor study performance (32). Therefore, adolescents with early alcohol initiation reduced the opportunity for cognitive growth and potentially leading to school drop-out and limiting the opportunity to pursue higher education. This may also explain why higher education level acted as a protective factor.

Contrary to previous study, we didn't find any association between earnings and its role in the survivability of alcohol consumption. Previous study stated that lower income was associated with alcohol abstinence (33). One possible argumentation is that this was because everyone could afford alcohol regardless of socioeconomic status, depending on the type of alcohol. Bootleg alcohol was cheap and accessible, suitable for adolescents with little to no money, while legal alcohol was expensive due to its tax (27), thus suitable for higher socioeconomic adolescents. However, due to the unavailability of data on the type of alcohol consumption (legal or bootleg), we were unable to verify this, and further studies may be needed to address this issue.

While we employed a nationally representative dataset with an approach of generalized gamma regression, a notably new approach in Indonesia public health scheme, our study also came with limitations. First, since we utilized a secondary dataset, there were some variables that were not available, for example parental behavior (i.e., parental advisory, parental closeness to adolescents), peer pressure, and religiosity. However, we successfully identified several risk factors and protective factors that would be beneficial for targeted interventions.

CONCLUSIONS AND SUGGESTIONS

Conclusion

Our study highlighted the importance of the presence of other risk factors that shorten the survival years of adolescents to consume alcohol. Smoking was found to be the most substantial variable, shortening the survivability by 19%. Since such behaviors including smoking, having sex, alcohol use, and drug use tend to cluster together, cross-sectoral approaches are needed to intervene in such behavior.

Suggestion

The Health Ministry of Indonesia, in collaboration with the National Narcotics Board (BNN or *Badan Narkotika Nasional*) and the National Population and Family Planning Board, is advised to strengthen and enforce existing policies, including setting a legal age for purchasing and consuming alcohol, even bootleg alcohol, to prevent early initiation.

Adolescents who have already consumed alcohol, a monitoring and evaluation framework is needed to track those with multiple risky behaviors, such as smoking, drug use, and sexual activity. One-on-one counseling-based interventions can be implemented to address these behaviors, particularly in rural areas and among less educated adolescents where risks are elevated.

Counseling approaches may include behavioral counseling, substance use counseling, and sexual health counseling, ensuring guidance tailored to the adolescents' specific conditions. Primary healthcare centers (*Puskesmas* or Pusat Kesehatan Masyarakat) could serve as the main vocal point, especially in rural areas where funding is limited and local healthcare systems are supposed to be utilized comprehensively instead of creating a new one. Local communities could also be empowered to promote such counselling services.

Regarding the research focus, future studies are encouraged to incorporate additional variables to examine associations with adolescent alcohol use. Employing longitudinal studies with quasi-experimental designs is recommended to identify the actual points of alcohol consumption and validate these findings.

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