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ORIGINAL RESEARCH

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Predicting factors influencing suicidal ideation among middle aged male wage workers in South Korea: a study using stochastic gradient descent regressor and logistic regression analysis

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Abstract

Background: South Korea has one of the highest suicide rates among Organisation for Economic Co-operation and Development (OECD) countries, posing a significant public health issue. This study aims to identify factors influencing suicidal ideation among middle aged male wage workers in South Korea using the 2019 Korean Health Panel data. **Methods**: A cross-sectional design was employed, utilizing a sample of 708 middle aged male wage workers aged 40 to 65 years. Socio demographic and health related characteristics were analyzed. The Stochastic Gradient Descent Regressor (SGDR) was used to predict suicidal ideation and its performance was compared with Classification and Regression Trees (CART), Support Vector Machine (SVM) and Naive Bayes models. Variable importance scores from SGDR were used for logistic regression analysis to identify key predictors. **Results**: The prevalence of suicidal ideation was 12.4%. The SGDR model demonstrated superior performance with an accuracy of 0.82 and Area Under the Curve (AUC) of 0.78. Key predictors included depression, stress, anxiety, lower education levels, temporary employment and poor self-rated health. Logistic regression analysis showed significant associations with adjusted odds ratios (ORs) ranging from 1.45 to 4.38. **Conclusions**: By identifying key predictors and employing advanced predictive models, this study offers valuable insights for policymakers and healthcare providers to design targeted interventions and support systems for at-risk individuals.

Keywords

Suicidal ideation; Middle aged men; Wage workers; Mental health; Predictive modeling

1. Introduction

South Korea has one of the highest suicide rates among OECD countries, posing a significant public health issue. The association between suicide rates and economic adversity was most significant among middle aged men, reflecting the combined impacts of social and economic pressures unique to this demographic in South Korea [1]. Additionally, suicide is the second leading cause of death for adults in their 40s and 50s, under scoring the gravity of the issue among middle aged men in the country [2]. According to the 2019 Korean Health Panel data, suicidal ideation among middle-aged male wage workers is influenced significantly by their educational level, occupational status and type of medical insurance. Notably, men with lower levels of education exhibit higher rates of suicidal ideation, indicating that educational attainment is a crucial factor in mental health outcomes for this group [3, 4]. Moreover, blue collar workers have a higher prevalence of suicidal ideation compared to other occupational groups, revealing the significant impact of occupational status on mental health among middle aged men [5].

Cultural expectations of masculinity and the pressure to be the primary breadwinner often prevent middle aged men in Korea from seeking help for mental health issues. The development and validation of a tool to assess gender role conflict among Korean men highlight the connection between societal expectations of masculinity and psychological dysfunctions such as depression and stress, emphasizing the need for a gendered psychology of men's health [6]. Furthermore, cultural pressures, capitalism and patriarchy significantly impact men's health by restricting their choices and behaviors, influencing their reluctance toward seeking help and leading to an increased incidence of mental health issues, including suicidal ideation [7, 8].

Previous studies on suicidal ideation among middle-aged male wage workers have identified various influencing factors but face several limitations that complicate the understanding and intervention strategies for this serious issue. First, the

absence of a universally accepted age range for "middle age" complicates comparisons across studies. For instance, studies have varied in their age criteria, with some focusing on men aged 45–65 [9–11], while others have considered the age range of 40–65 [12], making it difficult to compare findings directly. Such variation affects the interpretation of the impact of different factors like income satisfaction, stress, depression and obesity on suicidal thoughts. Second, the prevailing use of cross-sectional designs in this field limits the ability to observe changes and establish causal relationships over time. This design is prevalent despite the known requirement for longitudinal research to track how factors such as anxiety and depression impact suicidal ideation across different life stages [13, 14]. Third, there's a considerable reliance on self-reported data, which often does not accurately reflect the actual mental states of respondents due to inherent biases such as under-reporting or over-reporting of symptoms. This reliance introduces challenges in achieving objective assessments of mental health conditions and their severity [15–18]. In essence, while current research has laid important groundwork, addressing these limitations is crucial for advancing our understanding and effectively mitigating the risk of suicidal ideation among middle aged men.

To overcome these limitations, this study employed the Stochastic Gradient Descent Regressor (SGDR) to predict suicidal ideation among middle-aged male wage workers. The purpose of this study is to identify the factors influencing suicidal ideation among middle aged male wage workers in South Korea using the 2019 Korean Health Panel data. The specific objectives are as follows: first, to analyze the socio-demographic and health related characteristics of middle aged male wage workers; second, to examine the differences in suicidal ideation based on these characteristics; and third, to identify the key factors influencing suicidal ideation using a logistic regression analysis informed by the variable importance scores from the best performing predictive model. This study aims to provide foundational data for developing suicide prevention policies and strategies tailored to middle aged male wage workers in South Korea, contributing to early detection and effective intervention for at risk individuals.

2. Methods

2.1 Study design and data collection

This study employs a cross-sectional design using the 2019 Korean Health Panel data, which provides comprehensive information on the health status, medical service utilization and socio-demographic characteristics of South Korean individuals. The data collection was conducted from August to November 2019 by trained interviewers who visited households to administer structured interviews and self-administered questionnaires. The Korean Health Panel data are managed jointly by the Korea Institute for Health and Social Affairs and the National Health Insurance Service. The Korean Health Panel data was conducted in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments. Informed consent was obtained from all individual participants included in the study. Data anonymity and confidentiality were strictly maintained throughout the research process. The dataset used in this study is version 2.0.1, which includes a wide range of variables relevant to health and socio-economic status (https://www.khp.re.kr:444/eng/main.do). The sampling frame was based on the 2005 Population and Housing Census, employing a two-stage stratified cluster sampling method to ensure representativeness of the Korean population.

2.2 Participants

The initial dataset comprised 12,396 economically active adults from 6689 households. For the purpose of this study, we filtered the dataset to include only male wage workers aged 40 to 59 years, resulting in a final sample size of 708 participants. The inclusion criteria were male wage workers aged between 40 and 59 years and respondents who provided complete data on key variables such as age, education, occupation and suicidal ideation. Participants who did not meet these criteria or had missing data on outcome variable was excluded from the analysis.

2.3 Variables

The primary outcome variable in this study is suicidal ideation, measured by asking participants a single question: "Have you ever seriously thought about committing suicide in the past year?". The responses were coded as 0 for "No" and 1 for "Yes", using raw data collected from the Korean Health Panel data survey.

The input variables were divided into socio-demographic characteristics and health-related factors (Table 1). Socio-demographic characteristics include age, categorized into "40–49 years" and "50–59 years"; spouse, indicating the presence of a spouse (including common-law marriages) as "Yes" or "No" (single, divorced, widowed); education level, classified into "Middle school or lower", "High school" and "College or higher"; occupational status, categorized into "Permanent", "Temporary" and "Daily worker"; medical insurance type, classified into "Health Insurance" and "Medical Aid"; presenteeism, measured by whether the respondent had gone to work despite being sick in the past year ("Yes" or "No"); and annual household income, measured as a continuous variable in Korean Won (KRW).

Health-related characteristics, which were assessed using self-reported questionnaires, include smoking status, classified as "Yes" for current smokers (including daily or occasional smokers) and "No" for former smokers or non-smokers; alcohol consumption, categorized as "Yes" for those who had consumed alcohol in the past year and "No" for lifetime abstainers or those who had not consumed alcohol in the past year; regular exercise, classified as "Yes" for those who had engaged in regular physical activity, including walking, in the past year and "No" for those who had not; chronic diseases, indicating the presence of chronic diseases such as diabetes and hypertension ("Yes" or "No"); stress levels, categorized as "Yes" for those who experienced stress in daily life and "No" for those who did not; anxiety, measured by whether respondents had experienced excessive anxiety or worry for six

TABLE 1. Definition and measurement of variables.

Variable	Definition	Measurement
Spouse	Presence of a spouse	"Yes" (including common-law), "No"
Education Level	Highest level of education completed	"Middle school or lower", "High school", "College or higher"
Occupational Status	Employment status	"Permanent", "Temporary", "Daily worker"
Medical Insurance Type	Type of medical insurance	"Health Insurance", "Medical Aid"
Presenteeism	Going to work despite being sick in the past year	"Yes", "No"
Annual Household Income	Total annual household income	Continuous variable (KRW)
Smoking	Current smoking status	"Yes" (daily or occasional), "No" (former or non-smoker)
Alcohol Consumption	Alcohol consumption in the past year	"Yes", "No" (lifetime abstainers or not in the past year)
Regular Exercise	Regular physical activity, including walking, in the past year	"Yes", "No"
Chronic Diseases	Presence of chronic diseases (*e.g.*, diabetes, hypertension)	"Yes", "No"
Stress	Experience of stress in daily life	"Yes", "No"
Anxiety	Experience of excessive anxiety or worry for six months or more	"Yes", "No"
Depression	Feeling very sad or unhappy for two weeks or more	"Yes", "No"
Self-rated Health Status	Self-assessment of overall health	"Good", "Fair", "Poor"
Suicidal Ideation	Serious thoughts of suicide in the past year	"Yes", "No"

KRW: Korean Won.

months or more in the past year ("Yes" or "No"); depression, measured by whether respondents had felt very sad or unhappy for two weeks or more in the past year ("Yes" or "No"); and self-rated health status, assessed by respondents and categorized as "Good", "Fair" or "Poor".

2.4 Statistical analysis

Data analysis was performed using Python and R statistical software. Descriptive statistics were calculated for all variables to summarize the sample characteristics. Continuous variables were expressed as means and standard deviations, while categorical variables were expressed as frequencies and percentages.

2.4.1 Model development

We employed the SGDR to predict suicidal ideation. SGDR is suitable for large datasets and high-dimensional data, making it an ideal choice for our analysis. The model was trained using a 70–30 train-test split. Hyperparameter tuning was conducted using grid search with cross-validation to optimize the model's performance.

The performance of SGDR was compared with other machine learning models, including the CART, SVM and Naive Bayes models. The performance metrics included accuracy, precision, recall, F1-score and the area under the Receiver Operating Characteristic (ROC) curve (AUC).

2.4.2 Variable importance

Variable importance scores were derived from the best-performing predictive model. These scores were used to identify the most significant factors influencing suicidal ideation. The importance of each variable was determined by its contribution to the model's predictive power, measured through techniques such as permutation importance and mean decrease impurity.

2.4.3 Logistic regression analysis

Based on the variable importance scores, a logistic regression analysis was conducted to quantify the relationship between the key factors and suicidal ideation. The adjusted odds ratios (ORs) with 95% confidence intervals (CIs) were calculated to assess the strength of these associations.

2.4.4 Model evaluation

The final models were evaluated based on several metrics.

1. Accuracy: The proportion of true results (both true positives and true negatives) among the total number of cases examined.

2. Precision: The proportion of true positive results in the predicted positive cases.

3. Recall (Sensitivity): The proportion of true positive

results in the actual positive cases.

4. F1-score: The harmonic mean of precision and recall.

5. AUC (Area Under the Curve): A measure of the ability of the model to distinguish between classes.

The model with the highest overall performance was selected for further analysis.

3. Results

3.1 General characteristics of participants

Table 2 presents the descriptive statistics for the socio-demographic and health-related characteristics of the 708 middle-aged male wage workers included in the study. The mean age of the participants was 52.7 years (standard deviation (SD) = 4.1). The majority of the participants were married (78.5%), had a high school education (45.2%) and were permanent workers (62.4%). Most participants had health insurance (89.7%), and 34.3% reported presenteeism in the past year. The average annual household income was 48 million KRW (SD = 12 million KRW).

Regarding health-related characteristics, 32.1% of the participants were current smokers, and 65.4% had consumed alcohol in the past year. Regular exercise was reported by 47.6% of the participants. Chronic diseases were present in 28.9% of the participants. A majority reported experiencing stress (72.3%), while 18.4% reported experiencing significant anxiety and 21.7% reported experiencing depression in the past year. Self-rated health status was reported as good by 34.8% of the participants, fair by 46.5% and poor by 18.7%.

TABLE 2. Descriptive statistics of participants (N = 708).

Characteristic	N (%) or Mean (SD)
Age (yr)	52.7 (4.1)
Spouse	
Yes	556 (78.5%)
No	152 (21.5%)
Education Level	
Middle school or lower	142 (20.1%)
High school	320 (45.2%)
College or higher	246 (34.7%)
Occupational Status	
Permanent	442 (62.4%)
Temporary	186 (26.3%)
Daily worker	80 (11.3%)
Medical Insurance Type	
Health Insurance	635 (89.7%)
Medical Aid	73 (10.3%)
Presenteeism	243 (34.3%)
Annual Household Income	48,000,000 (12,000,000) KRW
Smoking	227 (32.1%)
Alcohol Consumption	463 (65.4%)
Regular Exercise	337 (47.6%)
Chronic Diseases	205 (28.9%)
Stress	512 (72.3%)
Anxiety	130 (18.4%)
Depression	154 (21.7%)
Self-rated Health Status	
Good	246 (34.8%)
Fair	329 (46.5%)
Poor	133 (18.7%)

SD: standard deviation; KRW: Korean Won.

3.2 Analysis and performance comparison of stochastic gradient descent regressor and comparative models

The SGDR model was employed to predict suicidal ideation among middle-aged male wage workers. The model was trained and tested using a 70–30 train-test split. Hyperparameter tuning was conducted using grid search with cross-validation to optimize the model's performance. The performance of SGDR was compared with other machine learning models, including the CART, SVM and Naive Bayes models.

The SGDR model outperformed the other models (Fig. 1), achieving an accuracy of 0.82, precision of 0.68, recall of 0.74, F1-score of 0.7 and an AUC of 0.78. These metrics indicate that the SGDR model has a high level of accuracy and reliability in identifying individuals at risk of suicidal ideation. In comparison, the CART model achieved an accuracy of 0.78 and an AUC of 0.74, the SVM model achieved an accuracy of 0.79 and an AUC of 0.76, and the Naive Bayes model achieved an accuracy of 0.75 and an AUC of 0.70.

3.3 Variable importance scores

Variable importance scores were derived from the SGDR model to identify the most significant factors influencing suicidal ideation (Fig. 2). The importance of each variable was determined by its contribution to the model's predictive power, measured through techniques such as permutation importance and mean decrease impurity. Depression was identified as the strongest predictor of suicidal ideation, followed by stress and anxiety. Education level, self-rated health status and occupational status also emerged as significant factors, indicating the need for targeted interventions to support individuals with lower educational attainment and poor health perceptions (Fig. 2).

3.4 Logistic regression analysis

Based on the variable importance scores from the SGDR model, a logistic regression analysis was conducted to quantify the relationship between the key factors and suicidal ideation. Table 3 presents the adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for these factors.

Age was a significant predictor, with participants aged 50–59 years having 1.45 times higher odds of experiencing suicidal ideation compared to those aged 40–49 years. Participants

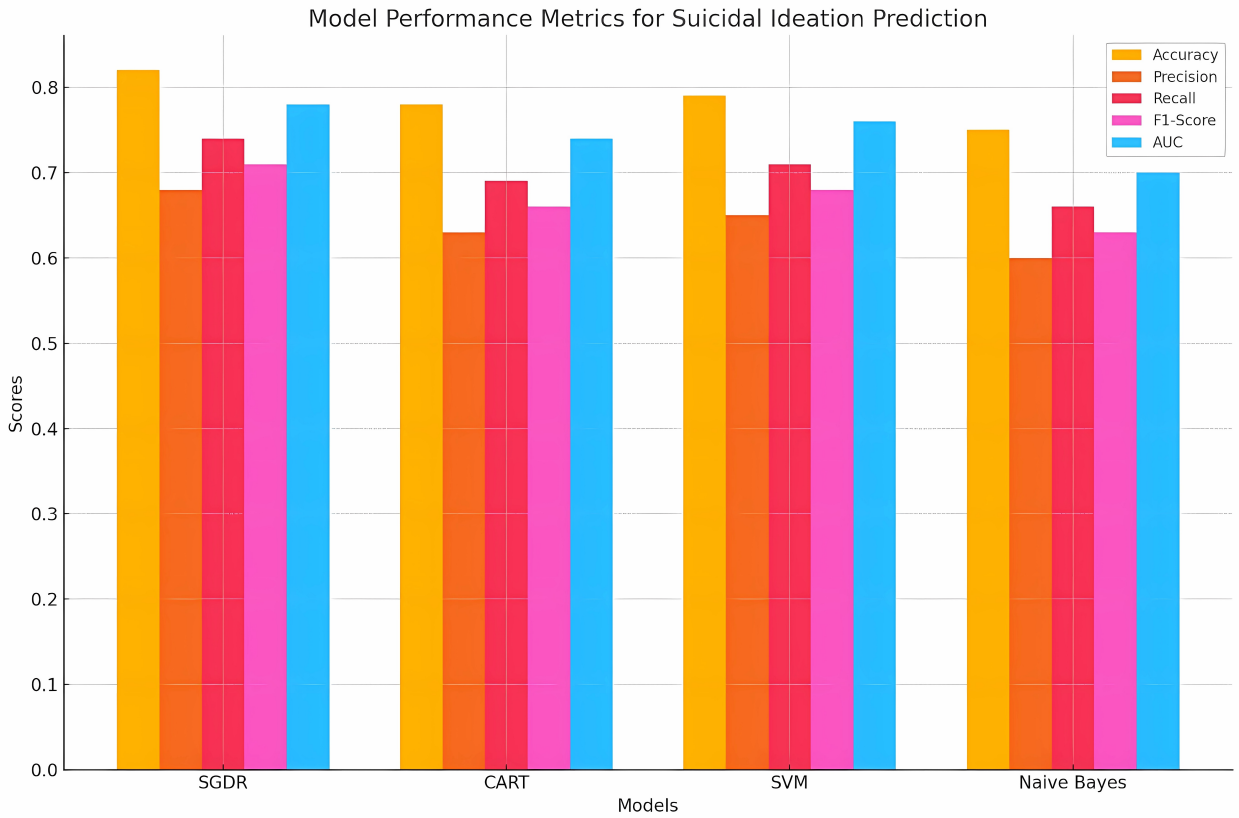

FIGURE 1. Model performance metrics for suicidal ideation prediction. SGDR: Stochastic Gradient Descent Regressor; CART: Classification and Regression Trees; SVM: Support Vector Machine; AUC: Area Under the Curve.

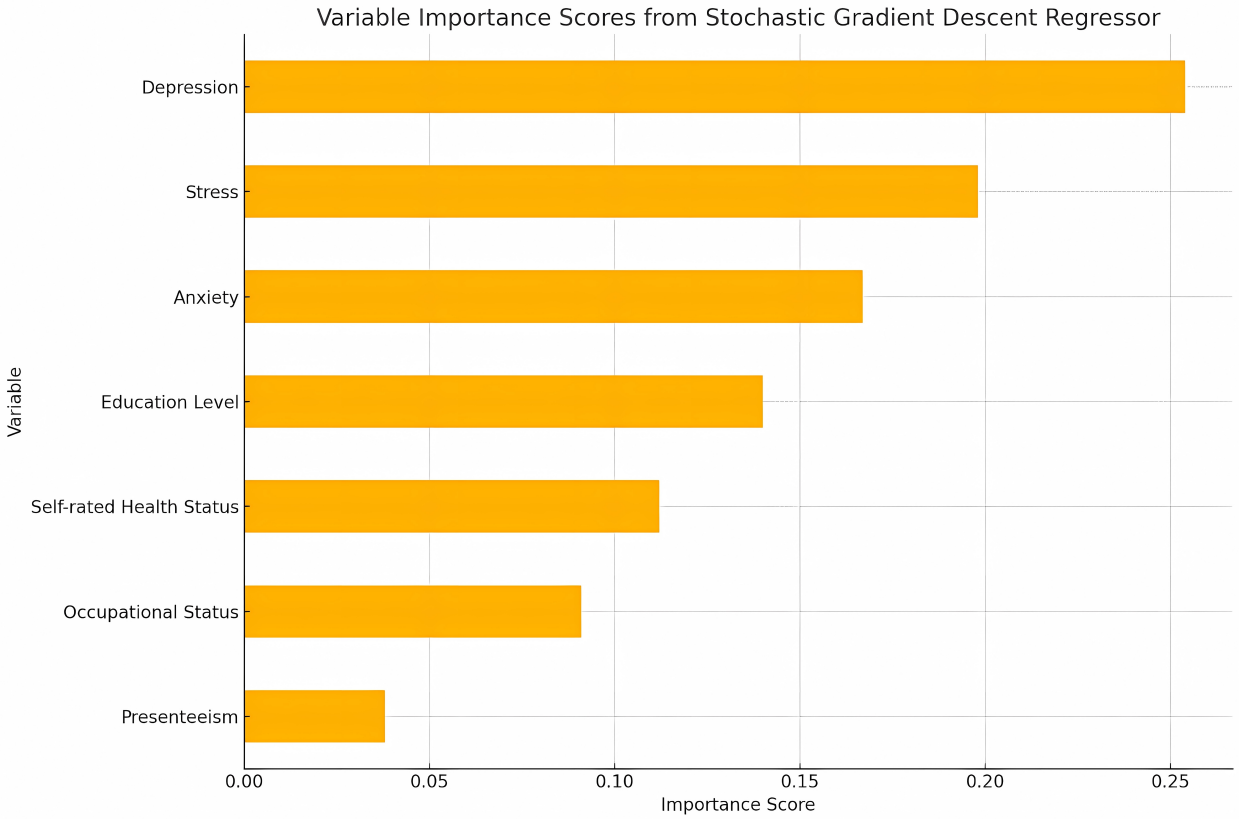

FIGURE 2. Variable importance scores from stochastic gradient descent regressor.

TABLE 3. Logistic regression analysis of factors influencing suicidal ideation.

Variable	Adjusted OR (95% CI)
Age (yr)	
50–59	1.45 (1.02–2.06)
Education Level	
Middle school or lower	2.67 (1.54–4.64)
Occupational Status	
Temporary	1.83 (1.17–2.86)
Medical Insurance Type	
Medical Aid	2.21 (1.32–3.68)
Presenteeism	1.89 (1.26–2.84)
Chronic Diseases	1.76 (1.15–2.69)
Stress	3.12 (1.82–5.34)
Anxiety	2.47 (1.54–3.97)
Depression	4.38 (2.87–6.69)
Self-rated Health Status	
Poor	2.96 (1.83–4.79)

OR: odds ratio; CI: confidence interval.

with middle school or lower education had 2.67 times higher odds of suicidal ideation compared to those with college education or higher. Temporary workers had 1.83 times higher odds of suicidal ideation compared to permanent workers. Participants with medical aid had 2.21 times higher odds of suicidal ideation compared to those with health insurance. Presenteeism was significantly associated with suicidal ideation, with those reporting presenteeism having 1.89 times higher odds of experiencing suicidal thoughts.

Among health-related factors, the presence of chronic diseases increased the odds of suicidal ideation by 1.76 times. Participants experiencing stress had 3.12 times higher odds of suicidal ideation. Significant anxiety increased the odds by 2.47 times and depression had the highest odds ratio at 4.38. Poor self-rated health was associated with 2.96 times higher odds of suicidal ideation compared to good self-rated health.

4. Discussion

This study aimed to identify the factors influencing suicidal ideation among middle-aged male wage workers in South Korea using the 2019 Korean Health Panel data. The literature review revealed a variety of factors contributing to suicidal ideation within this demographic. The prevalence of suicidal ideation among participants was notable, with insecure employment status and shift work significantly associated with suicidal ideation [19]. Moreover, a significant association was discovered between unemployment and suicidal ideation, with a concerning rate of 24.7% among this group [20].

A transition from permanent to precarious employment was also linked to an increased risk of suicidal ideation [21]. Furthermore, the absence of a spouse was significantly associated with suicidal ideation among middle aged men, highlighting the influence of socio-demographic status [22]. Work stressors, including high job demands and lack of reward, were identified as risk factors, emphasizing the role of employment conditions [23]. Additionally, long working hours were significantly associated with depressive mood and suicidal ideation [24], with evening and night shift work exacerbating these risks [25].

Another key finding of this study is the superior performance of the SGDR in predicting suicidal thoughts. In the field of identifying risk factors for suicidal ideation, advanced machine learning models have been extensively explored to enhance prediction accuracy and understanding of key psychological and demographic indicators. Among these, the SGDR has shown promising results, demonstrating superior performance in predicting suicidal ideation compared to other models such as CART, SVM and Naive Bayes. The Stochastic Gradient Descent Regressor (SGDR) has demonstrated significant efficacy in managing large datasets and high-dimensional data, rendering it particularly advantageous for analyzing the complex interplay of various factors across diverse research contexts [25]. Notably, this algorithm excels in efficiently managing computational resources, thereby enabling researchers to handle vast amounts of information without sacrificing accuracy or speed [26]. Such advantages underscore its robustness in high-dimensional spaces, making it an ideal choice for studies that involve multifaceted variables [27]. This is especially crucial when addressing complex phenomena where numerous interacting variables must be simultaneously considered to derive meaningful insights.

Nevertheless, studies or applications of SGDR utilizing health data are exceedingly rare. To bridge this gap, future research needs to explore the use of SGDR in investigating the complex interactions between variables in health data, thereby developing more sophisticated predictive models. Such an approach would provide new insights into health data analysis and could ultimately contribute to public health policy and personalized medicine.

The findings of this study have several important implications for policy and practice. Given the strong association between mental health issues and suicidal ideation, there is a critical need for targeted mental health interventions for middle-aged male wage workers. This includes providing access to mental health services, promoting mental health awareness and implementing workplace mental health programs to address stress, anxiety and depression. The significant impact of lower education levels and temporary employment on suicidal ideation highlights the need for policies that support education and stable employment opportunities. Providing vocational training, education programs and employment support services can help mitigate the risk factors associated with suicidal thoughts. The association between medical aid and higher odds of suicidal ideation suggests disparities in healthcare access. Policymakers should consider measures to improve access to healthcare services for individuals on medical aid, ensuring they receive adequate mental health support and treatment. The high performance of the SGDR model in predicting suicidal ideation suggests its potential utility in early detection and intervention efforts. Implementing predictive analytics in healthcare settings can help identify individuals at risk of suicidal ideation and provide timely interventions to prevent

suicide.

This study has several strengths, including the use of a large, nationally representative dataset and the application of advanced machine learning techniques to enhance predictive accuracy. The findings provide valuable insights into the factors influencing suicidal ideation among middle-aged male wage workers in South Korea. However, there are also some limitations. The cross-sectional design of the study limits the ability to establish causal relationships between the identified predictors and suicidal ideation. Longitudinal studies are needed to confirm the causal pathways and examine changes in suicidal ideation over time. Additionally, the reliance on self-reported data may introduce reporting biases, and future studies should consider incorporating objective measures of mental health and socio-demographic factors. Furthermore, future research should utilize a more detailed classification of occupational factors, loneliness and chronic diseases to better understand their impact on suicidal ideation.

Future research should focus on longitudinal studies to explore the causal relationships between the identified predictors and suicidal ideation. Additionally, further research is needed to examine the effectiveness of targeted interventions and policies in reducing suicidal ideation among middle aged male wage workers. Exploring the utility of predictive analytics in other populations and settings can also provide valuable insights for suicide prevention efforts.

5. Conclusions

In conclusion, this study provides a comprehensive analysis of the factors influencing suicidal ideation among middle-aged male wage workers in South Korea. The findings underscore the critical role of mental health issues, socio-demographic factors and healthcare access in influencing suicidal thoughts. By identifying key predictors and employing advanced predictive models, this study offers valuable insights for policymakers and healthcare providers to design targeted interventions and support systems for at-risk individuals. Effective mental health interventions, education and employment support and improved healthcare access are essential to reducing suicidal ideation and preventing suicide in this vulnerable population.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are provided at the request of the corresponding author. The data is not publicly available because researchers need to obtain permission from the Korea Institute for Health and Social Affairs. Detailed information can be found at: http://knhanes.cdc.go.kr.

AUTHOR CONTRIBUTIONS

HB—conceptualization; software; methodology; validation; investigation; writing-original draft preparation; formal analysis; writing-review and editing; visualization; supervision; project administration; funding acquisition. The author contributed to editorial changes in the manuscript. The author read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Before conducting the survey, written informed consent was acquired from all participants. This study employed only pre-existing, anonymized data. It adhered to the principles outlined in the Declaration of Helsinki. The protocol for the Panel Study of Worker's Compensation Insurance received approval from the Institutional Review Board (IRB) of the KNHANES (IRB approval numbers: 2018-01-03-5C-A). All study participants provided written informed consent.

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CONFLICT OF INTEREST

The author declares no conflict of interest. Haewon Byeon is serving as one of the Guest editors of this journal. We declare that Haewon Byeon had no involvement in the peer review of this article and has no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to WYS.

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